EXPLORING THE MUNICIPAL SOLID WASTE RECYCLING OPTION: THE CASE OF SÃO PAULO, BRAZIL

by

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ABSTRACT

Solid waste disposal is now recognized worldwide as a critical issue that demands immediate attention. Environmentally unsafe techniques have been either banned or forced to comply with numerous standards of operation. In addition, the throw-away ethics of modern societies combined with the decreasing available space in urban areas, have helped aggravate the problem. As a result, finding suitable places to dispose of waste is becoming a much more difficult and expensive endeavor. The recycling option, therefore, has little by little emerged as an appealing waste management technique to fight the increasing economic and environmental costs associated with traditional methods. What was once waste is now a valuable resource.

This thesis investigates the concepts of recycling as a waste management tool by breaking the analysis down in three main parts. In the first part, the economics behind recycling is explored through the use of a cost-benefit analysis approach where the social costs and benefits of recycling in a given community are identified. The necessary steps that the public sector must take in order to correct imperfections in the solid waste disposal market are also evaluated. In the second part, existing technologies in municipal recycling programs are examined, underscoring both the collection and processing phases. The focus in this section is primarily on large, densely populated cities, like São Paulo. In the third part, the case of São Paulo is presented and evaluated. After recommendations for improvements of the city's recycling program are made, the cost-benefit model developed earlier is applied.

The analysis shows that recycling in São Paulo yields a net social benefit, therefore confirming preliminary presumptions that recycling pays off. However, due to recycling's limited role of diverting only the recyclable portion of the waste from the city's landfills, recycling is only part of the solution for the waste disposal dilemma. Ultimately, the answer will rely on effectively integrated waste management systems, where each system is designed to complement the others.

Thesis Supervisor: Dr. Fred Moavenzadeh
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EPA	U.S. Environmental Protection Agency.
GSPA	Greater São Paulo Metropolitan Area.
IRR	Internal Rate of Return.
LDCs	Less Developed Countries.
LIMPURB	São Paulo's Urban Waste Management Department.
MRF	Materials Recovery Facility.
MSW	Municipal Solid Waste.
NIMBY	Not in My Back Yard Syndrome.
NIMTOF	Not in My Term of Office Syndrome.
NOx	Nitrogen Oxides.
NPV	Net Present Value.
O&M	Operation and Maintenance Costs.
PICs	Products of Incomplete Combustion.
RDF	Refuse-Derived Fuel-Fired Facility.

CHAPTER 1

INTRODUCTION

Due to the enormous population growth and industrial development experienced by modern societies, the issue of waste disposal which until recently has been taken for granted by most communities has now become paramount. Appropriate places to dispose of waste have become increasingly more difficult and expensive to find. In addition, growing public awareness has created the demand for more environmentally conscious disposal methods in order to minimize adverse effects to the environment and the public health.

While traditional methods such as landfills and incineration plants continue to lose appeal because of there unsightly and often unhealthy characteristics, recycling has emerged as an interesting alternative. Recycling is not only an environmentally friendly waste disposal technique, but it can also serve as a tool for sustainable economic development. In creating resource from waste, recycling promotes employment, fosters a secondary materials industry, and permits the reduction of scarce raw materials imports. While this is true for both the developed and developing worlds, the developing nations are even more likely to profit from a shift to recycling.

To the lay observer, what distinguishes the developed world from the developing or underdeveloped world is often its physical appearance. A cleaner environment often signals a coordinated approach to waste disposal. In many developing countries, cities have grown at unprecedented rates and waste generation has skyrocketed. This fast population growth combined with government and industry emphasis on short term industrialization--"catching up" with their developed counterparts--have prohibited a planned and otherwise organized solution to the increasingly critical waste disposal issue. While waste management should clearly command high priority status, it is often grossly overlooked.

The case of São Paulo is especially interesting because it has issues in common with both the developed and the developing worlds. With 12 million inhabitants, São Paulo is Brazil's largest city and the world's second largest; it generates an average of 2.3 million metric tons of domestic waste annually, which is considered a high generation rate even when compared to the large cities of the developed world. At the same time, it suffers, as do many other developing nations, from improper planning and increasingly scarce space for waste disposal. Brazil's clear economic leadership in Latin America, however, and the respect that it commands in the developing world makes its solid waste disposal solutions realistic examples to be followed by other less developed countries (LDCs).

Other reasons for exploring the recycling option in Brazil include its timeliness. In June of 1992, Brazil will host the United Nations Conference on the Environment and Development. Brazil is obviously concerned with its environmentally unfriendly image, especially in regards to the rain forest issue sensationalized by the international media. A viable solid waste recycling program in São Paulo could positively affect this image and demonstrate Brazil's efforts toward environmentally conscious development which has obvious positive political ramifications.

This thesis in examining the recycling program in São Paulo will demonstrate that substantial improvements can be made to expand the current program's limited role in order to provide the city with an economical and socially preferable waste disposal alternative. The cost-benefit analysis approach will be used to identify and measure the associated costs and benefits of recycling.

The following chapter will review the solid waste disposal dilemma from a global perspective. In addition, Chapter 2 will briefly examine the traditional solid waste disposal methods currently in use and evaluate their positive characteristics as well as their drawbacks. Lastly, the recycling option, including its appeal as well as its limitations, will be explored.

Chapter 3 will investigate the economics behind municipal solid waste (MSW) recycling. First, environmental costs and who bears them will be outlined. Then, the cost-benefit analysis approach will be introduced. It will define what constitutes a cost and what constitutes a benefit and determine the net social benefit of recycling. Finally, Chapter 3 will discuss the need for government intervention through the use of policy instruments in order to foster economic efficiencies in the waste management sector.

The next chapter will examine available technologies for recycling programs, underscoring the collection and processing phase technologies for large and densely populated cities like São Paulo. Specifically, the case of Tokyo and the reasons why Japan has one of the world's highest recycling rates will be reviewed.

Chapter 5 will analyze the case of São Paulo by first presenting an overview of the solid waste situation there and then suggesting the need for alternative disposal methods.

Chapter 6 will review São Paulo's current recycling program and recommendations for improvements will be made. By applying the cost-benefit model developed in Chapter 3, the costs and benefits of recycling will be identified and measured in efforts to determine the net social benefit of recycling to São Paulo.

The last chapter will present its conclusions about the recycling option in São Paulo and introduce the principles of an integrated waste management system. Finally, the lessons to be learned from São Paulo's case will be highlighted.

CHAPTER 2

THE SOLID WASTE DISPOSAL DILEMMA

2.1. Magnitude of the Problem

As the world population grows and more waste is produced daily, the lack of appropriate solid waste disposal methods have become a major issue for many communities around the world. The problems associated with ill-suited waste disposal techniques have impacted both the developed as well as the developing world.

In many industrialized countries, the waste disposal problem has reached a critical point. Environmentally unsafe methods, such as open dumping and ocean disposal, have been banned. Furthermore, old, inefficient sanitary landfills and incinerators have been forced to comply with numerous energy and natural resources conservation programs in order to reduce their negative impact on the environment.

In the United States alone, 293 million tons of solid waste were disposed of in municipal facilities in 1990, which represents a 23 million ton increase compared to the previous year. From this total of 293 million tons, 77% went to sanitary landfills, 11.5% was incinerated, another 11.5% was recycled, and a fraction of a percent of the waste was composted. However, by the end of 1990, there were 6,326 operating municipal sanitary landfills, compared to 7,379 in the year before and 8,000 in 1988.[1] While there is a clear upward trend in the amount of waste generated, the number of operating sanitary landfills, which is by far the most popular waste disposal destination in the United States, is on the decline. This is a reflection of the "landfill crisis" in the U.S. in which old landfills are either reaching capacity or are being forced to close, while new ones are not being granted permits.

According to the U.S. Environmental Protection Agency (EPA), most of the solid waste landfills that are in operation are not environmentally acceptable and the Agency predicts that 50% of today's landfills will close by the year 1995. These landfills do not comply with the new rules that set standards for the location, design, operation and closure of sanitary landfills as well as ground water monitoring requirements.[2] As a result of the "landfill crisis", an increasing number of communities have turned to incineration and recycling as a means of addressing their waste disposal problems. Nevertheless, both pollution-related hazards caused by some incinerators and public resistance to siting of any waste management facility, have contributed to create an impasse in coming to an MSW solution in this country.

Although Americans may lead the world in waste generation per capita, their waste disposal problems are not atypical within the developed world. In

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[1]Glenn, Jim, and David Riggle. "The State of Garbage." BioCycle Apr. 1991: 34-35.

[2]Gutfeld, Rose, and Jeff Bailey. "EPA Sets Rules for Pollution Curbs on State Landfills." The Wall Street Journal 12 Sep. 1991.

many European countries, including Sweden and Germany, the waste problem has also reached alarming proportions. In these nations, incineration accounts for a great deal of the domestic waste disposal. And today, incineration has been the target of intense control by regulators. Imposition of tighter standards on waste incineration, especially with regards to heavy metals, dioxins, acid gases, ash disposal and operator training, are now common.[3]

In view of these new mandatory requirements, incinerators are becoming very expensive to operate and very difficult to site. Moreover, similar to the U.S., sanitary landfills in Europe and Japan are also reaching capacity and failing to comply with environmentally safe provisions. Japan is expected to run out of landfill space by the year 2010. Holland has practically run out already. The former West Germany, which in 1988 exported over two million tons of waste to East Germany has now lost that convenient dumping ground. And the Swiss authorities have constantly denied new sitings for incineration facilities.[4]

While the MSW situation in the developed world is becoming increasingly worse, the situation is even more dramatic in the LDCs, especially in the metropolitan areas. These urban areas have experienced an explosive population growth mainly due to an uncontrolled migration rate of individuals coming from the rural, less developed regions. Attracted by the major cities' industrialization phase, many of these migrants live in slums, where basic services such as potable

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[3]Goldstein, Nora. "The Global Waste Management Challenge." BioCycle July 1987: 23.

[4]"Throwing Things Away." The Economist 5 Oct. 1991: 13.

water, sewage and waste collection are unavailable. This industrialization, which has caused severe damage to the environment, is expected to intensify by the year 2000 when over one billion more people in the LDCs are likely to be living in the urban areas than were living there in 1980.[5]

In spite of this astounding scenario, waste generation and environmental pollution are often overlooked by developing nations that are more concerned with "catching up" to their developed counterparts than they are with managing waste disposal. In other words, many industries, usually supported by their governments, are more concerned with production in the short run than they are with long term environmental problems. The government's lack of proper planning and regulatory controls only contributes to the problem. In general, a common characteristic of all open dumps, the most popular disposal method in the LDCs, is the lack of equipment and trained personnel needed for managing the operation according to the minimum standards of the public health and the environment.[6] As a result, the presence of rats and other pests, toxic gases, smoke from continuous burning, ground water contamination and hazardous substances in those open dumps impose a constant human and ecological threat.

Brazil is no exception to this LDC dilemma; it too has experienced serious problems with regards to improper handling of its MSW. Whereas almost 70% of

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[5]Cointreau, Sandra J. Environmental Management of Urban Solid Wastes in Developing Countries: A Project Guide. Washington, D.C.: World Bank, June 1982.

[6]Diaz, Luis F., and Clarence G. Golueke. "Solid Waste Management in Developing Countries." BioCycle July 1987: 55.

the Brazilian population lived in the rural areas in 1950, today, 40 years later, 76% of the over 150 million Brazilian inhabitants lives in the urban areas. This urbanization, however, was not accompanied by consistent implementation of basic sanitary facilities, including proper MSW treatment. This is seen primarily in Brazil's big cities. Although about 90% of the domestic garbage produced in the state of São Paulo is collected, the majority of it is improperly disposed of in open dumps outside the city limits.[7] In the city of São Paulo, where each of its 12 million inhabitants produces close to one kilo of MSW every day, the landfills (which are responsible for roughly 85% of the MSW disposed of) are almost filled to capacity and yet no other viable alternative has emerged to address the city's future needs.

In the city of Rio de Janeiro, Brazil's second most industrialized city, more than 90% of the six thousand metric tons of MSW produced daily goes to four sanitary landfills, in which three of them are "sanitary" in name only. The largest one, that is responsible for 60% of the total MSW collected is almost reaching capacity and it is currently acknowledged as one of the main polluters of the Guanabara Bay. In addition, during the 15 years that this landfill has existed, remarkable urbanization growth has occurred and as a result, approximately 20 thousand people risk their lives because they live in such close proximity to the

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[7]Buralli, G.M. "Soil Dispose of Residues and the Proliferation of Flies in the State of São Paulo." Water, Science and Technology 19 (1987).

landfill.[8]

In the less-privileged regions of Brazil, the situation is even worse. These regions lack an infrastructure necessary to provide the most basic human need. In communities located near rivers or lakes, for example, it is often common that water used for drinking and fishing is the same one used for waste dumping. And despite this alarming situation, little has been done to remedy it.

In short, the MSW disposal crisis has been apparent in numerous communities around the world, regardless of their development stages. Nevertheless, answers to their problems must be tailored to address each community's unique situation.

2.2. Traditional Solid Waste Disposal Methods

In addition to recycling, the following are the five main MSW disposal methods: (1) composting, (2) incineration, (3) sanitary landfilling, (4) ocean dumping, and (5) open dumping. Note that source reduction is not included in this list. Basically, source reduction is defined as "the design, manufacture, and use of products so as to reduce the quantity and toxicity of waste produced when the products reach the end of their useful lives".[9] Thus, despite its positive impact

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[8]Silva, Marcia. Reciclagem de Lixo no Rio de Janeiro. Rio de Janeiro: Universidade Santa Úrsula, Junho 1991. (Unpublished).

[9]U.S. Environmental Protection Agency. Decision-Makers Guide to Solid Waste Management. Washington, D.C.: Nov. 1989. 51.

on waste management operations, source reduction is not a MSW disposal method but rather a waste management strategy.

(1) Composting[10]

In its broad definition, composting is the biochemical degradation of organic matter under controlled conditions. This process involves the decomposition by microorganisms in the biodegradable organic portion of the waste. As a result, the compostable waste volume may be reduced 50 to 85% and the end product is a dark-brown substance referred to as humus or compost that is used primarily as a soil conditioner.

Encouraged by both environmental and economic reasons, many communities have found composting a good alternative for diverting considerable amounts of organic wastes away from their landfills, dumps and incinerators. In the LDCs, for instance, composting looks very attractive for three reasons. First, the organic waste constitutes the largest portion of the waste stream, therefore creating a large, continuous supply of raw material. Second, in most LDCs the climate positively influences the quality of the compost; the high moisture content is one example. And third, usually the agricultural activity represents the largest sector of the economy, therefore creating a large demand for the commercialization of the end product.

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[10]See: U.S. EPA 81.

There are five types of composting: (1) yard waste composting (leaves, grass clippings, brush, stumps and wood); (2) MSW composting (requires pre-processing of incoming materials to isolate the compostable portion of the MSW stream); (3) sludge composting (involves mixing sludge with some bulking agent such as wood chips and leaves); (4) co-composting (simultaneous composting of two or more diverse waste streams with sludge or some other nitrogen-rich product); and (5) agricultural/animal waste composting (involves mixing of animal manures with bulking agents).

Although composting is often identified as an environmentally conscious alternative, the method, however, is not free of adverse effects. Odors at composting plants and the presence of pathogens (primarily found in manure, sewage sludge and MSW) are frequent problems. Proper monitoring, therefore, of both the material to be composted and the end product are essential. Furthermore, composting may negatively impact both water and soil. Leachate (contaminated liquid percolated from the solid waste) from MSW compost plants, for instance, may contain volatile organics and metals that could adversely affect the soil, in addition to both surface and ground water. Thus, practices such as careful pre-processing of MSW to control potentially hazardous substances and the use of retention basins to limit water runoff are very important.

While landfill space preservation and economic return from the sales of compost are the driving forces for many communities engaged in composting programs, this method also looks attractive because it is also beneficial for incineration. By diverting high moisture organic waste from incinerators, the incineration process becomes more effective due to the increase of the heating value and the decrease of the amount of air pollutants, such as nitrogen oxides (NOx).

(2) Incineration

Modern incinerators are no longer rudimentary waste burners, but instead waste-to-energy systems aimed to produce steam and electricity. In general, it is estimated that roughly 75% (by weight) of the MSW in the U.S. is combustible, and that combustion of the MSW can reduce its volume by 70 to 90%.[11] Basically, all refuse-to-energy systems fall into three categories: mass burn plants, modular units, and refuse-derived fuel-fired facilities (RDF).

Mass burn plants, burn unprocessed, heterogeneous MSW exactly as it is delivered to the plant. These facilities usually have two or three combustor units, in which each unit may range in capacity from 50 to 1,000 tons per day. While the new systems have waterwall combustion chambers designed for energy recovery, older facilities typically have refractory-lined furnaces with no energy recovery.[12]

Modular units, also burn unprocessed MSW, but they are used for smaller-scale operations. Here, the modular combustion facilities usually have one to four combustor units, and each unit can range in capacity from 5 to 120 tons per day.

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[11]U.S. EPA 95.

[12]U.S. EPA 100.

All new modular units are expected to have energy recovery.[13]

Finally, refuse-derived fuel-fired facilities (RFD), burn pre-processed MSW usually prepared by removing toxic and unburnable items and drying and shredding the remainder. There are several different types of RDF and a variety of RDF-fired combustors used. Generally, the RDF plants use two to four combustion units, each unit ranging in capacity from 300 to 1,000 tons per day.[14]

Although incineration (or waste-to-energy systems) may sound like an environmentally preferable option to landfilling, in view of the waste reduction and energy recovery functions, this method also has many serious drawbacks. The major concerns are related to the poorly designed or operated incinerators which can produce dangerous levels of air pollutants, including dioxins and furans which are products of incomplete combustion (PICs). Dioxins, for instance, are highly toxic chlorinated organic compounds in which even few minutes of exposure can cause a diverse list of health effects, including birth defects, cancer, and death. Dioxins have been found in every incineration facility and incinerator ash inspected by the U.S. EPA.[15]

The other major concern is the residual ash produced during combustion operations which can contain heavy metals, especially lead and cadmium.

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[13]U.S. EPA 100.

[14]U.S. EPA 100-101.

[15]Stone, Robert F., and Nicholas A. Ashford. Package Deal: The Economic Impacts of Recycling Standards for Packaging in Massachusetts. Boston: The Massachusetts Public Interest Research Group, March 1991. 13.

Therefore, appropriate ash management, which involves properly handling the ash from its generation until its final disposal (preferably in a leachate-proof landfill) is imperative.[16]

In the developing world, waste-to-energy facilities are frequently questioned not only because of their poor standards of operation but also because of their applicability. In the LDCs, where high moisture organic wastes make up the highest portion of the waste stream, incineration would require supplementary fuel in order to provide a comparable amount of energy that incineration provides in industrialized countries. As a result of this supplementary fuel, a net energy deficit occurs.[17] Furthermore, it is often said that the "mass burn" approach to MSW incineration, which is the one used in most LDCs, simply converts a MSW disposal problem into an air pollution and toxic waste disposal problem.[18]

(3) Sanitary Landfilling

A sanitary landfill is commonly defined as "an engineered method of disposing of refuse on land, in a manner that protects the public health and the environment, by spreading the waste in thin layers, compacting it to the smallest

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[16]U.S. Environmental Protection Agency. Decision-Makers Guide to Solid Waste Management. Washington, D.C.: Nov. 1989. 104.

[17]Cointreau, Sandra J., et al. Recycling from Municipal Refuse: A State-of-the-Art Review and Annotated Bibliography. Washington, D.C.: World Bank, 1984. 19.

[18]Elkington, John, and Jonathan Shopley. Cleaning-Up: U.S. Waste Management Technology and Third World Development. World Resources Institute, March 1989. 27.

practical volume, and covering it with compacted soil after an adequate period of time".[19] Landfill operations can employ two different methods, which are the trench method and the area method.

In the trench method, the solid waste is spread and compacted in an excavated trench. Cover material, which is taken from the spoil of the excavation, is then spread and compacted over the waste to form the basic cell structure (a cell is the basic building block of sanitary landfills, which is the compacted waste and soil cover. A series of adjacent cells, all of the same height, constitutes a lift). In the area method, the solid waste is spread and compacted on the natural surface of the ground. Cover material is then spread over it and compacted.[20] There is also the possibility of combining these two methods. Trenches are excavated and filled as in the trench method, after which the entire area is covered using the area method. Cover material in the area operation is basically used from excess spoil from the trenches. In general, the method used depends upon the depth restrictions dictated by ground water levels and height restrictions dictated by aesthetics or cover material availability.[21]

Sanitary landfills, however, have faced tremendous opposition largely due to potential damage to the environment and public health. There are several

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[19]Mendes, J.M.O. "Legal Aspects of the Disposal of Industrial Wastes on Soil." Water, Science and Technology 19 (1987).

[20]Robinson, William D., ed. The Solid Waste Handbook: A Practical Guide. John Wiley & Sons, Inc., 1986. 260-262.

[21]Russell, Stuart H. Resource Recovery Economics: Methods for Feasibility Analysis. Marcel Dekker, Inc., 1982. 117.

disadvantages to sanitary landfills. First, is the possibility of ground water and surface water contamination that occurs when uncontrolled leachate formed in landfills, carrying hazardous substances, comes in contact with water. Second, is the formation of methane gas that can constitute a fire or explosion hazard. Third, is the difficulty of siting because of intense public opposition, especially in densely populated areas. This is largely because of two powerful emotional and political phenomena called NIMBY (not in my backyard) and NIMTOF (not in my term of office) syndromes, where nobody wants a waste disposal facility nearby. Fourth, is the large piece of land required, which is hard to find as well as expensive, especially in urban areas. And fifth, is the difficulty in obtaining adequate cover material.

Despite the environmental concerns associated with sanitary landfills, every community still needs access to a landfill. Although composting and recycling may divert considerable portions of the waste stream from final disposal, not all materials are recyclable. Even incineration, which significantly reduces refuse volumes, still requires the dispose of residual ash. As a result, any MSW management system must have a landfill for unprocessed waste or for the residues resulting from processing facilities. Nevertheless, proper sanitary landfill standards must be observed or the operation may degenerate into an open dump.

(4) Ocean Dumping

Ocean dumping may be simply defined as any deliberate discharge into the ocean of refuse or other matters. This method has caused great concerns in the international community, especially with regards to the harmful effects of heavy metals in the aquatic food chain, which impose a major threat to the lives of millions of seafood consumers. This environmental aggression, however, also puts marine life at risk. In addition to heavy metals, oxygen depletion is another issue impacting the ocean. Organic wastes, for example, require oxygen to decompose and depending on the amount of waste to be decomposed, the oxygen in the area may be quickly depleted resulting in the killing of marine creatures.

In order to mitigate the negative effects of ocean dumping, some nations have strictly prohibited dumping of unprocessed waste within a safe distance from their coasts. Furthermore, disposal of hazardous materials have been banned. In spite of this method's risks, many countries have relied on ocean dumping as a MSW disposal alternative, especially in the densely populated areas along the ocean of LDCs. If properly handled, many people argue that this method is an effective low-cost waste disposal option. Nevertheless, its serious associated risks probably outweigh its benefits.

(5) Open Dumping

Open dumping is the indiscriminate dumping of wastes on land. They provide breeding grounds for foul odors, open fires, rats, flies, and other pests carrying diseases. This method is no longer an accepted MSW disposal alternative for many communities in the world, especially in the developed countries. In these countries, closed open dumps are either being modified to become sanitary landfills or being transformed into public parks or other facility to better serve society. Unfortunately, however, many less privileged communities still have open dumps as their only waste disposal alternative.

2.3. The Recycling Option

Although recycling is not a new waste disposal alternative, this option has recently become extremely important in MSW management as communities and industries fight the increasing economic and environmental costs associated with traditional waste disposal methods. Through recycling, communities keep their cities clean by achieving major ecological objectives.

Contrary to what many believe, recycling is not limited to the separation and collection of reusable materials from the waste stream. This is only the first step. The next step includes the reprocessing or remanufacturing of these post-consumer materials. Then, the third and last step, which completes the recycling loop, is the return and reuse of the now recycled material as a part of other products.

Among the valuable advantages of recycling are reduction in the amount of waste to be sent to landfills or other final destinies, conservation of raw materials and energy, the potential impetus to a recycling industry, and the stimulus to environmental awareness. There are, however, significant differences in the driving forces behind the operations between developed and developing nations. In industrialized countries, recycling activities result from the high cost of waste disposal, increasing public outcry to protect the environment, and strong political pressures to create markets. In the LDCs, on the other hand, the driving forces are mainly associated with the low opportunity cost of labor, low purchasing power of the large consumer groups, and scarcity of productive inputs. And among the benefits that may be achieved through recycling in the LDCs are the creation of jobs and marketable products, reduction of environmental pollution, and reduction of imports of raw materials.[22]

The following two examples illustrate the savings of natural resources and energy that may result from recycling. Paper is one of the most popular materials found in the waste stream. Basically, for each metric ton of recycled paper, 30 trees, 100 thousand liters of water, and 2.5 thousand kilowatts of energy are being saved. Aluminum is one of the most valuable products within the waste stream. In general, whereas 17,600 kilowatts of energy is necessary to produce one metric ton of aluminum through bauxite, only 750 kilowatts (or five percent as much) is needed to produce the same quantity through scrap.[23]

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[22]Arlosoroff, Saul, and Carl Bartone. "Assisting Developing Nations." BioCycle July 1987: 43.

[23]Ferrari, Luis C. "Indústria do Lixo Não Pára de Crescer." O Globo 18 Aug. 1991.

Recycling, however, as opposed to popular belief, is not an environmentally risk free option. Reprocessing and remanufacturing materials may impact the environment. One example is waste paper's de-inking process. Colored inks and inserts used in magazines and newspaper may contain heavy metals such as lead and cadmium. After de-inking, if these substances are not properly treated and disposed of, these metals could eventually leach into ground water. Another example is the additional vehicles involved in recycling collection that could potentially affect air quality, especially in already polluted urban areas. Additionally, unsafe handling by some recycling centers of household hazardous wastes, such as batteries and waste oil, could create water run-off from stockpiles.[24]

Nevertheless, since these environmental risks are perfectly manageable, the recycling option turns out to be a great opportunity for worldwide communities. However, for communities to benefit from this alternative, a consistent recycling program has to be well planned, implemented and monitored.

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[24] "Recycling Guidelines." Public Works Apr. 1991: 58.

CHAPTER 3

ECONOMICS OF MUNICIPAL SOLID WASTE RECYCLING

3.1. Environmental Costs and the Cost-Benefit Analysis Approach

The various consumptive and productive activities carried out by individuals, businesses and governments are certainly not free of environmental costs. These activities generate materials and residuals that are not incorporated into the economic system and therefore are returned to the environment as wastes in either solid, liquid or gaseous forms. In general, this occurs as a result of the principle of materials balance, the law of conservation of mass.[25]

Excessive waste can depreciate the environmental asset if the waste exceeds the absorptive capacity of nature, causing pollution. A common example is air pollution, which may cause respiratory problems and cancer. In this thesis, however, the environmental costs that will be evaluated are the ones resulting only from the handling of solid waste.

In general, inappropriate handling of MSW is considered to be a major source of air, water and land pollution that imposes adverse effects to public health and to the environment. Although this condemned action may be practiced

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[25]Ortolano, Leonard. Environmental Planning and Decision Making. John Wiley & Sons, Inc., 1984. 26-27.

by only a certain number of individuals and industries, its large and sometimes irreparable environmental costs are borne by the whole society. Take the example of industrial waste illegally dumped by a chemical company in a river that is used as a source of drinking water, food supply and leisure by a community located downstream. Regardless of the reason for the company's action (lack of proper knowledge, financial interests, etc.) the full environmental costs are shared by society.

Environmental costs, however, are also apparent in the case of acceptable MSW disposal methods, such as incineration and landfilling. As mentioned in the preceding chapter, these two disposal techniques impose numerous risks to human health and to the fauna and flora. In the state of Massachusetts, for example, the monetary value of social costs in form of environmental harm and disamenities associated with incineration and landfilling is US$139/ton for the former (which constitutes 48% of the total social cost of incineration) and US$75/ton for the latter (which constitutes 36% of the total social cost of landfilling).[26]

Through the use of recycling as an alternative MSW disposal option, communities worldwide may avoid the costs of environmental hazards and disamenities imposed by some of the traditional methods. Furthermore, recycling may positively impact the overall economy by fostering the development of the

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[26]Stone, Robert F., and Nicholas A. Ashford. Package Deal: The Economic Impacts of Recycling Standards for Packaging in Massachusetts. Boston: The Massachusetts Public Interest Research Group, March 1991.

recycling industry. Nevertheless, for an accurate evaluation of the use of recycling and its impacts, a cost-benefit analysis is essential.[27]

Cost-benefit analysis is defined as a systematic, quantitative method for the comparative evaluation of proposed public expenditures or regulatory activities. The analysis should be carried out from a social perspective and its goal is to identify the alternative that will make the most efficient use of society's scarce resources in promoting social objectives.[28] The procedure followed in a cost-benefit analysis consists of five steps: (1) the project to be analyzed is identified; (2) all impacts, both favorable and unfavorable, present and future, on all of society are determined; (3) Monetary values are assigned to these impacts, in which favorable impacts will be registered as benefits, and unfavorable ones as costs; (4) the net social benefit (total benefit minus total cost) is calculated; and (5) the choice is made.[29]

The costs and benefits of recycling, which should be determined at the time that they occur, may have primarily three types of effects: (1) real and transfer effects; (2) primary and secondary effects; and (3) tangible and intangible effects.

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[27]In this thesis, the cost-benefit analysis method will be used as a tool to help quantify whenever possible all associated social costs and benefits of recycling. The reader should realize, however, that the method has merits as well as limitations. These limitations are especially evident when placing monetary values in intangibles.

[28]Campen, James T. Benefit, Cost and Beyond: The Political Economy of Benefit-Cost Analysis. Cambridge: Ballinger Pub. Co., 1986.

[29]Stokey, Edith, and Richard Zeckhauser. A Primer for Policy Analysis. New York: W.W. Norton & Company, Inc., 1978. 136.

Real effects are those that consist of either additions to the welfare of final consumers or actual use of resources that would otherwise have been used elsewhere. Conversely, transfer effects result from price changes (transfers) that increase revenues for some people by the same amount that they decrease revenue for others.[30] In recycling, the use of scrap as raw material instead of being dumped is a real effect, while the use of taxes paid by one neighborhood to cover the start-up costs of recycling in another neighborhood (within the same community) is a transfer effect.

Primary and secondary effects are those resulted from direct and indirect consequences of the project, respectively. A primary effect of recycling is the creation or expansion of a recycling industry, while this effect will cause a secondary effect which is the increase of employment opportunity in this industry.

Lastly, tangible effects are those that are traded in markets (can be assigned a monetary value) and intangible effects are those that are not traded in markets (can not be assigned a monetary value). A tangible effect of recycling is the revenue from sales of recyclables, while a typical intangible effect is the preservation of environment and human health. Intangible effects should be quantified to the extent possible.

In addition to these three effects, a cost-benefit analysis should also consider costs and benefits as they (1) occur in different time periods (issue of dis-

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[30]Campen, James T. Benefit, Cost and Beyond: The Political Economy of Benefit-Cost Analysis. Cambridge: Ballinger Pub. Co., 1986. 32.

counting--obtain the net present value); (2) accrue to different individuals or groups of people (distributional issues--assign weights to the net benefits of different groups. This is a highly subjective matter); and (3) occur in different possible future circumstances (issue of risk and uncertainty--choose a meaningful discount rate).[31]

3.2. Identifying Costs and Benefits of Recycling

MSW recycling is universally recognized as an environmentally conscious waste disposal option and also as an economic way of dealing with the waste disposal issue. Ad hoc social benefit estimates of recycling, however, are typically restricted to the calculation of revenues from recyclable materials plus the avoided costs of traditional disposal methods. Clearly, this rough estimate fails to consider the true social costs of conventional waste disposal as well as the incurred costs of recycling.[32]

The net social benefits of recycling may be obtained from six elements: (1) the revenues from recyclable materials; **plus** (2) the avoided subsidy to virgin materials; **plus** (3) the benefits from substituting secondary materials for virgin materials; **minus** (4) the costs of running a recycling program; **plus** (5) the

[31]Campen 38-43.

[32]The following analysis is an adaptation from the experience of the state of Massachusetts indicated in: Stone, Robert F., and Nicholas A. Ashford. Package Deal: The Economic Impacts of Recycling Standards for Packaging in Massachusetts. Boston: The Massachusetts Public Interest Research Group, March 1991. 1-23.

avoided disposal costs of incineration; **plus** (6) the avoided disposal costs of landfilling.[33]

(1) The Revenues from Recyclable Materials

The procedure to be followed in the calculation of the expected revenues from sales of recyclables is summarized in Exhibit 1 in a hypothetical example. The first step is to list the typical recyclable materials normally accepted in recycling programs (column (a)) such as paper, plastic, ferrous metals, non-ferrous metals, and glass. The second step (column (b)) is to obtain the composition by weight as a percentage of the total MSW. The third step is to estimate the overall recycling rate (column (c)), which is the combination among the rate of recyclable materials in the waste stream that are in suitable conditions to be recovered, the program's participation rate, and the rate of materials recovered in recycling plants. The fourth step is to obtain the average market price/ton of a given material (column (d)), and the last step is to calculate the combined revenue yield (column (e)), which may be determined by multiplying columns (b), (c) and (d).

In addition to the sales of recyclable materials, recycling programs may generate revenues from three other sources: contract payments; government grants; and tax revenues. Contract payments are revenues earned by the recycling program when communities contract its services. Government grants are provided by some local and state governments as incentives to the recycling initiative.

[33]Since most communities use incineration and landfilling as their leading disposal techniques, these two techniques will represent the avoided disposal costs of traditional disposal methods.

EXHIBIT 1

Revenues from Recyclable Materials
(Hypothetical Example)

(a) Material	(b) % by Weight	(c) Overall Recycling Rate (%)	(d) Avg US$/Ton	(e) Composite[1] US$/Ton
Paper	30	70	10	2.1
Plastic	10	70	100	7
Steel	5	70	50	1.75
Aluminum	1	70	500	3.5
Glass	5	70	40	1.4
Total				15.75

1. Column (e) = Column (b) * Column (c) * Column (d).

Finally, some communities charge each household a special monthly waste tax that goes to a recycling fund. Nevertheless, these three other sources of revenues are not qualified as social benefits, but rather as social costs, since they incur economic costs to be paid by society.

(2) The Avoided Subsidy to Virgin Materials

In general, virgin materials producers (like timber and petroleum, for instance) enjoy different types of subsidies by some governments. These subsidies may be in the form of tax benefits, such as depletion allowances; below cost sale of natural resources by the government; and uncompensated technical support and services, such as those provided by a country's Department of the Interior. In essence, all of these government subsidies to virgin materials, which are not available to producers of recycled materials, constitute a social cost that is not revealed in market prices. Therefore, recycling promotes reduction in the use of virgin materials and the associated social cost.

The extent of government subsidy to virgin materials depends upon the community in question. Nevertheless, the difficulty in estimating the tax subsidy savings through the adoption of recycled materials tends to be general. A rough approach would be the following: (1) estimate the average percentage size of the government subsidy for the price of a given virgin material; (2) estimate the price of a ton of this given virgin material in products that could be made of recycled materials; and (3) calculate the estimated economic value of government subsidy by multiplying steps (1) and (2).

(3) The Benefits from Substituting Secondary Materials for Virgin Materials

Worldwide societies may enjoy great economic savings in the manufacturing of goods by replacing natural resources by secondary materials. This is particularly true in countries that depend on imported raw materials, like Japan. Japan, for instance, produces a higher ratio of recycled paper to total production than any other country. However, many countries, including the U.S., have not yet taken full advantage of recycling. The U.S., for example, imports 91% of its aluminum and throws away one million tons of it annually, worth over US$400 million.[34]

Another major economic benefit realized by secondary materials is the huge savings in energy in the manufacturing process. In general, the process of producing a ton of secondary material requires considerable less energy than does the process of producing a ton of virgin material. This energy savings is particularly important for energy-intensive industries, such as the aluminum industry, and for countries short in fossil fuels.

The social benefits due to replacing virgin materials with recycled materials, however, are not limited to economic gains. Reduction in air and water pollution are important factors that should also be considered (see Exhibit 2). Despite the enormous difficulty in placing an economic value on these social

[34]Robinson, William D., ed. The Solid Waste Handbook: A Practical Guide. John Wiley & Sons, Inc., 1986. 220.

EXHIBIT 2

Benefits Derived from Replacing Virgin Materials with Secondary Materials (Percent Reduction)

	Paper	Glass	Steel	Aluminum
Energy	23-74	4-32	47-74	90-97
Air Pollution	74	20	85	95
Water Pollution	35	-	76	97
Mining Wastes	-	80	97	-
Water Usage	58	50	40	-

Source: Robinson, William D., ed. The Solid Waste Handbook: A Practical Guide. John Wiley & Sons, Inc., 1986. 220.

benefits listed in Exhibit 2 (especially with regards to pollution reduction), the benefits should be quantified to the extent possible and be monitored by using sensitivity analysis.

(4) The Costs of Running a Recycling Program

The costs incurred in any given recycling program consistently belong to one of two main categories: capital costs, and operation and maintenance (O&M) costs. Capital costs are non-recurring items such as land purchase, buildings, processing equipment, vehicles, and home storage containers. In addition, design and start-up costs, and financing of actual purchases should also be included as capital costs. On the other hand, O&M costs (which are usually divided into fixed and variable expenses) typically consist of ongoing costs such as labor costs, fringe benefits of labor costs, fuel, utilities, insurance, licenses, and maintenance costs. Additionally, O&M costs should include expenses with administration, promotional costs, leasing equipment costs, and any costs resulted from services provided by contractors.[35]

Exhibit 3 presents a typical "full service" recycling program cost breakdown in which the collection and processing phases are the major sources of costs.[36]

[35]Glenn, Jim. "Recycling Economics: Benefit-Cost Analysis." BioCycle Oct. 1988: 45-46.

[36]It is important to note that transportation's high impact on O&M costs must be considered. In essence, additional costs incurred by transporting reject materials to landfills or incinerators should be evaluated. In addition, because the costs (as well as benefits) are not stable and are incurred at very distinct times, the present value valuation should be used whenever possible. Note that considerations made for costs should be consistent with considerations made for benefits in the whole cost-benefit analysis.

EXHIBIT 3

Full Service Recycling Program Cost Breakdown

CAPITAL COSTS

		Total Cost	Annual Cost[1]
Site			
Land, Buildings and Site Improvements		$---------	$---------
Equipment			
Collection			
Trucks	$---------		
Trailers	$---------		
Other	$---------		
		$---------	$---------
Material Handling			
Forklift	$---------		
Loader	$---------		
Scale	$---------		
Other	$---------		
		$---------	$---------
Processing			
Flattener	$---------		
Separator	$---------		
Baler	$---------		
Other	$---------		
		$---------	$---------
Storage Containers (drop boxes, etc.)		$---------	$---------
Household Storage Units (bins, etc.)		$---------	$---------
Promotion			
One-Time, Start-Up Costs (signs, etc.)		$---------	$---------
TOTAL CAPITAL COSTS		$---------	$---------

1. A recycling program's accounting method will determine how to calculate annual costs (for example, depreciation of goods over their useful life, all in the year of purchase, etc.). In addition, annual costs should consider the appropriate financial charges.

OPERATION AND MAINTENANCE (O&M) COSTS

		Annual Cost
Fixed Overhead		
Mortgage, Rent, Lease	$---------	
Insurance	$---------	
Other	$---------	
		$---------
Variable Expense		
Labor (wages, taxes, benefits)		
Collection	$---------	
Processing	$---------	
Administration and Promotion	$---------	
		$---------
Collection		
Vehicle Operation (fuel, oil)	$---------	
Vehicle Maintenance (tires, etc.)	$---------	
Supplies (gloves, uniforms,etc.)	$---------	
Household Storage Unit Replacement	$---------	
		$---------
Processing		
Equipment Operation (mainly elect.)	$---------	
Equipment Maintenance (parts, etc.)	$---------	
Supplies (cleaning products, etc.)	$---------	
		$---------
Marketing (cost of shipping materials)		$---------
Overhead		
Site Maintenance	$---------	
Utilities (water, telephone, etc.)	$---------	
Administrative (office supplies, etc.)	$---------	
		$---------
Promotion (materials, advertising, services)		$---------
TOTAL ANNUAL O&M COSTS		$---------

Source: Glass Packaging Institute, Comprehensive Curbside Recycling: Collection Costs and How to Control Them. 1988.

(5) The Avoided Disposal Costs of Incineration

In addition to MSW collection, the total costs to society that are due to incineration may be obtained from seven social cost components: (1) capital costs; **plus** (2) operation and maintenance costs; **plus** (3) costs of additional pollution control equipment; **plus** (4) tax subsidy; **minus** (5) revenues from sale of electricity (or steam); **plus** (6) costs of ash disposal; **plus** (7) social cost of environmental harm and disamenities. Note that the net avoided cost of incineration should be further multiplied by the appropriate share of waste incinerated.

The first two cost components, capital and O&M costs, are analogous to the ones determined in the processing facility presented in Exhibit 3. Component (3), costs of additional pollution control equipment, may be treated like a capital cost. Component (4), tax subsidy, imposes social costs that are not reflected in market prices. Tax subsidy's value varies among different communities. Component (5), revenues from sale of electricity (or steam), may be obtained by the product of the net electricity (in Kwh) produced by the combustion facility, and the average price of Kwh received. Component (6), costs of ash disposal, translates the costs of transportation and disposal of the combustion ash residue to a landfill. In general, incinerators are estimated to leave 25% ash residue by weight.

Finally, component (7), social cost of environmental harm and disamenities, is related to the negative impacts caused primarily by the incinerator's emission of hazardous substances such as dioxins, furans, toxic heavy metals, and numerous carcinogenic organic compounds. While it is extremely difficult to place a monetary value on the environmental hazards and disamenities associated with incineration, some rough approaches may be used. A straightforward approach is to use survey questions to define homeowner's willingness to pay to avoid these environmental hazards. One option is to ask households to choose between two homes that were identical except for two reasons: the distance from an incineration facility and the price of the house. Then, the survey responses may be used to estimate a demand function for distance from the incinerator, where this function will reflect the associated environmental risk and disamenities.

Although this approach presented may not be able to reflect the true social costs of environmental harm, three facts imply that households do place a meaningful value on avoiding these costs. First, citizens spend considerable amount of time and expense challenging new siting of incinerators (the NIMBY syndrome). Second, the health consequences of the environmental hazards impose huge market costs in the form of medical treatment and lost productivity. In addition, property damage caused by incinerator's emissions also imposes real market costs. And third, the public's opposition is largest when the risk is unnecessary and when the safety of the facility cannot be assured.

(6) <u>The Avoided Disposal Costs of Landfilling</u>

Similarly to incineration, the total costs to society (in addition to MSW collection) that are due to landfilling may be obtained from six social costs components: (1) capital costs; **plus** (2) operating and maintenance costs; **plus** (3) clean-up and post-closure costs; **minus** (4) revenues from sale of methane gas; **plus** (5) landfill regulations costs; **plus** (6) social cost of environmental harm and disamenities. Note that the net avoided cost of landfilling should be further multiplied by the appropriate share of waste landfilled.

The first two cost components, capital and O&M costs, are also analogous to Exhibit 3. Component (3), clean-up and post-closure costs, are costs incurred (after the landfill is closed) to maintain the landfill's monitoring and leachate collection systems. In the U.S., clean-up costs are estimated to be approximately 10% of capital and O&M costs, while post-closure costs are estimated to be 15%. Component (4), revenues from sale of methane gas, may be determined by the product of the net volume of methane gas recovered from the landfill, and the average market price received for a volume unit. Component (5), landfill regulations costs, are costs regarding landfill siting, design, closure and long-term care. These costs, in the U.S., are estimated to increase landfill costs by approximately 23%. Finally, component (6), social cost of environmental harm and disamenities, mainly relates to directly-landfilled MSW that imposes serious contamination risks to surface and ground water. In order to place a monetary value on the environmental hazards and disamenities associated with landfilling, the same methodology employed in incineration may be used here.

In addition to the primary costs and benefits presented above, the recycling initiative should also consider the impacts of secondary effects on society, predominantly employment. Recycling creates job opportunities for many individuals, especially for the unskilled. The number of jobs created primarily depends on the size of the recycling industry and on the technology employed, in which a well developed secondary industry and a more labor-intensive recycling program would yield the largest job employment opportunity.

Because recycling competes with both the virgin materials industry and the disposal industry (mainly comprised of incineration and landfilling), the increased tonnage of reclaimed materials creates jobs on the one hand but also displaces jobs on the other. Nevertheless, many studies suggest that the potential employment gains due to recycling in the various sectors of the economy exceed the potential job displacements resulting from recycling. In the virgin materials industry, this may be illustrated by the paper manufacturing activity, in which "for every job created by harvesting paper from trees, five jobs are created if the same amount of paper is recycled".[37] Similarly, in the disposal industry, "for every 10,000 tons of waste materials recycled, 32.7 jobs are supported, compared with only 6.5 jobs if those same materials are used for landfill".[38] Furthermore, while waste-to-energy facilities create more temporary jobs from construction and capital equipment manufacturing contracts than recycling plants, recycling creates more permanent jobs in operations and maintenance.[39]

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[37]Robinson, William D., ed. The Solid Waste Handbook: A Practical Guide. John Wiley & Sons, Inc., 1986. 221.

[38]Robinson 221.

[39]Quigley, Jim. "Employment Impact of Recycling." BioCycle March 1988: 47.

3.3. The Need for Government Action on the Basis of Economic Efficiencies

Despite the potential benefits associated with the recycling initiative, private markets alone will not be able to provide the necessary support to properly develop this option. This primarily occurs because of imperfections in the solid waste disposal market. As a result, government intervention is imperative in order to promote the desired market efficiency. However, before evaluating the main forms of government intervention in the MSW sector, it is important to point out the reasons for market imperfections.

In an efficient market, all economic agents must bear the full marginal social costs associated with their actions. Thus, for an efficient recycling program to exist, all economic agents must incur the marginal social costs of disposing the solid waste that they generate. In practice, however, this is not the case.[40] In general, this market failure may be explained by the presence of two factors: externality and flawed price signals.

An externality exists whenever the welfare of some economic agent (either a household or a firm) depends not only on its activities, but also on activities under the control of some other agent(s). In other words, the exclusivity of property rights is violated.[41] This principle applies to the solid waste disposal

[40] Stone, Robert F., and Nicholas A. Ashford. Package Deal: The Economic Impacts of Recycling Standards for Packaging in Massachusetts. Boston: The Massachusetts Public Interest Research Group, March 1991. 24.

[41] Tietenberg, Thomas H. Environmental and Natural Resource Economics. Scott, Foresman and Company, 1988.

market when the social costs of environmental harm and disamenities are not reflected in the waste disposal prices to be paid by waste generators.

Flawed price signals in the solid waste disposal market, on the other hand, are associated with the fact that disposal costs borne by waste generators (households) are not related to the quantity of waste they discard. Usually, MSW collection and disposal services are charged as flat fees that do not vary with the amount of waste generated. As a result, the incremental cost, or marginal cost, to the household for generating an additional unit of MSW for collection and disposal is practically zero.

Government intervention occurs through the use of policy instruments intended to correct the flaws in the MSW disposal market. In essence, there are two categories of government action that can promote efficiency in recycling programs: regulatory instruments and economic instruments. In practice, however, these instruments currently used by different communities are not generating the expected returns. Therefore, a list of popular regulatory and economic measures will be presented and analyzed below in order to assist communities select the most effective policies for their recycling markets-related problems.

Regulatory Instruments[42]

• **Mandatory Separation and Collection of Recyclables.** Mandatory recycling programs do not necessarily lead to the enhancement of inefficient recycling activity taking place in private markets. Inadequate recycling capacity and markets for recyclables are serious obstacles for the success of recycling programs. This type of policy tends to stimulate the supply side for recycled materials but it overlooks the demand side for these materials. As a result, the amount of recycling activity may fall short compared to the total amount of materials recovered in recycling programs. It is not unusual, therefore, if communities that implemented mandatory recycling programs initially had to store or even landfill separated materials. Additionally, this policy is difficult and costly to monitor and enforce.

• **Government Procurement Policy.** In an effort to (partially) address the problem of the demand side for recyclables, the government may require that its purchased products be made of a given percentage of recycled materials or be recyclable. The government can also give price preferences to products containing recycled materials. Despite the potential help that this policy offers, the state procurement activities are somewhat limited to certain varieties of products. Thus, the state alone is unlikely to offset the gap between supply and demand.

[42]See: Stone, Robert F., and Nicholas A. Ashford. Package Deal: The Economic Impacts of Recycling Standards for Packaging in Massachusetts. Boston: The Massachusetts Public Interest Research Group, March 1991. 29-38.

• **Unconditional Bans on Packaging and Products.** This policy's main objective is to promote recycling and thereby to reduce the amount of MSW to be sent to disposal facilities. However, as an instrument to increase the demand for recyclables, this policy is highly ineffective. Unconditional bans eliminate the possibility of recycling the banned product without providing any additional demand for recovery of the substitute element. Moreover, bans limit consumers' choice for products that may have little impact on the waste stream.

• **Recycling Standards.** In practice, this policy promotes conditional bans on materials and packaging in which failure to comply carries the risk of market prohibition. Unlike unconditional bans, however, recycling standards are applied consistently to an entire class of material use and are also adapted to achieve meaningful improvements in the demand for recovered materials. A major application of this policy is in the packaging industry, since packaging is one of the leading sources of MSW and the largest contributor of recyclable materials. Consequently, recycling standards will stimulate recycling demand for all the major types of material used in packaging (paper, plastics, glass, steel, and aluminum) for diverse applications.

Recycling standards should require that products (packaging) either consist of a certain percentage of recycled material or be made of recyclable materials (which should be in accordance with a specified recycling rate considering both packaging and non-packaging materials). Although this policy tool, like all others, is also subject to some constraints, recycling standards (for packaging) is vital to remedying deficiencies in the demand side for recovered materials and is clearly superior to other regulatory approaches. Note, however, that the intent of this policy should not be to substitute other government policies and recycling activities, but rather to combine these activities as a means of providing the necessary stability in recycling markets.

Economic Instruments

• **Government Subsidies.** Subsidies to promote recycling may be provided to waste management authorities and the private sector in various forms. They may be in form of preferential tax treatment for the construction of recycling plants, tax credits to industries that use recycled materials, stabilization of markets for recyclables through price supports, guaranteed income to recycling centers, and investment grants, accelerated depreciation, and soft loans to encourage private sector investments.[43] In essence, all of these possibilities of subsidization respond to some of the symptoms of the MSW dilemma but do not, however, address its causes.

Recycling subsidies, although an important element in recycling programs, offer two main disadvantages. First, because the origin of the pricing distortion involves the solid waste disposal market (and not recycling itself), subsidies may create their own inefficiencies such as rewarding the recycling of a material when

[43]Bernstein, Janis D. Alternative Approaches to Pollution Control and Waste Management: Regulatory and Economic Instruments. World Bank, April 1991. 57.

reducing the amount of material used would be socially preferable. And second, subsidies impose economic costs on government.[44]

• **Deposit-Refund Systems.**[45] This type of policy tool requires that producers or initial users of selected materials pay a deposit fee when those materials enter the production process. Thus, as the product changes hands, the purchaser of the product pays a deposit to the seller until the ultimate consumer turns the product in to an authorized collection center responsible for recycling or proper disposal. In principle, the deposit amount should reflect the social cost of illegally disposing of a given product (a product in which the consequences of improper disposal are serious, such as lead acid batteries). In general, well administered deposit-refund systems look attractive for three reasons. First, government monitoring problem (and costs) of illegal dumping of small quantities of waste at different locations is radically reduced. Second, this policy creates an incentive to prevent losses of the material in its industrial process. Third, firms will look for less environmentally damaging substances (in which deposit fees do not apply) because of net losses in the production and consumption processes.

Recently, many deposit-refund systems have been adopted to encourage recycling, such as "bottle bills" for beverage containers. Despite the success of

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[44]Stone, Robert F., and Nicholas A. Ashford. Package Deal: The Economic Impacts of Recycling Standards for Packaging in Massachusetts. Boston: The Massachusetts Public Interest Research Group, March 1991. 33.

[45]See: Project 88 -- Round II. A Public Policy Study Sponsored by Senator Timothy E. Wirth and Senator John Heinz. Washington, D.C.: May 1991. 61-63.

these programs in some communities, the current basis of bottle bills as a tool to promote recycling is questionable. There are five main critical issues. First, by charging the same deposit fees for all types of container materials, the program does not encourage consumption of products with the lowest disposal costs. Second, bottle bills may encourage shifts in consumption from "more recyclable" materials, such as metals, to "less recyclable" materials, such as plastics. Third, by requiring separation and transportation of separated materials to redemption centers, this program may foster welfare losses rather than gains. Fourth, bottle bills may hurt curbside recycling programs feasibility by removing some of the most profitable materials from the waste stream. Fifth, bottle bills is a somewhat limited policy in terms of expanding demand for recyclables.

• **Economic Charges.**[46] In theory, economic charges are the perfect mechanism to correct existing flawed price signals in the solid waste disposal market. Economic charges should be designed in order to reflect the marginal social costs of waste disposal. In general, there are three approaches for economic charges, in which each of them focuses on a different point in the product life cycle: user charges, disposal charges and virgin material charges.

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[46]See: (1) Stone, Robert F., and Nicholas A. Ashford. Package Deal: The Economic Impacts of Recycling Standards for Packaging in Massachusetts. Boston: The Massachusetts Public Interest Research Group, March 1991. 33-34. and (2) Project 88 – Round II. A Public Policy Study Sponsored by Senator Timothy E. Wirth and Senator John Heinz. Washington, D.C.: May 1991. 48-54.

Ideally, user charges, which focus on the point of disposal, should be charged in proportion to the amount of refuse households leave at the curbside. In this way, households would have incentives to reduce waste generation. Moreover, by placing different charges on regular trash and separated materials, user charges may also promote recycling. Although user charges' two main techniques, pay-per-bag and bag-and-tag systems, are steps in the right direction, they clearly present important practical problems. In pay-per-bag systems, households are charged for a full standard-sized can of trash even if is only partially filled. If charges are by weight, the metering costs may be prohibitive. Moreover, there are programs where households are charged by a given pre-registered number of cans even if they do not use any in a particular week. In bag-and-tag systems, households may only dispose of garbage in special bags sold by the municipality. In addition, the sale of stickers to be placed on cans or bags of specified dimensions is another approach. Although bag-and-tag systems may keep metering costs low, this technique does not escape from the critical problems associated with user charges. Some of the problems are the possible encouragement of illegal dumping, limitations in the case of multi-family apartment buildings or densely populated neighborhoods (in which households may anonymously dispose of their garbage), disagreements over the charge base, and the high cost of monitoring.

Disposal charges, which focus on the point of sale, place surcharges on products made or packaged in non-recyclable materials to reflect the social costs of disposal. Although this approach may address some of the problems found in user charges, such as encouragement of illegal dumping, disposal charges also present other serious concerns such as the effectiveness of these charges (which would probably not exceed a few cents per packaged product) in influencing consumer behavior, and the high administrative costs in setting taxes for specific materials as well as collecting them at the point of sale.

Virgin material charges, which focus on the point of production, place surcharges on virgin materials to reflect their social cost of disposal. As a result, such charges would encourage the use of materials and products with lower disposal costs, and also favor recycling. The main advantage of this approach is the ease of administration. However, the problem with these taxes is that they need to be applied nationally. As a result, this approach is not a viable policy alternative for individual state and local governments. Furthermore, nationally applied charges tend to be insensitive to individual needs of local communities.

• **Tradeable Permits.**[47] Tradeable permits encourage recycling by using the forces of the market. The basis of this policy is very similar to "recycling standards" presented under regulatory instruments. However, the recycling standards policy in isolation may lead to significant economic inefficiencies since the costs of compliance vary among firms. In essence, while some manufacturers may lack proper capital and technological resources to meet the required

[47]See: Project 88 -- Round II. A Public Policy Study Sponsored by Senator Timothy E. Wirth and Senator John Heinz. Washington, D.C.: May 1991. 54-60.

recycling standards, there are others that are not only able to meet but also to exceed the requirements. With the tradeable permits policy, therefore, a firm that does not comply with the given recycling standard (for packaging or for other products) will still be able to meet the requirement by buying permits from other firms that exceeded their recycling requirements.

For a successful tradeable permits policy, the presence of efficient markets is essential. Therefore, four conditions are necessary for this to occur. First, firms must comply with the policy and accurately report their performance.[48] Second, transaction costs, including the costs of finding potential buyers and sellers as well as the costs of obtaining the necessary government approval, must be low enough. Third, the market for tradeable permits must be competitive. Under a competitive market, a firm's decision to enter the permit market should only be based on the market price of permits versus its internal costs of use of recycled materials. No firm should be allowed to manipulate prices. Fourth, the permit policy must assure a desired level of certainty in the permit market. This means that the rights of the permits as well as the legitimacy of transactions should be clearly defined.

In sum, this section introduced the concept of government intervention through the use of policy instruments. Note that the role of the government is not to displace the recycling market but to organize and support a market that is still

[48]Note that monitoring and enforcement costs for government are proportional to the number of companies in the program.

in its infancy and not independently sustainable. Furthermore, it should be clear that there are no perfect, universal policies. Policy instruments should be tailored (to the extent possible) according to each community's needs.

CHAPTER 4

ASSESSMENT OF MUNICIPAL RECYCLING TECHNOLOGY[49]

4.1. Collection Phase Technology

A "full service" recycling program (a program which manages the flow of recyclables from the point of generation to the point of sale) is typically comprised of two main phases, the collection and processing phases. In general, while the collection phase primarily consists of curbside and drop-off/buy-back systems, the processing phase essentially consists of recycling plants. This section will concentrate solely on the mechanisms of collection and the next segment will focus on processing technology.

The two leading technologies to boost collection participation are curbside collection and drop-off/buy-back systems. These two instruments, however, are fundamentally different since in the former the collection system goes to the households, while in the latter the households need to go to the collection system. As a result, these two technologies will be evaluated separately.

[49]Because this thesis will examine the case of São Paulo, this technology assessment chapter will concentrate primarily on issues regarding large, densely populated communities.

Curbside Collection Systems

In curbside collection programs, households are asked to separate recyclable products from regular refuse and to place them in specified collection points. Generally, curbside collection is responsible for the largest source of recovered materials in a recycling program and its success is associated with the convenience it offers homeowners. Curbside programs may use different approaches to foster higher participation rates in different communities. These approaches include degree of segregation of recyclables, household storage containers, centralized storage areas (in the case of apartment buildings), collection frequency and date, and collection vehicles.

Recycling programs may require participants to segregate recyclables of different materials (like glass, plastic, newspaper, etc.) to be stored in their own containers and to be collected separately. There are other programs that use only two containers to store recyclables (for instance, one for newspapers and the other for remaining recyclables) or even one container to store commingled recyclables. The higher the segregation required, the greater the inconvenience for participants. Inconvenience is also associated with the time needed to separate the recyclables, the area occupied by the different containers (especially in apartment units), and the annoyance of bringing multiple containers to the collection point. In addition, the collection crew's activity of loading also becomes harder to execute since segregated materials need to be sorted out at the curb.

There are two main reasons for segregation: to keep materials as dry and as contaminant free as possible, and to help (or even substitute) the processing phase in recycling plants. In communities with dense populations, like São Paulo, the need for recycling plants to better prepare and sell recyclables in secondary markets is considerable. Furthermore, high segregation most likely incurs higher social costs for participants (in view of the inconvenience factor) and consequently it may result in lower recovery rates. Therefore, segregation of materials, ideally, should be limited to two containers when programs such as separate newspaper collection are available or to one container if such programs do not exist.

Household storage containers, which should be standardized, serve important purposes in a recycling program. They provide a practical way to store recyclables, serve as a constant reminder to recycle, and make it easy for the collector to distinguish recyclables from regular waste.[50] Despite the wide variety of containers' models, bins and bags are certainly the most popular. Lightweight, storable and easy to handle bins that allow residents to commingle recyclables in one container is a widespread instrument used by many communities in the U.S.. However, bin-based recycling programs are only viable if preliminary sorting is made by the collection crew in the curb, which conflicts with the idea proposed in this chapter that sorting should occur in the recycling center. Moreover, the single bin system requires the purchase of special compartmentalized collection trucks. In sum, this system requires that a decision be made between curb sort or

[50]U.S. Environmental Protection Agency. Decision-Makers Guide to Solid Waste Management. Washington, D.C.: Nov. 1989. 68.

bulk collection approaches.[51]

For bulk collection approaches, the plastic bag system is the best method available, and the following are the five main reasons confirming this choice. First, bags provide an inexpensive one-way container that need not be returned to homes (by residents) or to the curbs (by collectors). Second, bag-based recycling is convenient for multi-family dwellings and allows residents to store recyclables in the kitchen area. Third, plastic bags protect recyclables from weather changes and insect infestation. Moreover, bags provide a cushion through commingling certain materials and reduce glass breakage and contamination from curbside to processing facility. Fourth, plastic bags, which should be made of a standardized semi-transparent color, are affordable and provide the necessary level of privacy to the participant (note that bags should be transparent enough so that haulers may detect if recyclables have been properly discarded but at the same time not so transparent that materials can be identified from a distance). And fifth, bag-based system can utilize existing equipment (mainly collection trucks) and crews.[52]

Another important piece of a good recycling program are centralized storage areas in multi-family dwellings since residents need an accessible common area to bring their recyclables. The most convenient option would be to place the sealed plastic bags filled with recyclables at each resident's door or in the

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[51]Wagner, T.C. "In Search of the Perfect Curbside System." BioCycle Aug. 1991: 34.

[52]Williams, John, and Maribeth S. Rizzuto. "Pittsburgh's One Bag Recycling Program." Public Works July 1991: 58-59.

hallways of each floor. The recyclables should be picked-up by a building's employee (or volunteer) on the eve of collection day. This individual would take the recyclables to the hauler's collection point. However, in residential complexes lacking the necessary resources to implement this convenient approach, an accessible centralized storage area within the building should be provided in which each resident would be responsible for bringing the separated materials. This centralized storage may be located in the basement or in the parking garage of the building, or even outside if viable. Ultimately, the residents themselves have to act together in order to promote high participation rates within the building.

Collection frequency in curbside programs should match the supply of recyclables generated. In dense neighborhoods, collection should occur at least once a week. It is also important that a fixed collection day be established and that the schedule be followed accurately. Unreliable services hinder participation. Lastly, collection vehicles for a bag-based system do not have to be state-of-the-art, compartmentalized vehicles. On the contrary, vehicles may be fairly low-tech, like existing dump trucks.

In addition to curbside programs, commercial recycling programs are also an option to collect recyclables generated from commercial establishments, office buildings, government institutions, schools and hotels. In general, if commercial sources contribute significantly to the local refuse stream, commercial recycling should be promoted.

Drop-Off and Buy-Back Systems

In drop-off and buy-back systems, residents (or businesses) need not only to source separate recyclables but also to transport them to specified locations within a given neighborhood. Drop-off centers range from single material collection points, like easy-access "igloo" containers, to staffed, multi-material collection centers.[53] The staffed centers may be run by the municipality, by volunteer groups, or by profit and nonprofit organizations.

In general, among the main advantages of drop-off centers are low capital costs, generation of market-ready materials (in case of staffed centers), ease of collection of multiple categories of materials, and 24-hour accessibility (in case of non-staffed centers). On the other hand, among the main disadvantages are low recovery rate compared to curbside collection, vulnerability to theft and vandalism, and the possibility that drop-off centers may become unsightly if not staffed.[54]

To encourage higher participation, drop-off centers should include the following four design factors. First, drop-off centers should be located in convenient, accessible, secure and visible locations. Examples are shopping centers and gas stations. Second, they should all have meaningful storage space and weather protection. This avoids possibilities of overloading and spoilage of

[53]U.S. Environmental Protection Agency. Decision-Makers Guide to Solid Waste Management. Washington, D.C.: Nov. 1989. 65.

[54]New Jersey Department of Environmental Protection. Steps in Organizing a Municipal Recycling Program. 1988. 2.

recyclables. Third, drop-off centers should provide easy access to collection vehicles. Fourth, drop-off centers should have an attractive design and always be kept clean.[55]

In general, the main reason for low participation in drop-off programs is the transportation inconvenience. In addition, this problem is further aggravated in densely populated communities (especially in multi-family dwellings) since residents are required to store the recyclables in their homes, which usually lack available storage space, until sufficient material is collected to warrant a trip.

The other system, buy-back centers, in simple terms are staffed drop-off centers that provide a monetary incentive to boost participation. Generally, residents are paid for their recyclables according to products's weight and materials' specification tied to prevailing market prices. Unlike drop-off programs, buy-back programs require more operational work, such as weighing and accounting, as well as additional equipment, like scales and calculators.

Buy-back programs have been operated by the aluminum industry for several years, mainly to recover aluminum cans. Nevertheless, recent trends show the expansion of buy-back programs' concept. In São Paulo, for example, a modified form of buy-back centers, sponsored by some grocery shops, exchange food products for separated materials that include plastics, aluminum and glass.

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[55]New Jersey DEP 3.

4.2. Processing Phase Technology

After being collected, recyclables need to be prepared for available secondary markets. This processing phase occurs in recycling plants which work as intermediary between the collection and marketing phases.[56] Recycling plants reviewed in this thesis are called materials recovery facilities (MRFs).

MRFs are central facilities that receive, separate, process, and market recyclables. These facilities usually operate in conjunction with both drop-off and curbside programs, and can process separated or commingled recyclable materials (which is the case of the preferable bag-based system). Whether to implement an MRF into a community's recycling program will depend on a variety of factors. Among the most important factors are market demands (buyers that have specifications for certain materials make an MRF more attractive); commingled separation (in systems where residents commingle their recyclables, intermediate separation and processing are required); quantity and type of materials (an MRF should handle a significant amount of separated materials and a large number of different recyclables to justify its costs); and economies of scale (a larger, more marketable supply for buyers should be created to enable an MRF achieve economies of scale).[57]

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[56]Note that in recycling programs that require segregation among recyclables, these materials may be sold directly to interested industries or be marketed using a broker. However, programs' higher collection costs, lower participation rates, and loss in revenues due to poor conditions of materials should not be overlooked.

[57]"Recycling Guidelines." Public Works April 1991: 56-57.

In general, MRFs may be classified as either first or second generation types. In the first generation type, which is the most traditional and simplest system, MRFs consist of nothing more than a linear conveyor with enough pickers to remove the recyclables that pass before them. In the second generation type, on the other hand, MRFs are more technically advanced systems which foster efficiency by replacing hands with machines. For a bag-based program, for example, a second generation MRF can offer notable features to help resolve important issues like how to separate the recyclables from the bag, and how to efficiently separate paper (which is the bulk of recyclables) from the remaining materials. To separate the recyclables from the bag, a possible option is to use an automatic splitter to open the bags. And to separate paper from other materials, a possibility is the use of an inclined, vibrating bar screen to drop out smaller materials followed by a secondary sorting device which would allow containers to roll off while flat paper products would lie on the surface.[58]

Nevertheless, because end-of-pipe technologies are not an economically viable alternative for most communities, most MRFs have to rely completely on the basic processing equipment (which are usually available in all facilities, regardless of their degree of sophistication). Exhibit 4 presents a brief description of an MRF's basic processing equipment.

In general, a community's decision regarding the selection of a processing facility may be narrowed down to three critical issues: ownership, location, and

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[58]Glenn, Jim. "Innovations in Processing and Sorting Recyclables." BioCycle Oct. 1991: 35-39.

EXHIBIT 4

MRF's Basic Processing Equipment

Equipment	Description
Balers	Newspapers, cardboard, and plastics are often baled to reduce transportation costs.
Can Densifiers	Can crushers are used to densify aluminum and steel cans prior to transport.
Glass Crushers	Used to process glass fraction separated by color, crushers break glass into small pieces. The material (now called cullet) can then be reprocessed into new glass products.
Magnetic Separators	These are used to remove ferrous metals from a mixture of materials.
Scales	Scales are used to measure the quantity of materials recovered and sold.

Source: U.S. Environmental Protection Agency. Decision-Makers Guide to Solid Waste Management. Nov. 1989. 69.

automation.

The degree of ownership is best illustrated by four possible types of MRF projects. The fist type is where the municipality owns and operates the facility by itself. The second type is where a municipality goes through a procurement process to select a private company to develop and operate an MRF according to the public body's specifications. In this approach, the city can choose to either own the facility or require a private company to own it. The third type is where the municipality calls for a private company to provide processing services (in some cases in conjunction with collection), but does not specify how the processing should be done. In this approach, the firm that wins the contract is responsible for the financing, building and operation of a system to process commingled recyclables. The city pays only for the services provided. Lastly, the fourth type is where the private sector develops processing facilities without the support or sponsorship of the public sector. In these facilities (also known as "Merchant MRFs") the private company is entirely at risk for ensuring the financing, the flow of commingled recyclables, and operation of the facility.[59]

Although private sector involvement is desirable, reliance strictly on the private sector initiative, like in "Merchant MRFs", is not a prudent practice. One reason for this is the private sector's need to make a profit. Inspired by the potential high profits, private companies tend to process primarily high value materials, such as aluminum, ignoring low market recyclables. Another reason is

[59]Glenn, Jim. "Materials Recovery Facilities Move Ahead." BioCycle May 1989: 66-68.

the lack of any control by the public sector over the operations of the facility. Thus, in case an MRF runs into financial problems or other difficulty, the whole recycling value chain may be compromised.[60]

As a result, the best option for running an MRF (and a recycling program in general) would be a risk-sharing venture between the public and private sectors, something like the second type described above. In such a venture, the dynamism and quality service provided by private companies allied with the support, understanding and commitment of the municipality would enable a more reliable and stable recycling program.

Location is another critical issue involved in selecting an MRF. Communities have to decide whether MRFs should be designed to serve a whole region (centralized facilities) or only the nearby area (decentralized facilities). In general, the decision is related to the MRFs' costs, the size of the supply and demand markets for recyclables, land availability, and transportation costs.

Centralized plants are usually expensive to build and operate, therefore resulting in high capital and O&M costs. Because these facilities are highly capital-intensive, communities that lack adequate resources tend to discard this possibility right away (even considering the risk-sharing ownership approach proposed earlier). In order for a facility to be economically viable and achieve economies of scale, both supply and demand for recyclables should be well defined and relatively stable, which is typically not the case in new recycling

[60]Glenn, Jim. "Materials Recovery Facilities Move Ahead." BioCycle May 1989: 67.

programs, like in São Paulo.

The major constraint of the decentralized system, on the other hand, is the higher number of sites demanded for decentralized facilities. However, because decentralized plants are much smaller and flexible than centralized plants, this problem may be overcome. Lastly, in large cities like São Paulo, where transportation costs are the bulk of a municipality's waste management budget, it is usually more economical to adopt decentralized facilities (in fact, savings in transportation would be the most important reason for adopting decentralized facilities in São Paulo).[61]

The issue of automation is the final consideration for selecting a suitable MRF. The degree of automation in a processing plant defines whether the technology to be employed in an MRF should be predominantly labor-intensive or mechanized. A rule of thumb says to pick the more labor-intensive technology in cities where wages are low and to pick the more mechanized option in cities where wages are high compared to equipment costs. However, the technology issue is not as simple as this rule of thumb implies. The decision should also take into account a complex range of elements, including employment opportunity and the facility's vulnerability to labor influence.

State-of-the-art facilities tend to be more efficient, and to employ less labor than simpler models. For places with labor shortages or for owners who want to

[61]Note that in cities with mature recycling programs and stable markets, centralized MRFs may be a good option. In these cases, MRFs may be able to achieve economies of scale and also increase the value added on the recycling processing phase by customizing materials according to end users specifications.

avoid the vulnerability created by more labor-intensive technologies and to increase efficiency, sophisticated plants are a good option. However, the price to be paid is the higher costs of developing and operating the facility, including the high demand for skilled personnel.

When capital and O&M costs for diverse types of MRFs are developed in a city like São Paulo, selection of the most appropriate technology should consider the following: foreign versus local investment, maintenance costs, employment needs and objectives, available skill levels and training opportunities, cash flow required for operation of equipment, land availability and value, and resource recovery potential and environmental consequences.[62]

In the case of São Paulo, state-of-the-art technology for MRFs are nonexistent in the city, but currently unnecessary. Economically, the deep recession hitting Brazil has made both private and public sectors uncapitalized and therefore very cautious towards new investments. In addition, São Paulo has a high number of unskilled people (many of them working in the informal recycling sector as scavengers). Therefore, given the current needs of (a city like) São Paulo, a centralized state-of-the-art MRF would not be the ideal solution. Instead, decentralized, middle size, moderate technology, privately operated MRFs would certainly better fit into the city's reality.

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[62]Cointreau, Sandra J. Environmental Management of Urban Solid Wastes in Developing Countries: A Project Guide. Washington, D.C.: World Bank, June 1982. 42.

4.3. Lessons from the Japanese Municipal Recycling Activity

It is evident that developing and implementing a recycling program is a difficult task after considering all of the elements discussed above. Tokyo, Japan offers us an example of a city that has managed this process well. Japan currently recycles or reuses about 50% of its solid waste, compared with 15% for the former West Germany and only 11% for the United States (see exhibit 5 for statistics on solid waste management technologies in these three countries). In 1988, for example, Japan recycled 50% of its waste paper, 55% of its glass bottles, and 66% of its beverage and food cans. By contrast, in 1986, the U.S. recovered only 23% of its paper products, 9% of its glass, and 25% of its aluminum.[63] So, what's the secret for Japan's success and leadership in the recycling activity? This section will address this question by exploring the philosophy behind Japan's waste management sector. In addition, Tokyo's methodology on the handling of domestic waste will be reviewed as a means of providing other large cities with an alternative way of dealing with the municipal recycling issue.

Waste in Japan

There are five basic reasons for Japan's success in the recycling industry: (1) over a century of experience; (2) dependence on imported raw materials; (3) commitment to pollution prevention; (4) government support; and (5) public

[63] Corson, Walter H., ed. The Global Ecology Handbook. Boston: Beacon Press, 1990. 270.

EXHIBIT 5

Solid Waste Management Technologies in the U.S., Japan, and West Germany (in Percentages)

Technology	United States	Japan	West Germany
Recycling or Reuse	11	50	15
Waste-to-Energy	6	23	30
Landfilling or Other	83	27	55
Total	100	100	100

Source: Corson, Walter H., ed. The Global Ecology Handbook. Boston: Beacon Press, 1990. 270.

education and cooperation.[64]

Because roughly 99% of the raw materials consumed in Japan are imported, the country has been forced to explore alternative ways to compensate for the virgin materials shortage. Recycling, therefore, has been promoted in Japan for many years primarily as an economic strategy to mitigate the country's vulnerability to international supply. The increasing industrialization experienced in Japan in the last fifty years, however, has created serious disposal problems, particularly in the urban areas. As a result, the use of recycling has also been furthered as a waste management technology.

Unlike many other national governments, the Japanese national government plays an active role in the MSW management sector by passing important economic and regulatory policies. The national government also mandates and helps to organize the collection of waste information needed to efficiently manage municipal wastes. In the U.S., for instance, the MSW sector is almost exclusively controlled by the state and local governments.[65] The federal government involvement in Japan, therefore, promotes a competitive advantage over many other countries in the waste management sector since its government can coordinate activities in such a way that all parties (government, industry and population) can benefit.

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[64]Hershkowitz, Allen, and Eugene Salerni. Garbage Management in Japan: Leading the Way. New York: INFORM, 1987. 64.

[65]Hershkowitz 3.

When it comes to municipal recycling, however, high level of public education and cooperation have certainly been the driving forces of successful recycling programs in Japan. The cooperation issue is specifically associated with the Japanese culture, which is very sensible in regards to the country's needs. Therefore, this social commitment to public causes is also reflected in the waste management sector. This is evident even from definition of solid waste. In Japan, MSW is only the material that, after recycling, requires treatment and disposal by the municipality. Recyclable materials are considered resources, not wastes.

Recycling in Japan, therefore, seems to offer a perfect match between the waste disposal problem and the raw materials shortage. The Japanese population is able to provide a steady supply of secondary products for industries requiring high demands for raw materials, where substitutes are unavailable in internal markets.

Waste in Tokyo[66]

Tokyo metropolitan area has one of the largest populations in the world and like almost every other big city, Tokyo has serious concerns about its MSW disposal issue. In Tokyo, every day approximately 17 thousand metric tons of MSW are separated in combustible and noncombustible materials by the city's residents. Through this separation program, the municipality plans to cut down

[66]The following information regarding the MSW services in Tokyo is based on documents from Tokyo Metropolitan Office and a personal interview in December 20, 1991 with Mr. Kazushi Wakita, visitor engineer at MIT.

its waste disposal expenses by reducing the city's dependence on landfilling (where old landfills are reaching capacity and new landfill sites are nonexistent) and encouraging waste-to-energy systems and recycling as alternatives.[67]

There are three different types of collection systems in Tokyo. The first type is a special collection of newspapers, magazines, books, and other similar printing materials. These paper products are source separated by individual households and brought to the collection point for further collection by private companies. Once collected, these materials are then sold to recycling plants which in turn sell them to industry. Participation in this program is voluntary and no fees are charged or paid to participants.

The second type is the collection of source separated combustible materials. In Tokyo's program, combustible materials include paper waste (except for newspapers, magazines, and books), small pieces of wood appliances, rags, and food waste. Although food waste is not a typical combustible material, food waste is included in the combustible waste stream as means of minimizing contamination of noncombustible materials, that may be recycled. This type of collection is carried out by Tokyo's municipality twice a week.

Finally, the third type is the collection of source separated noncombustible materials, which include glass, metal, and plastic wastes. Although plastics are excellent materials for waste-to-energy systems, the incineration of plastic products are prohibited in view of the danger of toxic gases emissions. Note that

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[67]Ministério da Indústria e do Comércio do Brasil. Reciclagem dos Resíduos Urbanos, Agropecuários, Industriais e Minerários. Brasília: 1985. 95.

these noncombustible products are all recyclable materials. Like the collection of combustible materials, noncombustible materials are also collected by the municipality twice a week (but in different days).

Although the separation of materials are not mandatory in Tokyo (there is no punishment for noncompliance), almost every resident follows the guidelines. The reason for high participation rates comes back to the issue of public education and culture.

After being collected, all combustible materials are taken to waste-to-energy plants located in the surrounding areas of the city. In Tokyo, waste-to-energy plants are also used as recreational sites for the city's residents. These facilities are usually provided with big gardens, soccer fields and warm water pools. In general, the electricity generated in the plants are usually used for the leisure activities.[68]

The noncombustible materials, on the other hand, are transported to either recovery plants or landfills. However, massive recycling campaigns are now under way in Tokyo because of the "landfill crisis" (the municipality predicts that all landfills in Tokyo will completely reach capacity, even with the construction of new ones, by the year 2005).

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[68]In American society (and many others), where communities and waste management facilities have been involved in major disputes for years, it would be very difficult for a project such as this one in Tokyo to occur. Nevertheless, in regards to this waste-to-energy project in specific, it is questionable whether those facilities can guarantee complete assurance that emissions of dioxins and other critical toxic compounds are totally under control and that they do not impose any health-related risk to visitors (and general population).

The following are some of Tokyo's municipality strategies (not in effect yet) to manage the solid waste problem in the city: recycling should be mandatory, waste minimization tactics should be carried out by commercial establishments and should also be mandatory, every building should have a special place for recycling and an appointed manager responsible for recycling issues, appointed managers should constantly report to the municipality about recycling efforts, recycling education and information centers should be introduced, recycling plants should be expanded, and more incineration facilities should be built.

In essence, incineration has been the main technology in Tokyo primarily because it is convenient, the facility's area can also be used for other means, and it is backed by a strong participation in the source separation program. Recycling in Tokyo has also shown its importance and potential for acting together with incineration, where the city's collection system provides exceptional conditions for this interaction.

CHAPTER 5

SOLID WASTE IN THE CITY OF SÃO PAULO

5.1. History and Characteristics of São Paulo's Urban Waste

The city of São Paulo, which is the capital of São Paulo State, has experienced a remarkable growth since the beginning of this century. São Paulo's population of 250 thousand people at the turn of this century, grew to nearly 600 thousand by 1920. From then on, groups of immigrants mainly from Italy, Portugal, other European countries, and Japan, started to arrive in great numbers. By 1940, the population was 1.4 million, and by 1950 it had nearly doubled to 2.2 million people. Today, São Paulo is the world's second largest city with a population of 12 million inhabitants with an annual population growth rate of 2.8%.

The city, located in the affluent Brazilian southeast, occupies an area of 1,500 km^2 and it is bordered by several industrial towns. The city and its surrounding towns make up Greater São Paulo Metropolitan Area (GSPA); and São Paulo municipality constitutes over 65% of GSPA.

The dramatic population growth that occurred in São Paulo was intensified during the 1960s by a massive migration of individuals coming from the rural and less privileged areas of the Brazilian northeast. These individuals, attracted by São

Paulo's growing industrialization, found a city unable to accommodate such a large number of people and still provide an orderly urbanization development. In part, this is one of the reasons why 45% of the current population of São Paulo lives in substandard housing.

This fast, unplanned urbanization also has particularly impacted the MSW situation in the city of São Paulo. With a daily MSW production of over 13 thousand metric tons, São Paulo has experienced serious difficulties in coping with the increasing waste disposal demand. Based on current trends, the MSW produced in the city only has assured disposal destinies until the first semester of 1997. And this estimate is based on the capacity that two projects which have not yet been completed will provide. Specifically, these two projects are the expansion of the two composting plants by the end of 1991, and the construction of two sanitary landfills in non-urbanized areas of the city. According to estimates, three of the four MSW sanitary landfills available in the municipality, which are responsible for over 82% of the MSW collected, will be filled to capacity by the end of 1993.[69]

In order to properly address the MSW problem, it is important to define the city's MSW categories. In this thesis, urban or municipal solid waste (MSW) is defined as abandoned material within the urban area which provides no utility to the primary generator or user. The following are São Paulo's five major solid waste categories, and their respective generation rates, based on the year 1990 (see

[69]Mello, Ana. "Coleta Seletiva Já Desafoga os Aterros." Jornal da Semana 26 Aug. 1990.

Exhibit 6 for a summarized version):[70]

(1) Domestic Waste (Household Refuse)

This category comprises waste resulting from household activities, such as food preparation, sweeping and cleaning. Domestic wastes collected in 1990 totaled 2.3 million metric tons which accounted for 58.5% of the total MSW disposed of in the municipality's facilities.

(2) Street Sweeping Waste

This type of waste largely consists of dirt and litter. In 1990, this category totaled 263 thousand metric tons which accounted for 6.8% of the total MSW disposed of.

(3) Health Care Waste

This category consists of waste originating in hospitals, pharmacies and veterinary clinics. Because the municipality considers all wastes within this category hazardous, they are collected separately and incinerated. In 1990, 38 thousand metric tons of health care waste were collected which accounted for 1% of the total MSW disposed of.

[70]The following information belong to a Set of Documents from São Paulo's Municipality.

(4) Assorted Waste

This category is comprised of two different kinds of refuse: commercial and institutional. Commercial refuse originates from establishments like stores, offices, hotels and restaurants that produce up to 100 liters of garbage per day (establishments that generate over 100 liters of garbage per day are within "private waste", item (5)). Commercial waste typically consists of packaging and container materials, used office supplies, and food wastes. Institutional refuse results mainly from schools, government offices, and religious buildings. This kind of waste typically involves a large portion of paper rather than food. Assorted waste collected in 1990 totaled 318 thousand metric tons which accounted for 8.3% of the total MSW disposed of.

(5) Private Waste

Private waste comprises refuse that is not within the municipality's responsibility and therefore is not collected by either the municipality or its waste hauler contractors. This waste is delivered by private parties to the city's waste disposal facilities, which are free of cost. This category includes two kinds of refuse: industrial and "others". Industrial waste originates primarily from processing and non-processing industries. Among the components are packaging materials, spoiled metal and spent processing chemicals. Industrial waste delivered to disposal facilities in 1990 totaled 659 thousand metric tons which accounted to 17.1% of the total MSW disposed of. The term "others" refers to all

EXHIBIT 6

Categories and Generation Rates of the MSW Disposed of in São Paulo's Municipality Facilities in 1990

Category[1]	Metric Tons/Year[2]	Metric Tons/Day	% Total MSW
Domestic	2,300,000	7,372	58.5
Street Sweeping	263,000	843	6.8
Health Care	38,000	122	1.0
Assorted	318,000	1,019	8.2
Total Collected	2,919,000	9,356	74.5
Industrial	659,000	2,112	17.1
Others	322,000	1,032	8.4
Total Delivered	981,000	3,144	25.5
Grand Totals	3,900,000	12,500	100

Source: Set of Documents from São Paulo's Municipality.

1. See definition in text.

2. 1 year = 312 working days (52 weeks/year * 6 days/week).

other wastes privately delivered such as construction and demolition debris. "Others" also includes the residues from incinerators and composting/recycling plants that are transferred to sanitary landfills. It totaled 322 thousand metric tons in 1990 which accounted for 8.4% of the total MSW disposed of.

In addition to determining the existing MSW categories in São Paulo, it is essential to understand the city's MSW characteristics as well. Basically, the four major characteristics are the following: waste density, moisture content, waste composition, and particle size distribution.

Waste density when combined with waste generation rates expressed by weight is valuable information since it enables an estimate of the payload capacity of the waste collection equipment. In general, the waste of industrialized countries has a lower density value as compared to developing nations due to the high percentages of non-putrescibles, such as paper, glass, plastics and metals. These materials often come from packaging and consumer goods and their low density figures are associated with large void spaces. In average, waste density in industrialized nations ranges between 100 and 150 kg/m^3 while in LDCs it ranges between 170 and 330 kg/m^3.[71]

Moisture content is associated with food waste content and climate. Moisture content is especially high in places where food waste is the largest component of the waste stream and that waste is stored on open ground while

[71]Cointreau, Sandra J. Environmental Management of Urban Solid Wastes in Developing Countries: A Project Guide. Washington, D.C.: World Bank, June 1982. 12.

awaiting collection. In the LDCs, therefore, in view of the presence of these two factors, the moisture content in the refuse tends to range between 40 and 70% whereas in industrialized countries it is generally between 20 and 25%.[72] In Chapter 2 we also saw that while high moisture content positively impacts composting, it also negatively affects incineration.

Waste composition is primarily affected by factors which are dependent upon economic, cultural, geographic and climatic differences among cities. Generally, the higher the income and the family size, the more solid waste and variety of solid wastes that are generated. A practical way to identify a community's development stage is to estimate both the quantity of paper and organic waste found in the community's waste stream. Usually, the higher the quantity of paper and the lower the amount of organic waste, the higher the development stage. Conversely, the higher the amount of organic waste and the lower the quantity of paper, the lower the development stage. The waste composition information is critical to determine potential recycling rates for the different recyclable materials in the waste stream.

Finally, particle size distribution determines whether or not mechanical size reduction would be needed. Generally, in developed countries it is assumed that the waste needs to be shredded as part of a resource recovery program. In most LDCs, however, size distribution is only additional data since the emphasis is on the collection phase rather than on disposal.

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[72]Cointreau 17.

Exhibit 7 presents the average figures of the physical components, waste density, and moisture content of the MSW of the city of São Paulo. Because the data were collected between the mid and late 1970s, a period in which Brazil experienced economic prosperity, today these figures would be considered optimistic as far as the development stage is concerned (this is due to Brazil's harsh economic recession). In fact, a recent study made by the waste management authority of Rio de Janeiro, concluded that between the years of 1981 and 1991, while the amount of organic waste increased by 10%, the amont of paper waste decreased by 15%.[73] It is also interesting to note that São Paulo's MSW characteristics correspond to what was mentioned in the above paragraphs regarding the typical figures in the LDCs.

5.2. Waste Management Services[74]

After long years of operation by São Paulo's municipality, the MSW management services have been gradually contracted out to the private sector. This transition process started in 1968 with the creation of the Urban Waste Management Department (LIMPURB), which was established to provide some

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[73]Araujo, Ledice. "Brasil Joga Fora US$40 Bi no Lixo a Cada Ano." O Globo 25 Nov. 1991.

[74] In this section, the information involving São Paulo is adapted from (1) Leite, Luiz H. Private and Public Services: Different Approaches to Solid Waste Management in São Paulo and Rio de Janeiro. Washington, D.C., World Bank, May 1989. and (2) Bartone, Carl R., et al. "Private Sector Participation in Municipal Solid Waste Service: Experiences in Latin America." Waste Management & Research 1991.

EXHIBIT 7

Composition of the MSW from the City of São Paulo in 1977

Component	% by Weight[2]
Paper	21.5
Cardboard	7.8
Wood	0.8
Rags	1.5
Leather	0.4
Rubber	0.3
Hard Plastic	3.6
Soft Plastic	6.4
Aggregate[1]	47.3
Ferrous Metals	5.2
Non-Ferrous Metals	0.8
Glass	4.4
Waste Density (kg/m^3)	173.3
Moisture Content (%)	45.9

Sources: Adapted from (1) Guaraldo, Claudio. "MSW Composting Facilities in São Paulo, Brazil." BioCycle June 1989: 82 and (2) Leite, Luiz. Private and Public Services: Different Approaches to Solid Waste Management in São Paulo and Rio de Janeiro. Washington, D.C.: World Bank, May 1989.

1. Organic matter, leaves, sand.

2. If we consider a regular recycling program that accepts paper, plastics, metals and glass, 49.7% of São Paulo's MSW is (in theory) recyclable.

services, but whose primary function was to oversee contract jobs. The privatization phase took off when private companies commenced operations of both street sweeping and refuse collection in 1968. In 1973, the municipality's sanitary landfills also began to be privately operated, and in 1985 the private sector services were further expanded to the composting plants, incinerators and transfer stations.

Similarly to some developed countries' cities that have contracted out the MSW management services to the private sector, São Paulo has also done so to enjoy the associated benefits. There are four reasons for greater private sector efficiency in the MSW management services: the use of smaller and more efficient pick-up crews; less absenteeism among contractors' employees; greater use of employee incentives to increase morale and productivity; and more use of standardized vehicles that are better maintained.[75]

Operationally, the private companies in charge of the waste management services report to the Regional Administrations, the bodies which administrate the districts into which the city is divided. Basically, the 33 administrative regions that make up São Paulo's municipality are responsible for contract supervision and payment for services provided within their boundaries. The Regional Administrations do not intervene in the running of any waste disposal facility; all control and inspection is carried out by LIMPURB that in addition is also responsible for competitive bidding, hiring of contractors and for supervising the

[75]Luger, Michael I. Private Sector Options for Solid Waste Disposal: A Background Survey for Applications in Nigeria. World Bank, December 1989. 17.

services.

Until 1985, close to 20% of the domestic waste in São Paulo was collected by municipal crews and the remaining by contracted haulers. Now, however, all collection services but the recycling curbside program are contracted out. Collection services in the city are made on alternate days (with the exception of Sundays) in residential areas and nightly in the central business district. This collection frequency is relatively high compared to North American standards because of the need to collect more frequently in warm climates to reduce health risks and because of the lack of household storage facilities in the lower-income areas. São Paulo's residential collection coverage is estimated at 95% of the total generated waste. This percentage is considerably high as compared to other developing country cities and to some extent as compared to many industrial cities.

Three large companies (Vega-Sopave, Cavo, Enterpa) and three medium-size companies are contracted by LIMPURB to provide the city of São Paulo with the basic MSW management services which are street sweeping, collection, transfer, and disposal facilities operations. All contracts are based on competitive bidding for exclusive operation in a specified service district. The private companies usually operate their own vehicle fleets and equipment, and the five-year duration contracts is the sufficient time to recover investments. The companies are paid based on either the tonnage of MSW collected or kilometers swept, with monthly inflation adjustments. Basically, cost recovery by the municipality for MSW services is achieved through a refuse tax that is billed together with a property tax. Nevertheless, this tax only covers 70% of the city council's MSW management costs.

Exhibit 8 shows the MSW management tasks and providers in the city of São Paulo.

5.3. Waste Disposal Techniques[76]

As of July 1991, São Paulo's municipality employed the following four different techniques to dispose of the 13,240 metric tons of MSW collected daily:

(1) Sanitary Landfills: 11,443 metric tons/day (86.4% of total MSW)

Sanitary landfills are by far the most popular destinies for the MSW generated in the city of São Paulo. Although not considered state-of-the-art facilities compared to the ones found in most cities of developed countries, the four sanitary landfills owned by São Paulo's municipality function to a reasonable standard. These four facilities are operated by the privately-run companies Enterpa, Vega-Sopave and Heleno Fonseca Construtécnica.

• Santo Amaro Landfill. This sanitary landfill began operations in April 1976 and its average daily load is 3,479 metric tons.

• Rodovia dos Bandeirantes Landfill. This facility has been in operation since September 1979 and its average daily load is 4,553 metric tons.

[76]The following information belong to a Set of Documents from São Paulo's Municipality.

EXHIBIT 8

MSW Management Tasks and Providers in the City of São Paulo

Task	Urban-Wide Authority (LIMPURB)	Urban Subjurisdiction Authority (Administrative Region)	Private Contractor	Informal Private Sector
Planning	YES			
Collection			YES	
St. Sweeping			YES	
Transfer			YES	
Recycling	YES			YES
Composting			YES	
Incineration			YES	
Landfilling			YES	
Billing		YES		
Contracting	YES	YES		

Source: Adapted from Bartone, Carl, et al. "Private Sector Participation in Municipal Solid Waste Service: Experiences in Latin America." Waste Management & Research 1991.

• Vila Albertina Landfill. This sanitary landfill started operations in March 1977 and its average daily load is 2,882 metric tons.

• Itatinga Landfill. This landfill only accepts construction and demolition debris and inert residues. It was established in October 1990 and its average daily load is 529 metric tons.

(2) Composting Plants: 1,052 metric tons/day (8% of total MSW)

Similar to sanitary landfills, the two composting plants in São Paulo are owned by the municipality but are administrated and operated by the private sector. The private company in charge, Enterpa, is responsible for the management, operation, and maintenance of the two plants, and also for the commercialization of the compost product, whose price is controlled by the municipality.

• Vila Leopoldina Plant. This plant was built in 1974 and its average daily capacity is 625 metric tons.

• São Matheus Plant. This facility was built in 1970 and its average daily load is 427 metric tons.

(3) Incinerators: 245 metric tons/day (1.8% of total MSW)

There are two incinerators in the city, which are also run by the private sector. Because these two incinerators units in operation are very old and lack pollution control equipment, they do not operate according to air emission standards.

• Ponte Pequena Incinerator. This incinerator burns a daily average of 114 metric tons of solid waste.

• Vergueiro Incinerator. This unit basically incinerates the health care waste of São Paulo's municipality plus a small fraction of domestic waste to balance the mixture. The daily average burnt is 131 metric tons.

(4) Recycling Program: 3.5 metric tons/day (0.03% of total MSW)

The recycling program is presently being run by the municipality which is responsible for all phases from collection to marketing of recyclables within the domestic waste stream. The program is currently limited to 10 curbside collection routes within selected neighborhoods (with a daily collection average of 3.1 metric tons of recyclables) and few drop-off centers spread out in strategic locations like public parks (with a daily deposit average of 0.4 metric tons of recyclables). These collected materials are further transported to the recycling center where they are prepared for sale.

Based on the average operational costs incurred by the city of São Paulo's MSW disposal facilities in 1990, sanitary landfills have the lowest cost (US$5/metric ton), followed by composting plants (US$9/metric ton), followed by incinerators (US$11/metric ton). Basically, no tipping fees are charged and transportation costs, which account for a great deal of the total MSW management costs, are not included in these figures. In general, these above costs for disposal may seem low compared to American standards. Some possible explanations are that less rigorous disposal standards are employed in São Paulo, costs of closure and post-closure monitoring are not incorporated, and differences of land costs and the forms of land acquisition.[77]

In addition to these above disposal methods adopted by the municipality, the city of São Paulo contains numerous illegal open dumps, especially in the east side of the city, imposing a major threat to the public health. In general, these dumps result from the so called practice of "midnight dumping" in which industrial waste generators (or other type of waste generators that do not have their wastes collected by the municipality) illegally dump their wastes in abandoned sites in order to avoid the municipality's waste treatment and disposal procedure requirements.

Exhibit 9 presents a summary of São Paulo's MSW disposal facilities.

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[77]Bartone, Carl R., et al. "Private Sector Participation in Municipal Solid Waste Service: Experiences in Latin America." Waste Management & Research 1991.

EXHIBIT 9

MSW Disposal Facilities Employed by São Paulo's Municipality as of July 1991

Facility Type	# of Operating Units	Metric Tons/Day	% Total MSW	Disposal Costs (US$/Metric Ton)[1]
Sanitary Landfills	4	11,443	86.4	5
Composting Plants	2	1,052	8.0	9
Incinerators	2	245	1.8	11
Recycling Plant	1	3.5	0.03	NA
Total MSW Disposed of		12,743.5	96.2[2]	

Source: Set of Documents from São Paulo's Municipality.

1. 1990 numbers. Transportation costs not included; no tipping fees charged.

2. The remaining 3.8% is believed to be in transfer stations.

CHAPTER 6

MUNICIPAL RECYCLING IN SÃO PAULO

6.1. Overview of Current Recycling Program[78]

In December of 1989, São Paulo's recycling program was launched by the municipality as an experimental initiative in one of the city's residential neighborhoods. Because of the program's popularity, however, the program was further expanded to adjacent neighborhoods shortly after its introduction. As of July 1991, the program consisted of 10 curbside collection routes within selected residential neighborhoods and few drop-off centers spread out in strategic locations of the city. The program, which is fully run by the municipality, serves approximately 200 thousand residents (1.7% of the population) and diverts a daily average of 3.5 metric tons of recyclable materials (0.03% of total MSW) from the city's landfills. By the end of 1991, the municipality expects to benefit 18% of the population and to recycle a daily average of 78 metric tons of waste.

A local recycling legislation was passed in January of 1991 which declares that residents and commercial establishments must source separate the inorganic (or recyclable) portion of the waste from the organic portion. The recyclables should be placed in standardized plastic bags, which should be of a distinct color

[78]The following information is based on a Set of Documents from São Paulo's Municipality.

from the ones used in the regular collection. The violators are subject to fines and other penalties. The legislation also announces that neighborhoods that are not yet recycling have a period of one year from January 1991 to comply with these requirements.[79]

The following are the four main phases of the program:

(1) Source Separation

Residents from the selected neighborhoods served by curbside collection, are given special plastic bags (free of cost) by the municipality to separate the recyclable materials from the regular waste. In general, the materials accepted in the program are papers (except napkins and toilet paper), plastics, glasses (including broken glass) and metals. The residents, then, are asked to place all the mixed recyclables in the special bag (no segregation is needed) and to put it out for collection.

(2) Curbside Collection

In the curbside collection, source separated recyclables are collected weekly by special trucks in all selected routes (each route has a defined curbside collection day). Then, after the collection is made, the trucks bring the recyclables to the city's only recycling center.

[79]Based on current recycling numbers in São Paulo, it seems very unlikely that all regional administrations (the public bodies which administrate waste-related issues of each neighborhood) will be able to meet the specifications. Moreover, the enforceability of this regulation is dubious in view of the lack of adequate enforcement agents and high monitoring costs that would be incurred.

Residents that are not served by the curbside collection program may also participate in the recycling campaign by separating the recyclables from the regular waste, and bringing them to drop-off centers sponsored by the municipality or to the buy-back centers sponsored by the private sector. In general, drop-off centers are located in the city's main public parks, while buy-back centers are located in some of the city's grocery shops, supermarkets, and shopping centers.

The two most important types of buy-back centers in the city are sponsored by the aluminum industry, and some private grocery shops. The aluminum industry sponsored programs are solely interested in recovering aluminum cans used for beverages. These programs are usually available in the big supermarkets and malls of the city, where participants are paid per can returned according to prevailing aluminum market prices.[80] Some grocery shops are also sponsoring programs where participants bring their recyclables (plastic, aluminum and glass containers) and get food products in exchange. Those recyclables are also appraised according to prevailing market prices.

(3) Processing

The processing phase takes place in the city's recycling center, the place where the recyclables are selected, sorted and prepared for sale. The center, located at a former incineration facility site, has a small physical space and a

[80]Note that this is not a bottle bill program, since no deposit fee is charged. The program is completely sponsored by the aluminum industry, which is interested in profiting from the shift of raw materials to recycled aluminum.

relatively small staff. In addition, the technology employed is primarily labor-intensive and the equipment used is largely obsolete.

(4) Marketing

After the recyclables are ready for commercialization, the municipality sells the secondary materials to dealers who in turn sell them to end users (industries). According to the municipality, the materials are not directly sold to end users because industries only buy in big quantities.

In general, São Paulo's current recycling program has a limited role for serving as a viable MSW disposal alternative for the city's huge disposal problems. Despite recycling's great potential, the city has not yet been able to satisfactorily pursue the recycling initiative, which diverts less than a tenth of a percent of the MSW produced from the city's landfills. In fact, the municipality's goal of serving at least 18% of the city's residents by the end of 1991, was hampered by organizational and financial problems, among many others. In the next section of this chapter, recommendations for improving São Paulo's current recycling program will be introduced and evaluated through the application of the cost-benefit analysis model developed in Chapter 3.

6.2. Cost-Benefit Analysis of Recycling in São Paulo

In this section, a cost-benefit analysis will be conducted evaluating desirable improvements to São Paulo's recycling program. The analysis will primarily be carried out from society's perspective in order to define the net social benefit (or cost) of recycling in case the city chooses to follow the suggestions to be made herein. In addition, since there is also an interest that the private sector invest in this area, the analysis will be further adapted to reflect the associated costs and benefits of a private company running the recycling program.

The cost-benefit analysis will hinge on the following recommendations:

• Recycling in the city should continue to be a bag-based program where residents should separate the organic portion of the waste from the inorganic (recyclable) portion. Despite commercial recycling's potential for success, this analysis will concentrate solely on domestic (residential) recycling.

• The recicling program should serve only the major neighborhoods of the city, in which the generation of recyclable materials per household is significant, therefore justifying the costs of curbside collection. Thus, it is estimated that 50% of the population will be attended by curbside collection. However, non-staffed drop-off centers should be placed in all neighborhoods.

• In the processing phase, decentralized, middle size, moderate technology MRFs should be employed. The majority of the sorting should be manual, with some sorting done by machine.

• Since recycling is the only waste management technology in the city that is run by the municipality, recycling services should also be contracted out to the private sector. In the discussion presented in Chapter 4, it was decided that the best option for a recycling program would consist of a risk-sharing venture between the public and private sectors. Therefore, for a sustainable recycling program, contracts with qualified private firms should be based on competitive bidding for exclusive operation in a specified service location for a predetermined period of time. The awarded firm should be responsible for the collection, processing and marketing phases for the specified location. In other words, the company should operate its own collection vehicle fleet, operate the municipality owned MRF (which may be sold to the private sector), and sell the recyclables to end-users. The company's collection services should be paid for according to the tonnage of separated materials collected. The processing and marketing services should be paid according to the quantity of materials processed and sold, and should also reflect the profits (or losses) incurred as a means of stimulating better services.

• More promotional campaigns, such as educational programs and advertisements, should be implemented.

Social Costs and Benefits of Recycling in São Paulo

(1) The Revenues from Recyclable Materials

Exhibit 10 shows the potential price to be paid for each metric ton of recyclable material recovered in São Paulo. In general, the following are the considerations made:

• Column (a). No distinction is being made among the different grades of materials. For example, newspapers, white paper, books, etc. are all classified as paper.

• Column (b). All these numbers are taken from Exhibit 7, where paper = paper + cardboard; plastic = hard plastic + soft plastic. All nonferrous metals are considered to be aluminum. It is assumed that this composition reflects the residential portion of the MSW.

• Column (c). An adjusting factor is being used to reflect the likely change that has occurred in the waste composition from 1977 (when the data was collected) to 1991. The waste composition change in Rio de Janeiro between the period of 1981 to 1991 was a 36% reduction in the amount of paper, 86% increase in the amount of plastic, 12% reduction in the amount of ferrous metals, and 50% reduction in the amount of glass discarded.[81] Therefore, it is assumed that an

[81] Araujo, Ledice. "Brasil Joga Fora US$ 40 Bi no Lixo a Cada Ano." O Globo 25 Nov. 1991.

EXHIBIT 10

Revenues from Recyclable Materials in São Paulo

(a) Material	(b) % by Weight[1]	(c) Adjusting Factor	(d) Overall Recycling Rate (%)	(e) Avg US$/Metric Ton	(f) Composite US$/Metric Ton
Paper	29.3	0.64	24	60.5	2.7
Plastic	10.0	1.86	24	90.7	4.1
Ferrous Metals	5.2	0.88	24	655.1	7.2
Aluminum	0.8	1	24	604.6	1.2
Glass	4.4	0.50	24	22.2	0.1
Total					15.3

1. Note that the quantity of recyclable materials in São Paulo without the adjusting factor is 49.7% (29.3% + 10% + 5.2% + 0.8% + 4.4%). However, by considering the adjusting factor this quantity decreases to 44.9% (29.3%*0.64 + 10%*1.86 + 5.2%*-0.88 + 0.8%*1 + 4.4%*0.5).

equivalent change occurred in São Paulo's waste composition.[82]

• Column (d). According to São Paulo's municipality, in July of 1990 the participation rate of the households served by the curbside program was 75%, while the reject materials from the recycling center was 27%.[83] However, because of the expansion of the recycling program, it is assumed that the participation rate will drop to 40%. Similarly, the reject materials from MRFs will also drop to 15% in view of better equipment and education campaigns. In addition, it is assumed that 30% of all recyclable materials in the waste stream will not be in suitable conditions to be recovered. Therefore, the overall recycling rate will be 24%. It will also be assumed that all materials share the same overall recycling rate.

• Column (e). These numbers are taken from secondary market prices paid by dealers in October of 1991 in Rio de Janeiro. Note that dealers resell the recyclables to industries with a 30 to 35% price increase.[84] Therefore, because the proposed MRFs in São Paulo will be able to market materials directly to end users, an additional 30% will be incurred to those prices. It is also being assumed

[82]Since the primary reason for the waste composition change is based on the economic recession experienced by the country, it is reasonable to assume that São Paulo and Rio have experienced similar changes.

[83]Mello, Ana. "Coleta Seletiva Já Desafoga os Aterros." Jornal da Semana 26 Aug. 1990.

[84]"Rio Lucra com Mudança na Coleta de Lixo." O Globo 20 Oct. 1991: 27.

that US$1 = CR$645 (the Brazilian currency is called Cruzeiro)[85].

• Column (f). Column (f) = column (b) * column (c) * column (d) * column (e).

According to Exhibit 6, 2.3 million metric tons (58.5%) of the MSW produced in São Paulo in 1990 was domestic (residential) waste. Therefore, assuming that the same amount of domestic waste will be generated in 1991 and that the 50% of the population to be served by the curbside program generates 65% of the recyclable domestic waste (which is reasonable to consider since the more affluent people consume more goods than the poorer populations), the following are the potential revenues for sale of recyclables:

Sales = 2.3 million metric tons/year * 65% * US$15.3/metric ton

Sales = US$22.87 million/year, where 1 year = 312 working days.

(2) The Avoided Subsidy to Virgin Materials and (3) The Benefits from Substituting Secondary Materials for Virgin Materials

In general, because these two elements reflect the benefits of recycling in the national level, it becomes very difficult to quantify these benefits at the local level. Therefore, instead of placing misleading monetary values for these two benefits, a short qualitative analysis reflecting the case of Brazil will be presented in order to show the high importance of these two factors.

[85] International Monetary Fund. International Financial Statistics. Dec. 1991. This exchange rate reflects the commercial (official) rate from the last day of October 1991.

According to a Brazilian study, the savings for reducing the imports of fossil fuel alone would be enough to justify the implementation of recycling programs in Brazil. It is estimated that for each US$1 invested in recycling, roughly US$1.8 would be saved in fossil fuel imports. Furthermore, if impacts of secondary effects (mainly employment opportunities) on society due to increased recycling are also considered, the same study concludes that investments for each job created in recycling are on the order of magnitude smaller compared to jobs created in the virgin materials industry. Therefore, these two factors alone would make recycling programs very appealing in Brazil.[86]

(4) The Costs of Running a Recycling Program

Processing Phase

Estimated Capital Costs

• MRFs. It is assumed that the use of 150 metric tons/day capacity facilities are spread out among selective locations of São Paulo. These middle size facilities will be of moderate technology and privately operated. As an example, in Rio de Janeiro, a 200 metric ton/day full stream plant (facility that processes regular refuse in recyclable and compostable portions) was built in 1976 using Brazilian technology and financed by the National Development Bank. This moderate

[86] Ministério da Indústria e do Comércio do Brasil. Reciclagem dos Resíduos Urbanos, Agropecuários, Industriais e Minerários. Brasília: 1985. 116-117.

technology facility had a total capital cost of roughly US$715,000.[87] Because this facility is located at a former incinerator site owned by the municipality of Rio, it was not necessary to buy land and also there were some savings in construction costs. Thus, considering that MRFs in São Paulo will be smaller and potentially sited under similar circumstances, it is assumed that each MRF will have a capital cost of approximately US$1 million.

> # of MRFs needed = 7,372 metric tons/day of domestic waste * 44.9% of recyclable materials composition (see Exhibit 10) * 70% of recyclables that can be recovered * 65% of recyclables generated by residents served by curbside program * 40% participation rate / 150 metric tons/day capacity MRF = 4 MRFs.

Because the existing recycling center in the city is very small, it is assumed that four MRFs will be built.[88]

> 4 MRFs * US$1 million each = US$4 million.

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[87]Monteiro, José. Primeiro Simpósio Paranaense Sobre Destinação Final de Resíduos Sólidos Urbanos. Rio de Janeiro: COMLURB, Nov. 1983.

[88]The MRFs' capacity of 150 metric tons/day is based on a single shift operation. In case there is an increase in the quantity of materials to be processed, these facilities can always add one more shift.

Estimated O&M Costs[89]

• Wages, Taxes, and Benefits of Labor. In Rio's processing facility, the average salary (including benefits) in April of 1991 for all of its 77 employees (which is a lot of people given the size of the facility) is US$325/month. Therefore, assuming that salaries are equivalent in São Paulo and that each MRF will employ an average of 25 people:

> 5 MRFs (4 MRFs to be built plus the existing recycling center) * 25 each * US$325 = US$40,625/month or US$487,500/year.[90]

• Equipment Operation (mainly electricity). In the facility in Rio, US$1,475 was spent in electricity in April of 1991. Assuming similar expenses in São Paulo:

> 5 MRFs * US$1,475 each = US$7,375/month or US$88,500/year.

• Equipment Maintenance. Considering that maintenance costs are 2%/year of total equipment capital cost (in Rio's facility, equipment capital cost was US$537,500):

> 5 MRFs * US$537,500 each * 2% maintenance = US$53,750/year.

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[89] All O&M considerations regarding the processing facility in Rio (as April of 1991) will be based on: Silva, Marcia. Reciclagem de Lixo no Rio de Janeiro. Rio de Janeiro: Universidade Santa Úrsula, Junho 1991. (Unpublished). It is also being considered that US$1 = CR$260.7 according to the official rate from the last day of April of 1991 (International Monetary Fund. International Financial Statistics. Dec. 1991).

[90] Note that by considering 5 MRFs in all O&M costs, as it is the case here, MRFs will be working at under capacity given the amount of recyclables to be processed. This is a conservative estimate.

• Supplies (cleaning products, gloves, etc.). In Rio, these costs were less than US$50 in April of 1991. Considering US$100/month for São Paulo:

5 MRFs * US$100 each = US$500/month or US$6,000/year.

Collection Phase

Estimated Capital Costs

• Trucks. Although there may not be a need for new collection vehicles, this analysis will consider the purchase of new trucks for the collection of recyclables. Note that vehicles do not have to be state-of-the-art, compartmentalized trucks in view of the ease of bag-based systems. Basically, the average quantity of refuse collected in São Paulo per vehicle/day is 29.15 metric tons/day.[91] Considering that the average quantity of recyclables collected per vehicle/day will be 30% less than that for regular refuse (since recyclables have lower density values), each truck will be able to transport an average of 20 metric tons/day of separated materials.

# of trucks needed = 7,372 metric tons/day of domestic waste * 44.9% of recyclable materials composition (see Exhibit 10) * 70% of recyclables that can be recovered * 65% of recyclables generated by residents served by curbside program * 40% participation rate / 20 metric tons/day for each truck = 30 trucks.

30 collection trucks * US$60,000 each = US$1.8 million.

[91]Leite, Luiz. Private and Public Services: Different Approaches to Solid Waste Management in São Paulo and Rio de Janeiro. Washington, D.C.: World Bank, May 1989. 17.

• Non-staffed Drop-Off Centers.

50 containers * US$2,000 each = US$100,000.

Estimated O&M Costs

• Wages, Taxes and Benefits of Haulers. For 30 trucks, a three person crew will be used in each truck. Therefore, assuming that salaries (including benefits) are equivalent to what is paid in MRFs:

30 trucks * 3 labor * US$325/month = 29,250/month or US$351,000/year.

• Fuel and Oil of Trucks. In the processing facility in Rio, the estimated costs of fuel and oil of the fleet responsible for the curbside collection is roughly US$ 75,000/month. Therefore, assuming these costs are equivalent to each MRF in São Paulo (which is clearly an overstatement since the decentralized MRFs will be able to save in transportation costs):

5 MRFs * US$75,000 each = US$375,000/month or US$4.5 million/year.

• Trucks' Maintenance. Assuming that maintenance costs is 2%/year of total equipment capital cost:

US$1.8 million in trucks * 2% maintenance = US$36,000/year.

• Supplies (gloves, uniforms, etc.). Similar to MRFs (that will employ 125 people), collection will employ 90 people. It is assumed that supply costs for transportation will be US$10,000/year.

In addition to all these costs, promotional costs, variable overhead and marketing costs should aslo be considered.

• Promotional Costs. It is assumed that a fixed budget of US$1 million/year will be used for promotional campaigns, which should also include the distribution of plastic bags for the collection of recyclables to participants.

• Variable Overhead. These costs include utilities expenses such as water, telephone, and administrative expenses. These costs will be estimated at US$100,000/-year.

• Marketing Costs. The MRFs should be able to sell secondary materials directly to industries. Because São Paulo is a major industrial city, the recycled materials will most likely be marketed with local industries. Therefore, the costs of shipping materials should be acknowledged. It is assumed that these costs will be 10% of the annual costs of fuel (which is US$450,000/year).[92]

[92]Fuel consumption in the collection phase combined with this additional 10% in annual fuel costs will be more than enough to pay for the costs of shipping. Furthermore, there are also the savings in transportation of recyclables (that would have to go to landfills if not collected) that are not being considered.

(5) <u>The Avoided Disposal Costs of Landfilling</u>

According to what was discussed in Chapter 3, the avoided disposal costs of landfilling should not only consider a landfill's capital and O&M costs, but also the clean-up and post-closure costs, revenues from sale of methane gas (if applicable), costs of complying with new regulations, and the associated social costs of environmental harm and disamenities. However, because of the lack of appropriate data to calculate the actual social cost of landfilling in São Paulo, this analysis will only consider the O&M costs of landfilling (which is a clear understatement, especially in the case of LDCs). Therefore, assuming that all separated materials in São Paulo would go to landfills if not recycled, and that operational costs of landfills in the city is US$5/metric ton (see Exhibit 9):

Avoided Disposal Costs = 2.3 million metric tons/year of domestic waste * 44.9% of recyclable materials composition (see Exhibit 10) * 70% of recyclables that can be recovered * 65% of recyclables generated by residents served by curbside program * 40% participation rate * 85% of materials recovered in MRFs * US$5 metric/ton = US$0.8 million/year.

Presentation and Discussion of Results

Exhibit 11 presents the preliminary results of this cost-benefit analysis and Exhibit 12 displays the net present value calculation. Note that the NPV of US$106.17 million is the net social benefit of recycling in São Paulo for the 15-year period analyzed. This number would still be higher if the analysis had considered

EXHIBIT 11

Preliminary Costs and Benefits of Recycling in São Paulo

SOURCES OF COSTS	CAPITAL COSTS	ANNUAL O&M COSTS
Processing Phase		
MRFs	(US$4 million)	
Labor		(US$487,500)
Operation		(US$88,500)
Maintenance		(US$53,750)
Supplies		(US$6,000)
Total Processing Costs	(US$4 million)	(US$635,750)
Collection Phase		
Trucks	(US$1.8 million)	
Containers	(US$100,000)	
Labor		(US$351,000)
Fuel		(US$4.5 million)
Maintenance		(US$36,000)
Supplies		(US$10,000)
Total Collection Costs	(US$1.9 million)	(US$4.9 million)
Promotional Costs		(US$1 million)
Marketing Costs		(US$450,000)
Variable Overhead		(US$100,000)
TOTAL CAPITAL COSTS	(US$5.9 million)	
TOTAL ANNUAL O&M COSTS		(US$7.09 million)

SOURCES OF BENEFITS	ANNUAL BENEFITS
Sales of Recyclables	US$22.87 million
Avoided Subsidy to Virgin Materials and Benefits from Substituting Secondary Materials for Virgin Materials	HIGH
Avoided Disposal Costs of Landfilling	US$0.8 million
TOTAL BENEFITS	US$23.67 million

<u>**EXHIBIT 12**</u>

Net Present Value Calculation[1]
(In Millions of US$)

	MRFs	Trucks and Containers	O&M Costs	Annual Benefits	NPV[2]
Present Value	(4)	(2.75)	(48.29)	161.21	106.17
Year 0	(4)	(1.9)	0	0	
Year 1	0	0	(7.09)	23.67	
Year 2	"	"	"	"	
"	"	"	"	"	
Year 7	"	"	"	"	
Year 8	"	(2.1)	"	"	
Year 9	"	0	"	"	
"	"	"	"	"	
Year 15	"	"	"	"	

1. Assumptions:
(1) 15-year life for the MRFs.
(2) In the eighth year of the project, new trucks and containers will be bought (with a 10% increase in the price) in order to substitute old ones.
(3) The discount rate (or return on investment) is 12%.
(4) Neither the salvage value of equipment nor the provision for resale of land is considered.
(5) There are no changes in O&M costs or annual benefits during the project's life.
(6) Except for new trucks to be bought in the eighth year, all capital costs will be fully considered before the project starts (year 0).

2. The internal rate of return (IRR) for the project is 281%.

the presence of other benefits that are not being quantified.

In Exhibit 12, O&M costs and annual benefits are the two elements that have the most impact on the NPV value. This sounds reasonable since these two elements have high values and occur every year. Therefore, in order to present a more pessimistic analysis for São Paulo's program, it is assumed that O&M costs will increase 2% annualy and that annual benefits will only be half of expected (this is the same as assuming that participation rate will drop from the current 40% to 20%). In addition, the MRFs capital costs will be based on the American average of US$16 thousand per incoming ton, or US$2.4 million for each 150 ton/day facility.[93] Exhibit 13 shows that the pessimistic NPV would still be positive, yielding US$14.82 million over a period of 15 years.[94]

It is important to realize, however, that small changes in the assumptions made may drastically influence the NPV value, therefore stressing the importance of sensitivity analysis. Among these assumptions imposing high influence in the outcome are inflation, currency exchange rate, discount rate, waste composition, market prices for secondary materials, disposal costs, and participation rate.

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[93]U.S. Environmental Protection Agency. Decision-Makers Guide to Solid Waste Management. Washington, D.C.: Nov. 1989. 70.

[94]Note that this cost-benefit analysis may be easily adapted to reflect the monetary benefit (profit) or cost (loss) of a private company interested in running the recycling program. This may be done by considering only the revenues from recyclables and the costs of running the recycling program. In the pessimistic case, for example, the NPV would be US$12.10 million in case the private company assumes the US$1 million/year promotional costs or US$19.64 million if these promotional costs are assumed by the municipality. Furthermore, a private company may increase its revenues by charging a tipping fee to the municipality according to the savings of disposal costs.

EXHIBIT 13

Pessimistic NPV Calculation[1]
(In Millions of US$)

	MRFs	Trucks and Containers	O&M Costs	Annual Benefits	NPV[2]
Present Value	(9.6)	(2.75)	(53.47)	80.64	14.82
Year 0	(9.6)	(1.9)	0	0	
Year 1	0	0	(7.09)	11.84	
Year 2	"	"	(7.23)	"	
Year 3	"	"	(7.38)	"	
Year 4	"	"	(7.52)	"	
Year 5	"	"	(7.67)	"	
Year 6	"	"	(7.83)	"	
Year 7	"	"	(7.98)	"	
Year 8	"	(2.1)	(8.14)	"	
Year 9	"	0	(8.31)	"	
Year 10	"	"	(8.47)	"	
Year 11	"	"	(8.64)	"	
Year 12	"	"	(8.82)	"	
Year 13	"	"	(8.99)	"	
Year 14	"	"	(9.17)	"	
Year 15	"	"	(9.36)	"	

1. Assumptions:
(1) MRFs capital costs are based on American average of US$16,000/ton. Therefore, US$16,000/ton * 150 ton/day * 4 facilities = US$9.6 million.
(2) O&M costs have a 2% annual increase.
(3) Annual benefits are only 50% of expected.

2. The internal rate of return (IRR) for the project is 37.1%.

Annual inflation in Brazil, which usually reaches four digits, is practically impossible to predict. The devaluation of the Brazilian Cruzeiro against the American Dollar (or any other strong currency) offers a good estimate of the inflation and presents a good argument for working in US$. However, inflation and devaluation rates do not necessarily move in tandem.

Currency exchange in Brazil is another major obstacle. There are three different rates in the country. There is one for tourism (called "tourism" rate). The second is for international commerce and government transactions (called "official" or "commercial" rate), and the third is obtained on the streets (called "parallel" or "black" rate). In general, the "parallel" rate is the one which better reflects the real border exchange value of the Cruzeiro with the US$. However, many transactions are controlled by the "official" rate. Because this thesis is using the "official" rate, which is always smaller than the "parallel" rate, both costs and revenues may be overstated.

The discount rate of 12% adopted in this analysis is assuming a real interest rate plus an additional return (the inflation rate is already considered when converting CR$ to US$). The discount rate, however, should also measure certain intangible risks not being considered here. For example, political risk in Brazil may be relatively high.

Waste composition and quantity change over time. In hard economic times, for instance, the decrease in the quantity of recyclable materials may negatively impact the recycling program. On the other hand, population growth tends to increase the amount of waste generated. In this analysis, both composition and amount of waste produced are considered constant.

Secondary market prices, as the name suggests, are set according to prevailing markets. The increase on the supply side for secondary materials due to the recycling program may not be followed by an equivalent increase on the demand side. As a result, the prices may fall. This analysis also does not consider possible market prices fluctuations.

The decreasing amount of space available in São Paulo's landfills and possible strict environmental regulations may drive current disposal prices way up, which is also not considered in this evaluation.

Lastly, the participation rate in the program is considered to be constant from beginning to end, which is unlikely. In general, participation rates may either increase or decrease over time according to many factors, such as services reliability and participants' environmental awareness. Thus, it is very difficult to predict the participation rate in a diverse city like São Paulo.

In essence, this cost-benefit analysis has shown that there is an excellent opportunity to profit from the recommendations and improvement made to São Paulo's recycling program. The tangible effects alone would be enough to yield a net social gain. However, some key elements necessary for the program's success should be examined and insured before the program starts. The next section will discuss these key elements and their respective roles.

6.3. Key Issues for São Paulo's Recycling Success

The success of a community's recycling program is not limited to the action of any individual factor, but rather to an effective interaction among a group of key elements. Although the last section demonstrated in monetary terms the profit potential of recycling in the city of São Paulo, at least three factors must be present to insure the program's success. These three key issues are (1) public participation, (2) private sector involvement, and (3) viable secondary markets. In general, these three issues will be examined by using the policy concepts reviewed in Chapter 3 wherever applicable.

(1) Public Participation

Public participation in recycling programs is one of the most important factors for a program's success. The government has a key role in involving and promoting public participation, which should be done with the community's needs in mind. The use of mandatory recycling programs, as being proposed in São Paulo, is not the optimal way to boost participation. This type of action may induce illegal dumping and the high monitoring and enforcement costs associated make this option very unattractive. The answer, therefore, is in the use of information mechanisms.

Information mechanisms, which are basically made up of public and school education, should be fostered by the government not only as a means of providing information about recycling programs, but also as a means of attempting to change public habits and behavior. In general, public education programs should include mass media campaigns (newspaper, radio, television, and audiovisual media which can infiltrate the message to illiterate populations), campaigns directed to target population with special objectives, and compulsory sanitary curriculum in the elementary school system. In addition, educational campaigns targeted to housewives and maids are particularly important in a city like São Paulo.[95]

Presently, São Paulo's recycling program does use information mechanisms through the circulation of brochures in the areas served by the curbside program, and through articles and press conferences. The program, however, may be further intensified with more public educational campaigns in the neighborhoods, especially in the ones with multi-family apartment buildings, and also with the implementation of a sanitary education curriculum in the educational system.

There are three basic steps in public education planning. The first step is to understand the different audiences that exist within communities and how these distinct groups receive information. The second step is to prepare a formal plan, which should include main challenges to be addressed, goals to be reached, and the timeline necessary to coordinate public education efforts with program implementation. Lastly, the third step is to establish a method for evaluating each

[95]Hershkowitz, Allen, and Eugene Salerni. Garbage Management in Japan: Leading the Way. New York: INFORM, 1987. 22-23.

of the program activities.[96]

Public participation in recycling programs is particularly impacted by cultural, educational, and social differences among communities. In most LDCs cities, these three factors suffer from enormous variations among neighborhoods. In São Paulo, curbside recycling programs have started in the relatively small, middle class neighborhoods with environmental-conscious residents. Participation rates in those neighborhoods are considered high. Nevertheless, in order for the recycling program to expand, the program will also have to target the larger neighborhoods of the city, where most of their residents live in multi-family apartment buildings. Therefore, it is essential that the recycling program correctly addresses the needs of these people, which are different from the needs of residents in smaller neighborhoods. In multi-family apartment buildings, the success of recycling will primarily depend on the effectiveness of condominium organizations which can be reached through targeted educational campaigns. Furthermore, close contacts with active neighborhood associations are an excellent means to increase participation rates.

Finally, public participation is also a function of reliable services and convenience. The more reliable and convenient the recycling program to the general public, the higher the participation rate. In addition, participants should feel they are getting something in exchange for their cooperation. Therefore, it is very important that recycling program administrators demonstrate their

[96]U.S. Environmental Protection Agency. Decision-Makers Guide to Solid Waste Management. Washington, D.C.: Nov. 1989. 126-127.

appreciation by using part of the revenues for social causes, such as renovations of public parks.

(2) <u>Private Sector Involvement</u>

Private sector involvement is an essential ingredient for successful recycling programs. The recycling industry's dynamism and complexity require quick adjustments to markets, which is not easily accomplished by the public sector. As a result, the use of private contractors in the daily operations of a recycling program is highly desirable.

At fist glance, it may seem that there is a conflict of motives for recycling between the public and private sectors. While the public sector sees and promotes recycling as a means of fostering a better alternative to traditional, environmentally unfriendly disposal methods, the private sector's main concern is profit. Nevertheless, if both sectors work together (as proposed in the risk-sharing approach) the results for both parties can be positive.

Another benefit of involving the private sector is the creation of employment for participants of the informal economy. In the city of São Paulo, like in many other LDCs cities, recycling of domestic waste has been done by individuals in the informal sector of the economy. Usually, the "recycling route" starts with individual scavengers who collect the recyclables in the streets, parks and even landfills of the city and sell them to small merchants. The small merchants, in turn, sell these products in bigger quantities to large merchants who then prepare the products and sell them to final users (industries).

The informal sector, however, in addition to providing inefficient services, does not help those who engage in this type of recycling - namely the scavengers. Scavengers are usually extremely poor, uneducated individuals that risk their lives by being in constant contact with the waste without any kind of protection. A formal and expanded recycling program, as a result, would provide both better services and employment opportunity for these individuals.

(3) Viable Secondary Markets

Another key to recycling is the availability and stability of markets for separated materials. Markets should be set up before recyclables are collected. Recycling is a market-based activity in which a failure to develop appropriate markets will result in the failure of the program.

Market conditions differ considerably from one area to another. The following are relevant factors: how close a community is to the recycling center and end users, whether communities can pool their recyclables to command greater marketing power, and whether foreign markets are available.[97] Consequently, fluctuations in secondary material prices, and unstable supply and demand between the recycling program and the end users are constant threats to the success of a recycling program.

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[97]Anderson, Carol. Recycling Promises and Problems. August 1990: 22A.

In Chapter 3, the policies that call for recycling standards and tradeable permits may be a good option to create stable markets for secondary materials in São Paulo. By matching expected supply of separated materials with required demand, both a recycling program and the recycling industry will be profitable.

In addition to overall economic market forces, the recycling industry is also vulnerable due to its infancy. Because the recycling industry is new, until it matures and stabilizes, the public sector should play an active role in order to avoid the possibility of interruption. In addition to government policies, a good way to preserve continuity is to develop long-term contracts between the recycling plants and the industries.

This chapter presented the overall situation of the city of São Paulo with regards to its recycling program. Recommendations to improve the current recycling program were made and evaluated, in which the potential for success was evidenced by the net social benefit achieved in the cost-benefit analysis. However, whether or not the recycling program will be improved from its current 0.03% role in the MSW disposal, will depend on how serious and effective the public and private sectors joint efforts are.

CHAPTER 7

CONCLUSIONS

7.1. Principles of an Integrated Waste Management System

This thesis has introduced recycling as a waste management option that offers an alternative way to deal with the existing MSW disposal dilemma. Recycling, however, should not be seen as the answer but rather as part of the solution for waste-related issues in a given community.

In the case of São Paulo, for instance, despite the net social benefit achieved, Exhibit 10 shows that only 45% of the domestic waste is recyclable. Furthermore, if this 45% is combined with the overall recycling rate, assumed to be 24%, only 11% of the waste generated can be diverted from the city's landfills. Therefore, although desirable, recycling alone cannot handle the whole MSW stream.

The answer for a community's waste disposal problems will rely on effective integrated waste management systems, where each system should be designed to combine with and complement the other. The waste stream is made up of different components, and as a result each one of these components should be managed and disposed of according to the best alternative.[98]

Waste management systems should preferably interact in the following order: source reduction, recycling, composting, incineration and landfilling. Source reduction practices would decrease the quantity of materials entering the MSW stream, while recycling programs would be able to remove inorganic materials from composting plants as well as noncombustible materials from incinerators. As a result, the amount of waste to be landfilled would be reduced. Although it is environmentally desirable that this order of preference be followed, this may be unrealistic in many communities. Therefore, each community should decide which combination of methods better addresses its needs without, of course, overlooking the potential use of preferable methods.

In rural communities, for example, composting programs probably look more attractive than recycling programs. However, even in industrialized cities like São Paulo and Tokyo, recycling priorities may be different. Chapter 4 showed how effective the program in Tokyo was by separating combustible from noncombustible (recyclable) materials. On the other hand, São Paulo's waste composition and availability of markets for both secondary materials and compost offer an excellent opportunity for developing a program that separates the organic (compostable) portion of the waste from the inorganic (recyclable) portion.

In essence, there is no conventional procedure for determining when and where to apply the recycling option in an integrated waste management system.

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[98]U.S. Environmental Protection Agency. Decision-Makers Guide to Solid Waste Management. Washington, D.C.: Nov. 1989. 3.

The process should be applied on a case-by-case basis. It is important, however, that integrated waste management systems be designed with the necessary flexibility to manage future changes in the local waste management sector. Ongoing program monitoring, therefore, is an important ingredient to the success of any waste management alternative.[99]

7.2. Lessons from the Case of São Paulo

The case of São Paulo has confirmed that recycling programs can be a profitable way for communities to deal with the MSW management issue. In industrial LDCs cities, for example, the potential for recycling tends to be quite good. Those cities usually have a fair supply and demand for recyclable materials, offer lower O&M costs for running a recycling program compared to cities of developed countries, and support secondary materials market prices that are close to international market prices. As a result, it is likely that the revenues for the sale of recyclables alone will outweigh the costs of running a recycling program, as is the case in São Paulo.[100]

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[99]U.S. EPA 143.

[100]Note that in most cities of developed countries, particularly in the U.S., the avoided disposal costs of landfilling and incineration are the leading factors for obtaining a positive NPV. In general, this is due to the high tipping fees charged by disposal facilities.

Although in São Paulo the tangible effects alone generate a net social gain, the recycling initiative is a long-term investment that should not only take into account the potential economic gains, but also the intangible social benefits (and costs) that are usually not considered in most evaluations. The monetary value determined in a cost-benefit analysis, therefore, should also be accompanied by a qualitative report assessing the project's impacts on society. As a result, the decision-making process should not be limited to the numeric value obtained. A negative net social benefit does not mean that the project should be abandoned immediately.

Despite the unique problems affecting each city, the case of São Paulo can serve as an example for cities in the developing world (especially for other Brazilian and Latin American cities) of how to benefit from recycling. Certainly, the waste situation in LDCs cities resembles more closer that of São Paulo than it does the situation in the first world cities. Similarities in waste-related issues include waste composition, disposal techniques, and cultural habits. As a result, adaptation of the recycling option is easier and more appropriate. In essence, Brazilian and foreign cities interested in São Paulo's recycling program may share this recycling program experience through waste management conferences and publications, interchange programs among waste management professionals, and joint-ventures in recycling pilot programs. Information exchange is the best instrument for keeping communities updated of new techniques and discoveries in the waste management sector.

Finally, the case of São Paulo underscores the importance of recycling programs as a waste management tool even if the amount of MSW to be diverted from disposal facilities is somewhat limited. While it is important that recycling makes economic sense (like in São Paulo), recycling is also an option designed to enhance some of the values of modern societies.

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