Life-Span Costing Analysis Case Studies

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BWPRR Overview

This report is one of a number of waste prevention reports prepared under a long-term contract by consultant Science Applications International Corporation, and issued at contract conclusion. The reports are listed below. The New York City Department of Sanitation (DOS, or the Department), Bureau of Waste Prevention, Reuse and Recycling (BWPRR), the sponsor, has issued a Foreword to the studies; it acknowledges the many contributors and frames a position based on its considerable efforts to review, practice, and measure waste prevention. The Foreword appears at the beginning of the first report in the series, *Measuring Waste Prevention in New York City.* Interested readers are strongly encouraged to access the material through the Department's web site at www.ci.nyc.ny.us/strongest. Print or electronic versions are available through BWPRR.

These product life-span costing studies were prepared prior to, and as input for, other reports, particularly *Measuring Waste Prevention in New York City* and *NYCitySen$e Summary Guide,* in a period of changing waste management costs. These studies used $41.50/ton as the estimated cost of waste disposal, for measuring avoided costs in comparing certain alternatives. The Department's recent *Comprehensive Solid Waste Management Plan Draft Modification (May 2000)* projects that disposal (through export) would cost approximately $75/ton in FY2002 (Table 4.3-2, SWMP Draft Modification). Readers who wish to make product choice comparisons can follow the descriptions and tables in each study, and alter this or other assumptions, as appropriate.

Readers should note that the methodologies for many of the product choices include certain labor costs of making changes, but not overall administrative costs. For example, labor costs for changing oil filters and for installing towel dispensers are included, while overall costs of managing rechargeable battery inventories are not. For some products, life-span costs of the seemingly more environmentally friendly product yield only modest savings over the competing product. Rechargeable and disposable alkaline batteries are one example, even excluding the administrative costs. For two of the products studied, large potential savings were found; results have been passed on to the appropriate City Agencies for their consideration (Finance Department for 2-way envelopes; MTA for synthetic motor oil). Finally, all City Agencies can avail themselves of the waste-saving potential of energy-efficient double-sided photocopiers through the normal purchasing processes of the Department of Citywide Administrative Services.

Waste Prevention Reports:

- *Measuring Waste Prevention in New York City*
- *Survey of Waste Prevention Programs in Major Cities, States and Countries*
- *Procurement Strategies Pursued by Federal Agencies and Jurisdictions Beyond NYC for Waste Prevention and Recycled Products*
- *Inter-Agency Task Force Action Plan to Encourage the Use of Recycled-Content Building Materials*
- *Materials Exchange Research Report*
- *Characterization of NYC's Solid Waste Stream*
- *Life Span Costing Analysis Case Studies*
- *Packaging Restrictions Research: Targeting Packaging for Reduction, Reuse and Recycled Content*
- *NYCitySen$e Summary Report*
- *NYC WasteLe$$ Summary Report*

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1. INTRODUCTION

The New York City Department of Sanitation, Bureau of Waste Prevention, Reuse and Recycling (BWPRR) commissioned the development of “life-span costing” studies of ten categories of products that the City procures. The ten case studies presented in this report were selected and prepared by the SAIC/Tellus consulting team in conjunction with BWPRR and other relevant City agencies.

Life-span costing is a method for assisting purchasing agents to minimize City costs by accounting for factors beyond the initial purchase price of a product. Two or more products may provide essentially the same function, but pose cost implications to the City that may not be apparent when comparing purchase prices. Life-span costing focuses on costs incurred over a product’s entire life, rather than considering only the purchase price of the product. Because product evaluation using life-span costing includes a consideration of the cost of disposing or otherwise discarding the product, life-span methods fit naturally with waste prevention efforts.

For example, two products may be offered for sale to the City at the same price, but one of the products may actually be a better “buy” because it lasts longer and/or results in less waste that the City has to pay to recycle or dispose. If bid specifications and purchasing decisions do not reflect costs to the City of using, replacing, and recycling/disposing of the product, in addition to the initial purchasing cost, the City may not be getting the best value for its limited purchasing dollars.

The case studies are intended to illustrate how life-span costing methods can be used by purchasing agents to help the City purchase products that are the most economical choices. The methods for conducting the analyses presented in each case study can be readily adapted by City purchasers to reflect their particular circumstances, such as unit price, quantities purchased, and other variables.

Through the application of life-span analysis, a purchasing agent can:

1) select the item on a requirements contract that is the most economical in the long-run;
2) purchase products/write bid specifications for non-requirements-contract purchases that incorporate life-span factors into the vendor/product selection criteria; and/or
3) propose to the Department of Citywide Administrative Services the development of new bid specifications that incorporate life-span factors into the vendor/product selection criteria.

There are a number of ways to apply life-span costing. In these case studies, a simple approach based on average annual costs is used. This approach does not attempt to discount costs over the life of the product. For major investments with significant up-front costs and with benefits realized over many years, the initial cost generally would be discounted to allow for a presentation of the net present value of the investment. However, the SAIC/Tellus team, in consultation with BWPRR elected to use average annual costs because the initial costs associated with the items studied in these ten case studies are not substantial and the findings would not be significantly altered through calculating the net present value of the investments.[1]

Life-span costing is used by some local and state government agencies, including the City of Tucson and the State of Wisconsin, to reduce procurement costs and to increase enhance efficiency by increasing insight into the true costs of products and services, including those that may appear more expensive if only the initial purchase price is considered.

[1] Net present value is calculated as the sum of PV = year I cost/1.03)raised to the year of the project. Using Excel, the net present value can be calculated using the following formula: NPV(rate,value1,value2,…), where value 1 = the year 1 cost, value 2 = year 2 cost, etc.

2. SELECTION OF CASE STUDIES

This report presents case studies of 10 items commonly procured by mayoral agencies in the City of New York. Case studies were prepared for the following ten items:

- Air Filters for HVAC Units
- AA Alkaline Batteries for Pagers
- Antifreeze for City Vehicles
- Envelopes
- Hand Dryers/Paper Toweling
- Motor Oil for City Buses
- Photocopiers
- Replacement Slats for Park Benches
- Sorbents to Absorb Oil Spills
- Toilet Tissue

The ten items evaluated in the case studies were selected because each is purchased in substantial quantities by the City and environmentally preferable alternatives for comparison are readily available. While the items were selected because they represent options for substantial savings and/or waste prevention for various City Agencies, they are not intended to represent the best possible options for any particular City Agency, nor are they intended to be construed as the only available options.

In addition to considering products highlighted in the 10 case studies, purchasing agents also can apply a life-span approach to examine other types of product alternatives for which there appear to be opportunities to save money. The 10 case studies were developed primarily to help motivate and assist purchasers to apply the principles of life-span analysis whenever it can result in cost savings for the City.

3. HVAC AIR FILTERS – CASE STUDY

Introduction

The SAIC/Tellus team, in consultation with BWPRR and the Department of Citywide Administrative Services (DCAS), selected air filters as one of the case studies because a variety of air filter options, with differing cost and waste generation characteristics, are available. In addition, air filters are used in HVAC units in most city-owned buildings.

This case study examines the cost and waste stream impacts of buying and using air filters for the two heating, ventilating, and air conditioning (HVAC) units in the New York City Department of Parks and Recreation's 5-Borough Technical Services building. The two units have one air handler each and each requires eight air filters per air handler. The units currently use pleated air filters. The basic results of this case study are that, compared to the currently used pleated filters, using synthetic air filters would save the Technical Services building annually:

- $22 in procurement costs.
- $20 in labor costs.
- 34 pounds of air filter waste and $1 in disposal costs.

Overall, the use of synthetic filters saves $43 compared to pleated filters.

In addition to synthetic filters, the analysis considered cardboard/fiberglass and metal filters as alternatives to pleated filters. Using cardboard/fiberglass filters would cost $598 more than pleated filters. Using metal filters would cost $361 more than pleated filters annually. However, use of metal filters could also result in high waste prevention impacts.

Reusable metal filters are difficult to compare to the other, single-use options. Sensitivity analysis as well as research elsewhere suggests that, despite their high costs in the "base case," metal filters may a reasonable option.[2] However, careful analysis of labor costs would be required in order to justify the use of metal filters.

The specific filter options available may differ depending on the system in use and the setting.[3] The lifespan analysis framework developed in this case study can be used to analyze air filter options for any building with air handlers in a central HVAC system.

Analysis

Two HVAC units at the New York City Department of Parks and Recreation's 5-Borough Technical Services building are the focus of this case study. Both are Governair units, model numbers TL 50-3526 and TL 50-4026. Three air filter options for the system were compared to the pleated filters (made of a cotton/paper material) currently in place: synthetic, a filter made of a plastic/polyester material; cardboard/fiberglass, a fiberglass filter in a cardboard frame; and metal, generally with a steel frame and aluminum mesh. The first three options are one-time use filters. The metal filters can be cleaned and reused.

The NYC Department of Parks and Recreation provided information on the characteristics of the systems in place and labor maintenance requirements at the 5-Borough Technical Services building. This information was supplemented by cost, lifetime, and other information provided by the supplier of the current air filters and by a case study on air filter waste prevention conducted in Minnesota.[4]

Initial Assumptions and Calculations

The case study began with a review of the relevant literature and by gathering background information on air filters. This review showed that purchase price, maintenance costs, frequency of air filter changes, and costs of disposal were relevant to the analysis.

Table 1 shows the key assumptions for this case study, as well as certain initial calculations that are based upon these assumptions. The information provided in Table 1 represents the current best assessment of cost and waste generation characteristics associated with the choice of air filter.[5] This information is used to perform the life-span cost analysis. The details of the life-span analysis are presented in Tables 2 and 3. Assumptions and preliminary calculations required for the life-span analysis are provided in Table 1 and endnotes.

There are two points concerning the performance and use of metal filters that should be noted:

- A case study in Minnesota indicates that metal filters could last longer than ten years, the lifetime used in Table 1.
- The same case study also notes that use of metal filters avoids the time to purchase, stock, and dispose of single-use filters.[6]

The impact of these factors is explored in the final section of this case study, "Sensitivity."

Table 1 – Key Assumptions and Initial Calculations[7]

Assumption/Calculation	Pleated	Synthetic	Cardboard/ Fiberglass	Metal
BACKGROUND				
Number of air handlers[8]	2	2	2	2
Number of air filters per air handler[9]	8	8	8	8
Percentage of spare or unusable air filters[10]	2%	0%	2%	100%
Number of air filters required at any given time[11]	16.32	16	16.32	32

Table 1 (continued) – Key Assumptions and Initial Calculations[7]

Assumption/Calculation	Pleated	Synthetic	Cardboard/ Fiberglass	Metal
PROCUREMENT AND INSTALLATION				
Purchase cost of one air filter[12]	$3.50	$4.25	$2.00	$20.00
Lifetime of an air filter (in years)[13]	0.25	0.33	0.06	10
Frequency of filter cleaning/ changing (per year)[14]	4	3	18	5
Number of filter cleanings/changes per year[15]	64	48	288	80
Cost of one can of filter spray[16]	N/A	N/A	N/A	$8.25
Filters that can be coated with one can of spray[17]	N/A	N/A	N/A	92
Number of cans of filter spray needed per year[18]	N/A	N/A	N/A	0.87
Labor cost per hour[19]	$15.00	$15.00	$15.00	$15.00
Time to clean or change one filter (in hours)[20]	0.08	0.08	0.08	0.5
Labor cost of cleaning/changing one air filter[21]	$1.25	$1.25	$1.25	$7.50
WASTE GENERATION AND MANAGEMENT				
Weight of one air filter (in pounds)[22]	1.08	0.75	0.75	3.5
Cost to dispose one ton of air filters[23]	$41.50	$41.50	$41.50	$41.50
Pounds of Air Filters Generated per Year[24]	70.72	36.36	204.00	11.20
Cost to dispose air filters	$1.47	$0.75	$4.23	$0.23
SUMMARY FINDINGS				
Total Average Annual Costs[25]	$309.95	$266.82	$908.23	$671.41

Life-Span Costing

The sum of average annual costs will provide a measure of the difference in life-span costs due to the choice of filter. An example will help to explain the process of annualizing costs.

- Table 1 shows that one pleated filter costs $3.50. Since 64 filters are needed per year, the average annual cost of purchasing pleated filters is $224.00 (64 filters x $3.50/filter = $244).

In general, one year's worth of each cost relevant to the case study must be identified.

Table 2 shows the average annual costs for filter options. These costs are obtained by annualizing the costs in Table 1. All the calculations necessary for annualization are explained in the endnotes. Table 3 shows average annual waste generation associated with each filter option. As in Table 2, the waste-generation information from Table 1 is annualized to provide the results shown in Table 3.

Table 2 – Cost Comparison of Air Filter Options

Cost Category	Pleated	Synthetic	Cardboard/ Fiberglass	Metal
Average Annual Cost of Purchasing Filters[26]	$228.48	$206.06	$544.00	$64.00
Average Annual Cost of Purchasing Filter Spray[27]	N/A	N/A	N/A	$7.18
Average Annual Cost of Labor[28]	$80.00	$60.00	$360.00	$600.00
Average Annual Cost of Air Filter Disposal[29]	$1.47	$0.75	$4.23	$0.23
Total of Average Annual Costs	$309.95	$266.82	$908.23	$671.41

Table 3 - Waste Generation Comparison of Air Filter Options

Waste Generation Category	Pleated	Synthetic	Cardboard/ Fiberglass	Metal
Pounds of Air Filters Generated per Year[30]	70.72	36.36	204.00	11.20

Results

Basic Results

The basic results of the analysis show that pleated filters, the current option, are far more cost-effective than cardboard/fiberglass filters or metal filters. Metal filters are shown to have the greatest effect on waste prevention. In addition, this analysis indicates that use of the synthetic filters would result in lower overall costs and waste generation than does the use of the current option, pleated filters.

As shown in Table 2, the cost assumptions show that switching from pleated filters to synthetic filters would save the Technical Services building annually:

- $22 in procurement costs.
- $20 in labor costs.
- 34 pounds of air filter waste and $1 in disposal costs.

Overall, the use of synthetic filters saves $43 compared to pleated filters. The basic results of the analysis show that using cardboard/fiberglass filters would cost $598 more than pleated filters and that using metal filters would cost $361 more than pleated filters annually. However, use of metal filters could also result in high waste prevention impacts.

Sensitivity

The cost-effectiveness of synthetic air filters for the Technical Services building is sensitive to some of the assumptions made in the analysis. These include:

- the estimated lifespan of the filter and
- labor costs for changing and maintenance.

If the lifetime of a synthetic filter were one quarter of a year instead of one third, pleated filters would be the most cost-effective option. The cost of the synthetic filters could also have a significant impact on the results; if synthetic filters cost about $5.15, the annual costs of using synthetic or pleated filters are about the same.[31] Assuming that 2 percent of pleated air filters are unusable, or that no cardboard/fiberglass air filters are unusable, does not change the results of the analysis.

Changing the lifetime of the metal filter has no effect on the results of the analysis; even if its lifetime were 100 years, it would still be the most expensive option. Similarly, assuming that only one set of metal filters is purchased does not change the results of the analysis; it lowers the average annual costs of using metal filters by about $32.

Labor costs are the primary reason for the expense of the metal filters. However, the base case does not account for the time required to purchase, stock, and dispose of the single-use filters. It is also possible that less maintenance time for metal filters may be necessary. Substantial changes in labor time for both metal and synthetic filters would be required in order for metal to become cost-effective. If the maintenance time for all four types of filters were estimated at 15 minutes, metal filters become the least-cost option. This possibility is discussed because a site in Minnesota reported that the total amount of time associated with single-use and reusable filter maintenance was about the same.[32]

The basic result shows that use of synthetic filters would save money when compared to pleated filters. Metal filter costs are high in the “base case” due primarily to the high labor maintenance costs estimated for metal filters. Clearly, filter maintenance costs are site-specific. Because metal has the potential for significant waste prevention, careful evaluation of the maintenance time and costs associated with each of the filter options is important for any site that considers changing to a different air filter option.

Endnotes – *Air Filter Options*

[2] The research elsewhere, presented in *Source Reduction NOW*, is discussed later in the case study.

[3] For example, the degree of air filtration required depends on the building’s use; hospitals and museums may require filters that are much more efficient than office buildings and repair shop filtration requirements may differ from those of offices. In addition, building codes, such as fire code regulations, may restrict the material types that may be used in air filters. In addition, the filter options that are available for a system may differ depending on the equipment in place.

[4] Scott Cunningham of NYC Parks and Recreation was the contact at the 5-Borough Technical Services building; he provided information during telephone conversations in February and March 1997. Larry Conley of Air Engineering, the supplier to the Technical Services building, contributed data on the current pleated filters and their three alternatives. The Minnesota Office of Waste Management’s *Source Reduction NOW* provided additional information on switching from disposal filters to reusable metal filters.

[5] The sources for this information are explained in the notes to Table 1, this section.

[6] Minnesota Office of Waste Management’s *Source Reduction NOW.*

[7] Information sources and calculations are provided in notes to this section.

[8] Conversation with Scott Cunningham, NYC Parks and Recreation. Cunningham currently buys the pleated filters used at 5-Borough Technical Services through a requirements contract with Air Engineering.

[9] Conversation with Scott Cunningham.

[10] Conversation with Larry Conley. Pleated and cardboard/fiberglass filters have a chance of being damaged in transit or of becoming moldy before use; this results in 2% of filters being unusable. Synthetic filters damaged during transit can still be used, while the other types cannot. For metal filters, Larry Conley said that the system would need two sets of metal filters; one set would be cleaned and then stored while the other set is in use.

[11] Number of air handlers multiplied by number of air filters per air handler multiplied by 1 plus the percentage of spare or unusable filters.

[12] Conversation with Larry Conley.

[13] Single-use filters: conversation with Larry Conley. Metal filter: *Source Reduction NOW*, pp. 75-76.

[14] Conversation with Larry Conley.

[15] Number of air filters multiplied by number of air filters per air handler multiplied by number of filter cleanings/changes per year.

[16] Conversation with Larry Conley. The spray makes the filters sticky, increasing their efficiency. Metal filters are the only option that use this spray. This is the price for a gallon; other sizes are available.

[17] 0.5 ounces of spray coats a square foot of filter. The filters are 20” x 20”. This is 2.778 square feet. 0.5 oz. of spray per square feet multiplied by 2.778 square feet equals 1.389 oz. per filter. Since there are 128 ounces in a gallon, 92 filters can be coated with one gallon of spray. Conversation with Larry Conley.

[18] Number of filter cleanings/changes per year divided by the number of filters that can be coated with one can of filter spray.

[19] Conversation with Patty Tobin, Bureau of Waste Prevention Reuse and Recycling, NYC DOS, 2/25/97.

[20] Metal: Conversations with Larry Conley and Scott Cunningham. Others: One-time use filters take approximately 5 minutes, or 0.08 of an hour to change. Conversation with Scott Cunningham.

[21] Labor cost per hour multiplied by time to clean or change one filter (in hours).

[22] Larry Conley provided these approximate weights.

[23] *New York City Solid Waste Management Plan: Final Update and Plan Modification,* February 15, 1996, pp. 3-26. This is the average cost of disposal in fiscal year 1994 and does not include collection costs. (See DOS Overview.)

[24] Number of air filters required divided by lifetime of an air filter (in years) multiplied by weight of an air filter (in pounds).

[25] See Table 2, this section, and accompanying discussion for details.

[26] Number of air filters required multiplied by purchase cost of one air filter divided by lifetime of an air filter (in years).

[27] Cost of one can of filter spray multiplied by number of cans of filter spray needed per year.

[28] Number of filter cleanings/changes per year multiplied by labor cost of cleaning/changing one air filter.

[29] Number of air filters required divided by lifetime of an air filter (in years) multiplied by weight of one air filter (in pounds) divided by 2000 (pounds per ton) multiplied by cost to dispose one ton of air filters.

[30] Number of air filters required divided by lifetime of an air filter (in years) multiplied by weight of an air filter (in pounds).

[31] This factor is important to consider since the only the price for the current filter option, pleated, is the price that is part of the requirements contract. The other prices were estimated by Air Engineering. Actual bid prices for these filter types may vary from the costs presented in the case study.

[32] The Itasca County Road and Bridges Department garage shop foreman reported this, as noted in *Source Reduction NOW.*

4. ALKALINE BATTERIES – CASE STUDY

Introduction

The SAIC/Tellus team, in consultation with BWPRR and the Department of Citywide Administrative Services, selected batteries as one of the case studies because alternatives to the current disposable batteries used, with differing cost and waste generation characteristics, are available.

This case study examines the cost and waste stream impacts of buying and using different types of batteries for 200 pagers in the DOS Bureau of Motor Equipment.[33] Each pager requires one battery. The units currently use disposable alkaline AA batteries, which could be replaced by rechargeable alkaline batteries.[34] Rechargeable alkaline batteries have similar characteristics to single-use alkaline batteries, except that their charge does not last as long. However, rechargeable alkaline batteries can be reused at least twenty five times.[35] The basic results of the study are that, compared to the disposable batteries currently in use, rechargeable alkaline batteries for all 200 pagers would save the Bureau of Motor Equipment annually:

- $55.54 in procurement costs.
- 78 pounds of battery waste and $1.62 in disposal costs.

These procurement and disposal savings are largely offset due to capital and electricity costs. Overall, the use of rechargeable alkaline batteries saves $6 compared to disposable batteries. The way these savings were calculated (*i.e.,* through the application of life-span costing) is fully explained in Analysis and Life-Span Costing Sections of this case study.

The specific alternatives to disposable batteries available for different applications may differ depending on the system in use and the setting.[36] The life-span analysis framework developed in this case study can be used to analyze battery options for any battery application.

Analysis

Pagers used by the DOS Bureau of Motor Equipment are the focus of this case study. The pagers are Bravo Plus models manufactured by Motorola.[37] A single AA disposable alkaline battery is currently used in each. A rechargeable alkaline AA battery could replace this. This case study focuses on a comparison between these two options.

The DOS Bureau of Motor Equipment provided information on the quantity and cost of AA batteries it uses annually, as well as the number of pagers and estimated battery life.[38] This information was supplemented by cost, lifetime, and other information provided by Motorola and Rayovac.[39]

Initial Assumptions and Calculations

SAIC/Tellus began the case study by gathering background information on batteries. This review showed that purchase price, length of time between battery changes, the number of recharges possible per battery, electricity costs, charger capital costs, and costs of disposal were relevant to the analysis.

Table 1 shows the key assumptions for this case study, as well as certain initial calculations that are based upon these assumptions. The information provided in Table 1 represents the current best assessment of cost and waste generation characteristics associated with the choice of batteries. This information is used to perform the life-span cost analysis. The details of the life-span analysis are presented in Tables 2 and 3. Assumptions and preliminary calculations required for the life-span analysis are provided in Table 1 and endnotes.

The discount assumed for the rechargeable alkaline batteries in this study may be understated. Were rechargeable batteries to be used throughout the City, and so purchased in large quantities by the Department of Citywide Administrative Services as disposable alkalines are currently, the discount achieved might increase somewhat. The impact of this factor is explored in the final section of this case study, "Sensitivity."

Table 1 – Key Assumptions and Initial Calculations[40]

Assumption/Calculation	Single-Use Alkaline	Rechargeable Alkaline	Calculations
BACKGROUND			
Number of Pagers[41]	200	200	
Batteries Per Pager[42]	1	1	
Weeks Between Battery Changes[43]	6.00	1.00	
Number of Charges Per Battery[44]	1	30	
Batteries Used Per Year	1,733	347	Weeks per year (52) / (Weeks btw changes x Changes per battery) x Total number of pagers[45]
PROCUREMENT AND INSTALLATION			
Cost of Single Battery[46]	$0.20	$0.86	
Cost of Charger[47]	N/A	$17.65	
Number of Batteries Per Charger[48]	N/A	8	
Number of Chargers Required	N/A	25	(Total number of pagers x Batteries per pager / Number of batteries[49]
Lifetime of Charger (years)[50]	N/A	10	
Hours to Charge a Battery[51]	N/A	5	
Wattage of Charger[52]	N/A	28	
kWh Required to Charge a Battery	N/A	0.02	(Wattage of charger / Number of batteries per charger / 1000 watts per kilowatt) x Hours to charge a battery
Cost Per kWh[53]	N/A	$0.04	
Cost to Charge a Battery	N/A	$0.001	Kilowatt hours to charge a battery x Cost per kWh

Table 1 – (continued) Key Assumptions and Initial Calculations[40]

Assumption/Calculation	Single-Use Alkaline	Rechargeable Alkaline	Calculations
WASTE GENERATION AND MANAGEMENT			
Weight of a Battery (ounces)[54]	0.9	0.9	
Cost Per Ton of Batteries Disposed[55]	$41.50	$41.50	
Cost to Dispose Used Batteries	$2.02	$0.40	(Weight of battery in ounces 16 / 2000) x Number of batteries per year x Disposal cost
SUMMARY FINDINGS			
Total of Average Annual Costs	$355.91	$350.16	See Table 2 and accompanying discussion for details.

Spreadsheet-based Calculations

Tables 1, 2, and 3 of this case study are reproduced as Tables A, B, and C, respectively, of a single Microsoft Excel spreadsheet which accompanies this case study. The spreadsheet contains an extra column for use in users' future analyses. This column is set up to accommodate a three-way comparison when Ni-Cd batteries and rechargeable alkalines are both feasible alternatives to disposable alkalines. The formulas used in this column are identical to those in the Rechargeable Alkaline column, as the same factors need to be considered.

Life-Span Costing

The data in Table 1 will be used to develop average annual costs for battery procurement and disposal. The sum of average annual costs will provide a measure of the difference in life-span costs due to the choice of batteries.

An example will help to explain the process of annualizing costs.

- Table 1 shows that a battery recharger costs $17.65. It also shows that 25 will be required to recharge all of the batteries, and that each recharger lasts 10 years. Therefore, the average annual cost of the rechargers is $44.13 ($17.65 x 25 / 10).

In general, one year's worth of each cost relevant to the case study must be identified.

Analysis

Table 2 shows the average annual costs for batteries options. These costs are obtained by annualizing the costs in Table 1. All the calculations necessary for annualization are explained in the endnotes. Table 3 shows average annual waste generation associated with each battery option. As in Table 2, the waste-generation information from Table 1 is annualized to provide the results shown in Table 3.

Table 2 – Cost Comparison of Battery Options

Cost Category	Single-Use Alkaline	Rechargeable Alkaline
Average Annual Cost of Batteries[56]	$353.89	$298.35
Average Annual Cost of Charger[57]	N/A	$44.13
Average Annual Cost of Recharges[58]	N/A	$7.28
Average Annual Cost of Disposal[59]	$2.02	$0.40
Total of Average Annual Costs[60]	$355.91	$350.16
Savings of Rechargeable Option Compared to Single-Use Option[61]	$5.75	N/A

Table 3 – Waste Generation Comparison of Battery Options

Waste Generation	Single-Use Alkaline	Rechargeable Alkaline
Pounds of Batteries Generated Per Year[62]	97.50	19.50

Results

Basic results

The basic results of the analysis show that reusable alkaline batteries are slightly more cost-effective than disposable alkaline batteries. In addition, they help to reduce the City's waste management.

In Table 2, the cost assumptions show that switching from disposable alkaline to rechargeable alkaline batteries would save the Bureau of Motor Equipment annually:

- $55.54 in procurement costs.
- 78 pounds of battery waste and $1.62 in disposal costs.

However, the use of rechargeable alkaline batteries also carries with it some costs that disposable batteries do not incur. Between the average annual cost of the recharger and the electricity used to recharge the batteries, the savings from rechargeable batteries is reduced by $51.41; thus, the use of rechargeable alkaline batteries for pagers saves $5.75 annually compared to disposable alkaline batteries, or roughly 2 percent.

Sensitivity

The cost-effectiveness of rechargeable alkaline batteries for the Bureau of Motor Equipment is sensitive to some of the assumptions made in the analysis–particularly the cost estimated to procure the rechargeable batteries.

In Table 1, a discount of 25% off the distributor price was used to estimate the rechargeable battery price. However, disposable batteries are purchased at roughly 74% off the estimated distributor price. This second discount is so high because DCAS purchases disposable batteries in huge quantities: in DCAS's last contract (when it was known as DGS), it contracted to purchase approximately 282,000 AA batteries annually.[63] Were the City to purchase rechargeable alkalines in greater quantities, it (and thus the Bureau of Motor Equipment) could achieve more favorable pricing. For example, if the City were able to purchase rechargeable alkalines at a 50% discount directly from Rayovac (still quite a bit less than the discount it currently receives for disposable batteries), the individual battery price for rechargeables would drop to about $0.57 per battery.[64] At this discount the overall savings due to rechargeable battery use would increase to about $105 annually.

Endnotes – *Alkaline Batteries*

[33] Pagers were chosen as the subject of the case study based on information provided by Ann Masters in a memo to Robert Lange, Director, BWPRR, dated 11/13/97. Information on the quantities and purchase prices of various types of batteries were presented, stating that the primary use of AA batteries is for pagers, while the other types are used in various kinds of flashlights. Therefore, because the battery information for pagers could be quantified fairly accurately, and because pager use is fairly standard (*i.e.,* they are used every day continuously), while flashlight use is highly variable depending on local factors, pagers were chosen as the focus for the study.

[34] Nickel-cadmium batteries (Ni-Cds) were not considered as an option for use in pagers because Motorola (the pager manufacturer) does not recommend their use due to their inability to deliver the same initial voltage as alkaline batteries. Telephone conversation with Motorola Paging Products Group Customer Service Call Center (800-548-9954), 11/25/97.

[35] Rayovac homepage, http://www.rayovac.com/prod/renewal/renewal2.html, as viewed 11/24/97.

[36] Rechargeable alkaline and Ni-Cd batteries have different characteristics, which will affect the applications for which they are most suited. For example: 1) Ni-Cds must be charged before they can be used the first time, whereas rechargeable alkalines can be put into devices straight from the package; 2) The best usage pattern for Ni-Cds is to drain them completely before recharging them, whereas rechargeable alkalines work best when recharged as frequently as possible; 3) Ni-Cds lose approximately 1% of their charge each day even when they are not in use, while rechargeable alkalines can hold their charge for up to five years while not in use; 4) Rechargeable alkalines can be recharged 25 to 100 times, depending on the devices they are used in and the pattern of recharging, while Ni-Cds can be recharged 500 - 1000 times; 5) During their first 25 charges, rechargeable alkalines last longer than Ni-Cds; and 6) Rechargeable alkalines are best used in low to moderate energy demand devices, while Ni-Cds can be used in high energy demand devices.

[37] The model of the pagers was determined based on a model number provided by Patty Tobin, BPWRR, in an 11/24/97 fax, and confirmed in a 12/22/97 telephone conversation with Lou DiMartino, Deputy Director, Bureau of Motor Equipment, Department of Sanitation.

[38] Memo from Ann Masters to Robert Lange, Director, BWPRR, dated 11/13/97, stating that AA batteries are used primarily for pagers. In addition, Lou DiMartino, Deputy Director, Bureau of Motor Equipment, Department of Sanitation, provided estimates on the number of pagers used in the Bureau, and on the number of weeks between battery changes.

[39] Pager information was provided by the Motorola Paging Products Group Customer Service Call Center (800-548-9954) and Motorola's home page (http://www.mot.com/MIMS/MSPG/Products/Numeric/Bravo_Plus, as viewed 11/24/97). Information on Renewal batteries was provided by Rayovac's Consumer and Technical Services Department (800-237-7000) and Rayovac's home page. (http://www.rayovac.com/prod/renewal, as viewed 11/24/97).

[40] Information sources and calculations are provided in notes to this section.

[41] Estimate provided by Lou DiMartino, Deputy Director, Bureau of Motor Equipment, Department of Sanitation, in a 12/22/97 telephone conversation.

[42] Estimate provided by Lou DiMartino, Deputy Director, Bureau of Motor Equipment, Department of Sanitation, in a 12/22/97 telephone conversation.

[43] An estimate of six weeks was used for disposable battery life, based on a 12/22/97 conversation with Lou DiMartino. He said the battery lasted about that time in his pager, and that he kept his on 24 hours per day. The estimate used for the rechargeable alkaline batteries is based on a 11/25/97 conversation with Rayovac's Consumer and Technical Services Department (800-237-7000). While the charge can last much longer than one week, it is suggested that batteries be recharged weekly to ensure the appropriate energy level. Doing this also increases the number of times the battery can be recharged.

[44] Disposable batteries must be disposed after their initial charge is used up. Rechargeable alkaline batteries can be recharged at least 25 times (http://www.rayovac.com/prod/renewal/renewal2.html, as viewed 11/24/97). Recharging them weekly as opposed to longer intervals will increase the number of times that they can be recharged. Rayovac reports that in some battery applications, customers have gotten as many as 100 charges through frequent recharging. So a slight increase to 30 charges per battery was assumed.

[45] For example, the formula for the rechargeable alkaline option would be : (52/(1 x 30)) x (1 x 200).

[46] The cost of the disposable AA batteries is based on a 11/13/97 memo from Ann Masters to Robert Lange, Director, BWPRR, which states that AA batteries are $2.45/dozen, or about 20¢ per battery. The cost for rechargeable alkaline batteries is based on a 12/1/97 conversation with Bernadette Cremmins of Rayovac Sales (800-362-7779 ext. 3267). For batteries bought directly from Rayovac by the City, the base distributor–as opposed to end-consumer–price is $4.59/four-pack; she said that purchasing 300 or so batteries at a time would probably allow the Bureau a 10% discount from that price. Bernadette would not give a discount percentage figure for procurements larger than that (because they would need to be addressed on a case-by-case basis); but were the DCAS to buy in much greater quantities, it is assumed it could obtain at least a 25% discount, and thus pay about 86¢ for each battery ($4.59 x .75/4 = $0.86). This is reasonable, given the following information: 1) The consumer price of AA rechargeable alkaline batteries is $6 per four-pack, which means that the distributor price of $4.59 per four-pack represents a 23.5% discount; 2) Applying this discount to the consumer price of a four pack of disposable batteries (which cost about $4 per four pack, or $1 per battery), the distributor price for a disposable battery is about 76¢ per battery; and 3) Thus, the DCAS receives a discount of approximately 74% off the estimated distributor price when it pays only 20¢ per battery (1-[.20/.76]).

[47] Based on a 12/1/97 conversation with Bernadette Cremmins of Rayovac sales (800-362-7779 ext. 3267). Chargers bought directly by the City from Rayovac would have a base distributor price of $17.65. She did not think there would be much of a discount beyond that because chargers would not be purchased very often, or in great quantity. Therefore, no discount was assumed.

[48] Rayovac Renewal Power Station PS2 specification sheet, as faxed from Rayovac Customer Service, 11/26/97.

[49] The result of this calculation was then rounded to the next highest integer. To be conservative, it was assumed each battery would require a slot in a charger. If the chargers were used to recharge more than one set of batteries per week, the number of chargers could be reduced.

[50] Rayovac Consumer and Technical Support (800-237-7000), 11/24/97.

[51] Rayovac Renewal Power Station PS2 specification sheet, as faxed from Rayovac Customer Service, 11/26/97. The sheet states 3-5 hours for AA and AAA batteries. Five hours was used to be conservative.

[52] *Ibid.*

[53] The cost per kWh is an average for City agencies.

[54] As weighed on a postal scale.

[55] Alkaline batteries can be disposed safely with regular trash (http://www.rayovac.com/prod/renewal/renewal5.html, as viewed 11/24/97). Therefore, the City's tip fee of $41.50/ton is used. (See DOS Overview.)

[56] Batteries used per year multiplied by the cost of a single battery.

[57] Cost of a charger multiplied by the number of chargers required, divided by the lifetime of a charger.

[58] Cost to charge a battery multiplied by the number of batteries used per year multiplied by the number of charges per battery.

[59] Weight of a battery (in ounces) multiplied by the number of batteries used in a year, divided by 16 ounces in a pound, divided by 2000 pounds in a ton, multiplied by the cost per ton for disposal.

[60] The sum of the four average annual cost lines in Table 2, this section.

[61] The total of average annual costs for the rechargeable option is subtracted from the total of average annual costs of the single-use option to determine the savings.

[62] Weight of a battery (in ounces) multiplied by the number of batteries used in a year, divided by 16 ounces in a pound.

[63] Based on information received from Virginia Ross, Deputy Commissioner, DGS (now DCAS), July 1996, DGS had a contract from May 1995-April 1997 (RC/OMPA No. 9587498) to purchase 47,000 dozen alkaline AA batteries. This calculates to 282,000 individual AA batteries annually.

[64] Based on data presented in Table 1, the base distributor cost to the City of a 4-pack of rechargeable alkalines would be $4.59; with a 50% discount instead of 25%, the price per battery would be ($4.59 x .50) / 4 = $0.57.

5. ANTIFREEZE – CASE STUDY

Introduction

The SAIC/Tellus team, in consultation with BWPRR and the Department of Citywide Administrative Services, selected antifreeze as one of the case studies because a variety of antifreeze options, with differing cost and waste generation characteristics, are available. In addition, the City maintains an extensive fleet of vehicles, spread among the different City Agencies, to which an analysis of antifreeze options would be applicable.

This case study examines the cost and waste stream impacts of buying and using antifreeze for a generic fleet of 600 City vehicles. The basic options available are 1) to use "regular-life" antifreeze and dispose of it in an environmentally responsible manner.[65] 2) to use "long-life" antifreeze and dispose of it in an environmentally responsible manner;[66] 3) to use regular-life antifreeze and recycle it "in-house"; and 4) to use regular-life antifreeze and have a private contractor recycle it for the City. An actual fleet was not chosen because there are several technical and warranty issues that constrain the utilization of regular-versus long-life antifreeze. The issues to be considered when considering selection of antifreeze options include the following:

1) Many new passenger vehicles, vans, and light trucks produced from 1995 on come with long-life antifreeze in them, and require that long-life antifreeze be used to maintain the warranty;

2) Due to this change in standard, and the fact that long-life antifreeze cannot currently be recycled back into long-life antifreeze, it may not be economically prudent for fleet managers to consider buying a recycling machine for regular-life antifreeze that may not be able to be utilized during its full useful life; and

3) Many passenger vehicles, vans, and light trucks produced after 1994 do not have copper/brass radiators, and thus can be "back-serviced" to switch to long-life antifreeze from regular-life antifreeze; the long-life antifreeze will not attain its 5 year/100,000 mile ratings, and should be changed on the regular-life schedule. (Fleet managers may be interested in doing this anyway in cases where they have a mixed antifreeze fleet of vehicles, but do not want to purchase two types of antifreeze and keep track of which vehicles require which type).

These issues aside, this case study still serves as an example of how life-span costing can be used to inform procurement choices and remains relevant to selection of antifreeze procurement and management options.

The basic results of the study are the following:

- Wherever it is technically feasible, use of long-life antifreeze to obtain 5 year/100,000 service intervals will result in annual cost savings of over 50% compared to any of the other options, regardless of fleet size. This is due to the labor savings that result in having to change the coolant half as often, and cost savings from purchasing roughly half as much antifreeze (even though on a per gallon basis it is more expensive).

- Where use of long-life antifreeze is not possible, use of an off-site recycling service to handle regular-life antifreeze can result in a slight cost savings over responsible disposal of regular-life antifreeze.
- In addition to modest cost savings, off-site recycling will result in zero antifreeze waste disposal by the fleet, compared to an annual average of 1.75 gallons per vehicle if regular-life were used and disposed.
- Use of an in-house recycling machine only becomes economically preferable to having antifreeze recycled off-site when fleet size is quite large, on the order of 960 vehicles or more at a single site.

Analysis

In order to prepare a case study analysis on a generic, changeable fleet, a spreadsheet model was created. As much local information as possible was obtained from City sources; in addition, information from General Motors (GM), a GM-approved antifreeze recycling service provider that services New York City, and a GM-approved antifreeze recycling machine manufacturer were obtained.[67]

Initial Assumptions and Calculations

SAIC/Tellus began the case study by gathering background information on antifreeze. This review showed that purchase price, product life, labor time to change coolant, recycling operating and capital costs, and costs of disposal were relevant to the analysis.

Table 1 shows the key assumptions for this case study, as well as certain initial calculations that are based upon these assumptions. The first section of the table quantifies the number of vehicles in the fleet, and the amount of antifreeze/water solution needed initially to fill all of the vehicles for a single coolant cycle. A coolant cycle, for purposes of this study, starts with each vehicle full of coolant, goes for the number of years specified, and ends once each vehicle has been drained, flushed, and refilled with coolant again.

The information provided in Table 1 represents the current best assessment of cost and waste generation characteristics associated with the choice of antifreeze. This information is used to perform the life-span cost analysis. The details of the life-span analysis are presented in Tables 2 and 3. Assumptions and preliminary calculations required for the life-span analysis are provided in Table 1 and endnotes.

In developing the assumptions in Table 1 and, more generally, conducting the life-span analysis, two key factors were considered:

- The size of the fleet has an effect on which of the antifreeze options besides long-life is the next most cost-effective.
- The price for regular-life antifreeze may be overstated. One source indicated that is as much as $2 /gallon less expensive than long-life antifreeze.[68]

The impact of these factors is explored in the final section of this case study, “Sensitivity.”

Table 1 – Key Assumptions and Initial Calculations[69]

Assumption/Calculation	Regular-Life, Disposal	Long-Life, Disposal	Regular-Life, Recycled In-House	Regular-Life, Recycled by Private Co.
BACKGROUND				
Number of Years Between Radiator Coolant Changes[70]	2.00	5.00	2.00	2.00
Number of Vehicles in Fleet[71]	600	600	600	600
Average Size of Radiator (Gallons)[72]	3.5	3.5	3.5	3.5
Gallons of Antifreeze/Water Solution Initially Put into Vehicles[73]	2,100	2,100	2,100	2,100
Ratio of Antifreeze to Water Used (Percentage of Antifreeze)[74]	50%	50%	50%	50%
Gallons of Pure Antifreeze Initially Put into Vehicles[75]	1,050	1,050	N/A	N/A
Labor Cost Per Hour[76]	$23.00	$23.00	$23.00	$23.00
PROCUREMENT AND INSTALLATION				
Cost Per Gallon of Fresh, Pure Antifreeze[77]	$2.90	$4.15	$2.90	$2.90
Cost Per Gallon of Recycled Antifreeze/ Water Solution (50/50 mix)[78]	N/A	N/A	$2.63	$2.25
Cost of Antifreeze Initially Put into Vehicles[79]	$3,045	$4,358	$5,530	$4,725
Amount of Antifreeze/Water Solution Lost Between Coolant Changes, Due to Leakage[80]	5%	13%	5%	5%
Gallons of Antifreeze/Water Solution Lost Between Coolant Change[81]	105.00	262.50	105.00	105.00
Gallons of Pure Antifreeze Lost Between Coolant Changes[82]	52.50	131.25	52.50	52.50
Cost of Lost Antifreeze[83]	$152	$545	$152	$152
Active Labor Time/Vehicle Needed to Change Coolant and Flush Radiator (per change, in hours)[84]	1	1	1	1
Cost of Labor to Change Coolant for All Vehicles[85]	$13,800	$13,800	$13,800	$13,800
WASTE GENERATION AND MANAGEMENT				
Gallons of Antifreeze/Water Solution that Need to be Disposed[86]	2,100	2,100	32	32
Cost/Gallon to Dispose of Waste Antifreeze/ Water Solution[87]	$1.00	$1.00	$1.00	N/A
Cost to Dispose of Waste Antifreeze/Water Solution[88]	$2,100	$2,100	$32	$0
Tons of Used Filters from Recycling Antifreeze Water Solution[89]	N/A	N/A	0.01	N/A

Table 1 – (continued) Key Assumptions and Initial Calculations[69]

Assumption/Calculation	Regular-Life, Disposal	Long-Life, Disposal	Regular-Life, Recycled In-House	Regular-Life, Recycled by Private Co.
Cost Per Ton to Dispose of Used Filters[90]	N/A	N/A	$41.50	N/A
Cost to Dispose of Used Filters[91]	N/A	N/A	$0.44	N/A
SUMMARY FINDINGS				
Total of Average Annual Costs[92]	$9,549	$4,160	$9,757	$9,339

Life-Span Costing

The data presented above in Table 1 will be used to develop average annual costs for antifreeze procurement and disposal/recycling. The sum of average annual costs will provide a measure of the difference in life-span costs due to the choice of antifreeze options.

An example will help to explain the process of annualizing costs.

- Table 1 shows that the cost to initially fill all of the radiators in the fleet in the "Long-Life, Disposal" scenario is $4,358 (really $4,357.50). However, once initially filled, the vehicles will not be filled again in this manner for 5 years. Thus, the annualized cost of the antifreeze initially put in the vehicles is $4,357.50/ 5 = $871.50.

In general, one year's worth of each cost relevant to the case study must be identified.

Table 2 shows the average annual costs for antifreeze options. These costs are obtained by annualizing the costs in Table 1. All the calculations necessary for annualization are explained in the endnotes. Table 3 shows average annual waste generation associated with each antifreeze option. As in Table 2, the waste generation information from Table 1 is annualized to provide the results shown in Table 3.

Table 2 – Cost Comparison of Antifreeze Options

Cost Category	Regular-Life, Disposal	Long-Life, Disposal	Regular-Life, Recycled In-House	Regular-Life, Recycled by Private Co.
Procurement Cost of Virgin Antifreeze per Year[93]	$1,599	$980	$76	$76
Cost of Recycled Antifreeze Per Year[94]	N/A	N/A	$2,765	$2,362
Cost of Antifreeze Disposal per Year[95]	$1,050.00	$420.00	$15.75	$0.00
Cost of Filter Disposal Per Year[96]	N/A	N/A	$0.22	N/A
Subtotal[97]	$2,649	$1,400	$2,857	$2,439
Labor Cost to Change Coolant Per Year[98]	$6,900	$2,760	$6,900	$6,900
Total of Average Annual Costs[99]	$9,549	$4,160	$9,757	$9,339
Savings of Long-Life Option Compared to Other Options[100]	$5,389	N/A	$5,597	$5,178

Table 3 – Waste Generation Comparison of Antifreeze Options

Waste Generation Category	Regular-Life, Disposal	Long-Life, Disposal	Regular-Life, Recycled In-House	Regular-Life, Recycled by Private Co.
Gallons of Antifreeze/Water Solution Disposed per Year[101]	1,050	420	16	16
Tons of Filters Disposed per Year[102]	N/A	N/A	0.005	N/A

Results

Basic Results

The basic results of the analysis show that long-life antifreeze is far more cost-effective than the other options, saving over 50% annually, regardless of fleet size. In terms of waste prevention, the two recycling options are by far the most effective, followed by the long-life option, which has a mid-range waste prevention effect relative to the disposal of regular-life antifreeze.
In Table 2, the cost and other assumptions show that using long-life antifreeze in vehicles where a five year interval between changes can be achieved results in the following annual cost savings per six hundred vehicles compared to regular-life antifreeze use and disposal:

- Procurement Cost of Virgin Antifreeze per Year: $618
- Cost of Antifreeze Disposal per Year: $630
- Labor Cost to Change Coolant Per Year: $4,140
- Gallons of Antifreeze Disposed Per Year: 630

The total savings is $5,338. Compared to the other options, long-life use and disposal will produce cost savings in the same range ($5,178 compared to private recycling, $5,597 compared to in-house recycling), although it will also result in more waste generation.

An initial comparison also shows that recycling regular-life off-site using a private company is the next most cost-effective option–but this result is dependent upon a number of the assumptions used, and can change with variations in them. This issue will be discussed below.

Sensitivity

While use of long-life antifreeze is the clear winner of the above comparison, the next best option is dependent on some of the assumptions used in the analysis. These include:

- the size of the fleet being serviced and
- the price used for virgin regular-life antifreeze.

The size of the fleet being serviced affects the relative cost-effectiveness of the in-house recycling option because there is a fairly large fixed cost to be accounted for from the initial capital cost of the machine and the $700 cost of replacing the main filter every year or two. If spread over a small fleet size, the annualized cost is high, and thus this option cannot compete with the other three options. However, once the size of the fleet reaches roughly 735 vehicles (all other assumptions in Table 1 remaining constant), the in-house recycling option becomes more cost-effective than using regular-life antifreeze and disposing of it. When the fleet size reaches roughly 960 vehicles, in-house recycling becomes more cost-effective than even off-site recycling. It never can achieve the economies of long-life antifreeze, however, because the single most important factor in the analysis–the length of time between coolant changes–is tilted heavily in long-life antifreeze's favor, at five years compared to two.

Another important but difficult to specify assumption is the price of regular-life antifreeze. In Table 1 it is estimated to be roughly $1.25/gallon less than long-life antifreeze. However, one source estimates that the price may be as much as $2/gallon less.[103] In order to examine this issue, the break-even point was determined between the "regular-life, disposal" scenario and the "regular-life, recycled by private company" scenario (the scenario ranked just above it in cost-effectiveness), while keeping all other factors constant. It turns out that if the price of virgin regular-life antifreeze is less than $2.50/gallon, using regular-life antifreeze and disposing of it becomes more cost-effective than recycling.

APPENDIX

Kleer Flo AF 250 Recycling Machine Information

Capital Cost Information—		
1)	Purchase Price	$6,554
2)	Expected Life (Years)	10
3)	Gallons Processed Per Batch	25
4)	Gallons Per Hour	5
5)	Gallons Processed Per Year (Based on Table 1)	1,050
6)	Capital Cost Per Gallon Processed:	$0.62
7)	Cost of Main Filter that Needs to be Replaced Every Year or Two	$700
8)	Assumed Number of Years Main Filter Lasts	1.50
9)	Cost of Main Filter Per Gallon Processed	$0.44
Operating Cost Information—		
10)	Cost of Inhibitors Per Gallon Processed	$1.29
11)	Cost of Pre-Filters Per Gallon Processed	$0.12
12)	Residue Rate	1.50%
13)	Gallons of Antifreeze Residue Per Gallon Processed	0.015
14)	Cost of Antifreeze Disposal Per Gallon	$1.00
15)	Cost of Antifreeze Residue Disposal Per Gallon Processed	$0.02
16)	Weight of One Pre-Filter (pounds)	1
17)	Pounds of Pre-Filters Used Per Gallon Processed	0.01
18)	Disposal Rate Per Ton of Pre-Filters	$41.50
19)	Cost of Pre-Filter Disposal Per Gallon Processed	$0.00021
20)	Electricity Used Per Hour (Kilowatts)	0.5595
21)	Cost of Electricity Per Kilowatt Hour	$0.04
22)	Cost of Electricity Per Gallon Processed	$0.0045
23)	Cost of Labor Per Hour	$23
24)	Active Time Per 25 Gallon Batch (minutes)	10
25)	Labor Cost Per Gallon Processed	$0.15
Summary—		
26)	Total Cost of In-House Recycled Antifreeze, Per Gallon Processed (disposal not included)	$2.63
27)	Cost of Antifreeze Residue Disposal Per Gallon Processed	$0.02
28)	Cost of Pre-Filter Disposal Per Gallon Processed	$0.00021
29)	Total Cost of In-House Recycled Antifreeze, Per Gallon	$2.65

Notes to Table by Row:

1. Kleer-Flo Company price list. Includes main unit, plus radiator filler and drain tray accessories.
2. Conversation with Jeff Tuttle, Kleer-Flo Technical Support, 9/17/97.
3. Kleer-Flo AF 250 Antifreeze Recycler Brochure/spec sheet
4. *Ibid.*
5. This figure is derived from Table 1 by dividing the gallons of antifreeze/water solution initially put into vehicles by the number of years between radiator coolant changes.
6. Purchase price divided by the expected life of the machine, and then divided by the gallons processed per year.
7. Conversation with Jeff Tuttle, Kleer-Flo technical support, 9/17/97.
8. Jeff Tuttle of Kleer-Flo said the main filter needed to be replaced every year or two, depending on the condition of the waste antifreeze being recycled. 1.5 years was used as the average.
9. Cost of the main filter divided by the assumed number of years it lasts, and then divided by the gallons of antifreeze processed per year.
10. A case of four 1-gallon bottles of inhibitors costs $129, and one bottle must be added for each 25-gallon batch recycled (as per the Kleer-Flo price list and brochure/spec. sheet). Thus, the cost per gallon processed is $129/4/25 = $1.29.
11. A case of 20 pre-filters costs $234, and each filter is able to recycle about 100 gallons of used antifreeze (as per the Kleer-Flo price list and Technical Bulletin). Thus the cost per gallon processed is $234/20/100 = $.012.
12. Kleer-Flo AF 250 Antifreeze Recycler Technical Bulletin.
13. One gallon processed multiplied by 1.5% is 0.015 gallons.
14. Based on a 6/3/97 conversation with Safety Kleen in NJ. Prices to dispose of spent antifreeze/water solution ranged from $139 for a maximum of 125 gallons (or $1.11/gallon) to a most favorable price of $425 for 500 gallons ($0.85/gallon). The $425/500 gallons price was quoted as a definite estimate, subject to negotiation based on frequency of collection, etc. $1/gallon was used as a mid-range price.
15. Gallons of antifreeze residue per gallon processed multiplied by the cost of antifreeze disposal per gallon.
16. Based on shipping weight of 20 pounds for 20 pre-filters (this is slightly overstated due to the weight of the cardboard the case is shipped in, but is insignificant).
17. Weight of one pre-filter divided by the number of gallons that can be processed using it (100).
18. Jeff Tuttle of Kleer Flo said that these filters would probably be handled in the same way that the City handles its motor oil filters. And since, from the Oil Study, the City is able to put their filters in with regular trash, a tip fee of $41.50/ton is used. See DOS Overview.
19. Pounds of pre-filters disposed per gallon processed divided by 2000 pounds per ton, and then multiplied by the disposal rate per ton of pre-filters.
20. From the Kleer-Flo brochure/spec. sheet, the recycling machine is 3/4 of a horsepower, which translates to power usage of .5595 kilowatts per hour (one horsepower is the equivalent of consuming 746 watts per hour, so 3/4 of a horsepower is 559.5 watts per hour, or .5595 kilowatts per hour.
21. The cost is an average for City agencies.
22. The kilowatts of electricity used per hour multiplied by the cost of electricity per KWH divided by the number of gallons processed per hour.
23. Conversation with Tim Walsh, Five Boroughs Garage, 6/12/97.
24. This is an estimate only. Jeff Tuttle said that there is little to do beyond pouring the used antifreeze in until there is a full batch, turning the machine on, and walking away (because when the antifreeze is finished going through the filter system, the machine turns itself off). To finish off a batch, one need only pour in a gallon of inhibitors into the "clean" antifreeze, and have the machine stir it up to mix it in well. Additionally, every four batches (or 100 gallons processed), the pre-filter needs to be replaced, which takes about five minutes, according to Jeff, and the main filter needs to be replaced every year or two (again a five minute process). 10 minutes seemed like a reasonable figure.
25. Active time per 25-gallon batch divided by 60 minutes in an hour, multiplied by the cost of labor per hour, divided by gallons processed per batch.
26. Capital cost per gallon processed plus cost of main filter per gallon processed plus cost of inhibitors per gallon processed plus cost of pre-filters per gallon processed plus cost of electricity per gallon processed plus labor cost per gallon processed.
27. Same as line 15. This cost was excluded from the total calculated on line 26 so that it could be reported on separately in Table 1.
28. Same as line 19. This cost was excluded from the total calculated on line 26 so that it could be reported on separately in Table 1. Note also that the cost of disposing of the main filter is not included in this analysis because the weight of that filter could not be ascertained. However, it is likely not to weigh that much more than the pre-filter; and since only one is disposed every year or two, the cost is not expected to be significant.
29. Cost of pre-filter disposal per gallon processed plus cost of antifreeze residue disposal per gallon processed plus total cost of in-house recycled antifreeze per gallon (disposal not included).

Endnotes – *Antifreeze Options*

[65] "Regular-life" antifreeze is conventional antifreeze that lasts two years or 30,000 miles.

[66] "Long-life" antifreeze is a newer type of antifreeze that last five years or 100,000 miles.

[67] The City uses many vehicles made by GM. Further, in order to ensure a fair comparison of recycling processes, a GM certified service provider and recycling machine manufacturer were chosen so that the end-products they produce are similar in nature, and equivalent to virgin antifreeze.

[68] Conversation with Drew Frye, Eastern Oil, 5/28/97. He said that regular-life is from $1-$2 less expensive than long-life.

[69] Information sources and calculations are provided in notes to this section.

[70] Conversation with Wayne Bradley, Senior Project Engineer, Service Technology Group, General Motors, 6/5/97. Regular-life antifreeze should be replaced after 2 years/30,000 miles, and that long-life antifreeze should be replaced after 5 years/100,000 miles (or later in newer model vehicles).

[71] This is a generic number, but is based roughly on a figure from Tim Walsh, Assistant Analyst for Vehicle Acquisition, Five Boroughs Garage, Department of Parks and Recreation. Tim said that his facility handles 600-700 vehicles in total, of all types (from passenger to heavy vehicles).

[72] Conversation with Wayne Bradley, GM, 9/4/97. Wayne said that passenger vehicle and light trucks generally have radiators of 12-16 quarts; so an average of 14 (or 3.5 gallons) was used.

[73] Number of vehicles in fleet multiplied by average size of radiator.

[74] Conversation with Tim Walsh, Five Boroughs Garage, 6/12/97. This is a standard industry ratio.

[75] Gallons of antifreeze/water solution initially put into vehicles multiplied by the ratio of antifreeze to water used. In the case of the recycled options, however, no fresh, pure antifreeze is put in initially; instead, a recycled 50/50 ratio antifreeze-water mixture is added.

[76] Conversation with Tim Walsh, Five Boroughs Garage, 6/12/97.

[77] The price for regular-antifreeze is 70% of the price for long-life antifreeze This discount factor was derived based on the price for regular- ($7/gallon) and long-life ($10/gallon) antifreeze at a major auto parts store, and then applied to the contract price the city receives for long-life antifreeze. The reason the cost of fresh, regular-life antifreeze is noted for both of the recycled options as well is because some new antifreeze must enter the system in those scenarios due to leakage in the radiators between coolant changes (see below); this is an on-going annual expense. The cost of long-life antifreeze is per conversation with Patty Tobin, BWPRR, 10/23/97.

[78] The cost per gallon of in-house recycled regular-life antifreeze/water solution is the culmination of extensive calculations. See the Appendix for details. The cost it represents includes capital, labor, additives, electricity and maintenance parts required to recycle used antifreeze/water solution with a GM approved recycling machine. The cost per gallon of antifreeze/water solution recycled off-site is based on a conversation with Mal Hickcock, a national representative for Antifreeze Technology Systems (ATS), 9/5/97. He said this price is a good estimate, and that depending on volume and other factors, it could go down. ATS is a national company that services the NYC area. ATS is also a GM approved antifreeze recycler.

[79] For the non-recycled scenarios, the cost is simply the gallons of pure antifreeze initially put into the vehicles multiplied by the cost per gallon for fresh antifreeze. For the two recycled scenarios, the cost is the cost per gallon for recycled antifreeze/water solution multiplied by the gallons of antifreeze/water solution initially put into the vehicles.

[80] For the "regular-life, disposal" scenario, the leakage rate is simply an estimate. The other scenarios derive their leakage percentage estimates according to the following calculation: (number of years between radiator coolant changes for the scenario in question / number of years between radiator coolant changes for the "regular-life, disposal" scenario) x "regular-life, disposal" leakage percentage. This is done to create a leakage estimate that is proportionate to the number of years between coolant changes. Figures have been rounded.

[81] Leakage percentage multiplied by the gallons of antifreeze/water solution initially put into the vehicles.

[82] Gallons of antifreeze/water solution lost between coolant change multiplied by the ratio of antifreeze to water used.

[83] Gallons of pure antifreeze lost between coolant changes multiplied by the cost of fresh, pure antifreeze.

[84] Conversation with Tim Walsh, Five Boroughs Garage, 6/12/97.

[85] Labor cost per hour multiplied by active labor time needed per vehicle to change coolant multiplied by the number of vehicles in the fleet.

[86] For the first two scenarios, the antifreeze/water solution that needs to be disposed is simply the number of gallons of antifreeze/water solution that were initially in the vehicles (because they have been topped off to account for any leakage). For the in-house recycling scenario, the recycling process is estimated to have a 1.5% residue rate per gallon processed (see the Appendix for source). Therefore, the gallons of residue are calculated by multiplying the gallons of antifreeze/water solution initially put into vehicles by 1.5%. Finally, for the off-site recycling scenario, from the City's perspective there is no antifreeze/water solution to be disposed (because the recycling company comes, empties each 55 gallon drum of used antifreeze/water solution, and replaces it with an equivalent amount); but due to the City's recycling, some waste is generated by the recycling company (in the same manner as the "in-house" scenario). So the 1.5% residue figure was used in this scenario as well.

[87] Based on a 6/3/97 conversation with Safety Kleen in NJ. Prices to dispose of spent antifreeze/water solution ranged from $139 for a maximum of 125 gallons (or $1.11/gallon) to a most favorable price of $425 for 500 gallons ($0.85/gallon). The $425/500 gallons price was quoted as a definite estimate, subject to negotiation based on frequency of collection, etc. $1/gallon was used as a mid-range price. Important Note: Used antifreeze/water solution cannot be disposed in a conventional landfill because it is a liquid. How it can actually be disposed depends on whether it is characterized as a hazardous waste, which can only be determined through testing, and depends to a large extent on the vehicles it is used in. If found to be non-hazardous, it could theoretically be put into a sanitary sewer system. If found hazardous, it must be handled appropriately. The disposal method used here was chosen as a best management practice to ensure it does not harm the environment.

[88] For the first three scenarios, the cost to dispose of the waste antifreeze/water solution is calculated by multiplying the gallons of antifreeze/water solution that need to be disposed by the cost/per gallon to dispose of them. For the fourth scenario, a cost of $0 is entered because the City does not pay for the disposal of the waste generated (see note 94 for clarification).

[89] Only the in-house recycling option produces used filters that need to be disposed. See the Appendix, this section, for details. Essentially, one filter (which weighs roughly one pound) is used per 100 gallons of antifreeze/water solution processed in the recycling machine. Thus, 1/100 of a pound of filter waste is produced per gallon processed. So the tonnage of filter waste produced by this option is derived as follows: (1/100 x the gallons of antifreeze/water solution initially put into the vehicles) / 2000 pounds per ton.

[90] Jeff Tuttle of Kleer Flo (the company that manufactures the recycling machine used in the analysis in the Appendix, this section) said that these filters would probably be handled in the same way that the City handles its motor oil filters. And since, from the Oil Study, the City is able to put their filters in with regular trash, a tip fee of $41.50/ton is used.

[91] Cost per ton to dispose of used filters multiplied by the tons of used filters. (See DOS Overview.)

[92] See Table 2 and accompanying discussion for details.

[93] For the first two scenarios this is calculated by adding together the cost of the antifreeze initially put into the vehicles and the cost of the antifreeze lost due to leakage, and dividing it by the number of years between coolant changes. The last two scenarios are calculated in a similar manner, except that only the antifreeze lost due to leakage is included here (because the antifreeze initially put into the vehicles is "recycled," and is thus accounted for in the third row of the table.

[94] The cost of the antifreeze/water solution initially put into the vehicles is divided by the number of years between coolant changes.

[95] The cost to dispose of waste antifreeze/water solution is divided by the number of years between coolant changes.

[96] The cost to dispose of used filters is divided by the number of years between coolant changes.

[97] The first four data rows of are added together.

[98] The cost of labor to change coolant for all vehicles is divided by the years between coolant changes.

[99] The Subtotal and annual labor cost line are summed.

[100] The total of average annual costs for the Long-Life Option is subtracted from the total of average annual costs of each of the other options to determine the savings.

[101] Gallons of antifreeze/water solution that need to be disposed divided by the number of years between coolant changes.

[102] Tons of used filters that need to be disposed divided by the number of years between coolant changes.

[103] See note 77.

6. ENVELOPES - CASE STUDY

Introduction

The SAIC/Tellus team, in consultation with BWPRR and the Department of Citywide Administrative Services, selected the envelopes used by the New York City Department of Finance ("Finance") as one of the case studies because Finance sends millions of mail pieces per year. In addition, two envelope options, with differing cost and waste generation characteristics, are available. The alternative to the "conventional" envelope mailing system is the "two-way" envelope system. A "two-way envelope" is an envelope in which part of the "outgoing" envelope is reused by the recipient to mail the reply back to the sender; this eliminates the need for the conventional "reply" envelope.

This case study examines the cost and waste generation characteristics of a potential switch from conventional envelope system to a two-way envelope system, based on envelope use at the New York City Department of Finance. The analysis shows that switching to two-way envelopes could save money and reduce waste.[104] The basic results of the study are that, by switching to two-ways, the Department of Finance could:

- Save an average of almost $72,000 annually on the cost of envelopes.
- Save $18,000 annually on envelope stuffing costs.

Postage costs are expected to be the same for two-way and conventional envelopes in this case.[105] Using two-ways is also expected to reduce disposal costs by $891 annually.[106]

Analysis

The Department of Finance sends out 18 million mail pieces that require a response each year. These include parking violations, unincorporated business tax invoices, general corporation tax invoices, and property tax invoices.[107] The bills are currently sent in conventional envelopes, along with a slightly smaller reply envelope inside for the recipient to use when mailing payment, and sometimes an additional insert. Using two-way envelopes results in procurement, stuffing, postage, and disposal costs different from those of conventional envelopes; this case study examines these impacts.

Initial Assumptions and Calculations

Table 1 shows the key assumptions for this case study, as well as certain initial calculations that are based upon these assumptions. The information provided in Table 1 represents the current best assessment of cost and waste generation characteristics associated with the choice of envelope. The Department of Finance and Sheppard Envelope, a maker of both conventional and two-way envelopes, supplied the bulk of the information for this case study, as documented in the endnotes.[108] This information is used to perform the life-span cost analysis. The details of the life-span analysis are presented in Tables 2 and 3. Assumptions and preliminary calculations required for the life-span analysis are provided in Table 1 and endnotes.

Table 1 - Key Assumptions and Initial Calculations[109]

Assumption/Calculation	Conventional Envelopes	Two-Way Envelopes	Calculations
BACKGROUND			
Number of mail piece per year[110]	18,000,000	18,000,000	
Number of envelopes in one order[111]	200,000	100,000	
Number of envelope orders per year[112]	180	180	Mail pieces per year / 100,000 outgoing envelopes per order = 180 orders per year.
PROCUREMENT AND MAILING			
Purchase cost for one order of envelopes[113]	$2,900.00	$2,500.00	
Annual purchase cost	$522,000	$450,000	Total annual orders x Cost per order
Cost to stuff one mail piece[114]	$0.036	$0.035	
Annual cost to stuff mail	$648,000	$630,000	Total annual mailing x Cost to stuff one piece
Average postage cost per mail piece[115]	$0.27	$0.27	
Annual postage cost	$4,860,000	$4,860,000	Total annual mailing x Average postage cost
Cost of envelope plate[116]	$0.00	$50.00	
Number of years envelope plate will be used[117]	N/A	5	
WASTE GENERATION AND MANAGEMENT			
Weight of one envelope[118]	0.022	0.017	
Weighted disposal/recycling cost per ton[119]	$19.38	$19.38	
Annual disposal cost for returned envelopes	$3,873	$2,982	Total annual mailing x Weight per mail piece/2000 x Weighted disposal cost
SUMMARY FINDINGS			
Total of Average Annual Costs	$6,033,873	$5,942,992	See Table 2 and accompanying discussion for details.

Life-Span Costing

The data in Table 1 will be used to develop average annual costs for envelope procurement and disposal. The sum of average annual costs will provide a measure of the difference in life-span costs due to the choice of envelope.

An example will help to explain the process of annualizing costs.

- Table 1 shows that the average postage cost per mail piece is $0.27. Since 18 million mail pieces are sent per year, the average annual cost of postage for Finance mail pieces is $4,860,000 ($0.27 x 18,000,000 = $4,860,000).

In general, one year's worth of each cost relevant to the case study must be identified.

Table 2 shows the average annual costs for envelope options. These costs are obtained by annualizing the costs in Table 1. All the calculations necessary for annualization are explained in the endnotes. Table 3 shows average annual waste generation associated with each envelope option. As in Table 2, the waste-generation information from Table 1 is annualized to provide the results shown in Table 3.

Table 2 – Cost Comparison of Envelope Options

Cost Category	Conventional Envelopes	Two-Way Envelopes
Envelope Procurement Cost per Year[120]	$522,000	$450,000
Average Annual Cost of Plate Fee[121]	$0	$10
Subtotal: Average Annual Cost of Envelopes	$522,000	$450,010
Average Annual Cost of Postage[122]	$4,860,000	$4,860,000
Average Annual Cost of Stuffing Envelopes[123]	$648,000	$630,000
Average Annual Cost of Disposal/Recycling[124]	$3,873	$2,982
Total of Average Annual Costs	$6,033,873	$5,942,992
Savings of Two-Way Option Compared to Conventional Option[125]	$90,881	N/A

Table 3 – Waste Generation Comparison of Envelope Options

Waste Generation Category	Conventional Envelopes	Two-Way Envelopes
Tons of Envelopes Generated per Year[126]	200	154

Results

Basic results

The basic results of the analysis show that using two-way envelopes would save money and reduce waste.

As shown in Table 2, the cost assumptions illustrate that, by switching from conventional envelopes to two-way envelopes, the City could:

- Save an average of almost $72,000 annually on the cost of envelopes.
- Save $18,000 annually on envelope stuffing costs.
- Reduce disposal costs by $891 annually.[127]

All of the approximately $90,881 in average annual savings would be realized by Finance, except for the avoided disposal costs. Switching to two-way envelopes would not increase postage costs for Finance. Since the weight of a two-way is less than the weight of two conventional envelopes, some two-way users experience significant postage savings by being able to mail in a lower rate class. However, Finance's mailings, weighing one ounce, are currently mailed in the lowest weight rate class available. Therefore, lessening the weight by switching to two-ways is not expected to make a difference in Finance's postage costs.

Sensitivity

The cost-effectiveness of using two-way envelopes is a rather robust result. That is, even if one were to make somewhat different assumptions, two-way envelopes would still be more cost-effective than conventional envelopes. The discussion that follows will help to illustrate this point, providing examples relating to:

- the price of two-way envelopes,
- stuffing costs, and
- waste disposal costs.

The price of the two-way envelope used for this case study is an estimate by the envelope manufacturer, while the price of Finance's current envelope is, of course, the actual price paid. The price that Finance might eventually pay for two-ways could be lower or higher than the price estimate in this case study. However, if the savings on stuffing costs and all other assumptions prove to be accurate, only if an order of 100,000 two-ways cost over $3,000 would the overall cost of using two-ways equal the overall costs of using conventional envelopes. It should be noted that the NYC Department of Consumer Affairs purchased 100,000 two-way envelopes at approximately the same price as they had been purchasing conventional envelopes. Therefore, it seems highly unlikely that changing to two-way envelopes would result in additional purchase costs for a large-volume envelope user such as Finance.

In addition, if one assumes that using two-ways would result in no savings in envelope stuffing costs, using two-ways would still result in overall savings of almost $73,000 annually, if the purchase savings and other assumptions prove to be accurate. Assuming that purchase costs and stuffing costs were the same for two-way and conventional envelopes, the only savings from using two-ways would be from disposal savings, which would be $891 annually. However, if the two-ways cost slightly *more* than the conventional envelopes and stuffing costs were the *same* for two-ways and conventional envelopes, then there would be no cost savings from using two-ways;[128] of course, two-way use would still result in less waste.

The length of time that the envelope plate will be used has no effect on the outcome of the analysis, since this cost is minor compared to other cost categories. Changing the estimated cost of disposal does not change the results of the analysis either. Whether the cost of disposal for both envelope types is estimated at zero or $41.50 per ton, two-ways are still the more cost-effective.

APPENDIX

This Appendix provides information related to the calculation of disposal costs. It takes into consideration the percentage of envelopes recycled and landfilled, the cost of disposal by landfilling, and revenue received from recycling in order to calculate a weighted average cost of disposing/recycling.

Table 4 – Cost of Disposal/Recycling

Category	Cost or Percentage
1) Percentage of envelopes landfilled	75%
2) *Revenue* of recycling per ton	$47.00
3) Cost of disposal/ton	$41.50
4) Weighted average cost of disposing/recycling per ton	$19.38

Notes to Table by Row Number:

1. New York City's mixed paper recycling rate is approximately 25 percent, according to an October 1996 report by Eric Zimiles, a BWPRR Deputy Director. This figure is applied to both returned and the non-returned portion of the two-way envelopes. Finance does not have any more specific information about recycling rates since return envelopes, together with payment, are returned to lock boxes in banks, not to Finance itself.
2. Revenue of $47 per ton is the FY 1997 average paid to DOS for government agency office paper, collected by a private contractor. The actual revenue received per ton fluctuates.
3. *New York City Solid Waste Management Plan: Final Update and Plan Modification,* February 15, 1996, pages 3-26 indicates that disposal by landfilling costs $41.50 per ton. See DOS Overview.
4. While disposal costs, disposal savings, and recycling revenues do not impact on individual City agencies (such as Finance) directly, these costs and revenues do impact on overall City costs. This is the weighted cost of disposal per ton, considering both the cost of landfilling and the cost (revenue) from recycling: percentage of envelopes landfilled multiplied by cost of disposal per ton plus cost (revenue) of recycling per ton multiplied by 1 minus the percentage of envelopes landfilled.

Endnotes – *Envelopes*

[104] The methodology for these calculations is fully explained in the body of the case study.

[105] Postage costs will not change because Finance's mailings are already in the lowest rate class available. Users whose mailings are just over one ounce would be in the 55-cent rate class for first-class mail. If the lessened weight due to the switch to two-ways were enough to put the mail piece into the 32-cent class, such users would experience significant postage savings: 23 cents per mail piece. Note that this is significantly more than the cost of the two-way envelope itself, 2.5 cents ($2,900 per order / 100,000 envelopes = 2.5 cents each).

[106] This is a savings to the City as a whole, not to particular municipal departments, which do not pay for disposal costs themselves.

[107] Letter from Sheila Gutis, Assistant Commissioner, Administration, New York City Department of Finance, dated 4/7/97.

[108] Sheppard Envelope is one of three U.S. manufacturers known to be making two-way envelopes. Sheppard Envelope Company, located in Worcester, MA, calls its two-ways "Boomerangs." Two other two-way envelope manufacturers have their own versions of the two-way envelope: Tension Envelope Corporation, located in South Hackensack, NJ, markets the "Send-n-Return" envelope, and American Mail-Well Envelope, with offices in New York City, sells the "Mail & Return" envelope.

[109] Information sources and calculations are provided in notes to this section.

[110] Letter from Sheila Gutis. The Department of Finance sends 18 million mail pieces with reply envelopes annually.

[111] Letter from Sheila Gutis. The size of individual orders varies.

[112] Letter from Sheila Gutis. 18,000,000 envelopes per year / 100,000 outgoing envelopes per order = 180 orders per year.

[113] Letter from Sheila Gutis. Finance uses #9 and #10 envelopes. It pays $14.50 per 1,000 envelopes. An order consists of 100,000 outgoing (#10) envelopes and 100,000 reply (#9) envelopes. Therefore, the order costs $2,900 {since (($14.50/1,000 envelopes) x 100,000 envelopes) x 2 = $2,900}. Two-way: Conversation with Brook Spaulding, Sheppard Envelope. This approximate price is based on orders of 18 million envelopes per year, the current level of mailing in Finance. However, two-way envelopes are not currently on City requirements contracts, and the price given by Sheppard does not reflect the result of a bid. Therefore, the pricing of two-way envelopes is tentative.

[114] Conventional: Finance uses a mailing house. It is charged $35 per thousand items for a “basic mail item,” which is one bill, form, or letter passed once through a folding machine and inserted into the outgoing envelope. Each additional item, such as return envelopes or other miscellaneous materials, costs an additional $1 per thousand. Letter from Patrick Sullivan, Executive Assistant, NYC Department of Finance, dated 10/28/97. Therefore, stuffing a conventional envelope should cost $0.036. This includes: $35/1000 for one insert and outgoing envelope, $1/1000 for the return envelope, and 45% of $1/1000 (for the informational inserts included in 45% of mailings according to Finance). The informational inserts, printed after the bills themselves, contain updated regulations or other last-minute information that Finance needs to convey to recipients. Two-Way: Stuffing a two-way has similar costs, except that it is not necessary to insert a separate return envelope, saving the $1/1000 it costs to send a return envelope.

[115] Letter from Sheila Gutis. This is a weighted average of the two per-piece postage costs incurred by Finance.

[116] An “envelope plate” is used to print the sender’s address onto the envelope. The plate charge is a cost to set up the envelopes to have the address on them. Conventional: Letter from Sheila Gutis. There is no plate charge for their current envelopes. Two-Way: Sheppard Envelope price list. This is a one-time charge for making a plate from camera-ready art.

[117] Estimate. The Department of Finance has not estimated how long an envelope plate would be used.

[118] See the Appendix, this section, for an explanation of this calculation.

[119] This cost is based on costs and revenues for the expected mix of recycling and disposal. See the Appendix, this section, for an explanation of this calculation.

[120] Purchase cost for one order of envelopes multiplied by number of envelope orders per year.

[121] For conventional envelopes, there is no plate fee. For two-way envelopes, this is the cost of the envelope plate divided by the number of years the envelope plate will be used.

[122] Average postage cost per mail piece multiplied by number of mail pieces per year.

[123] Cost to stuff one mail piece multiplied by number of mail pieces per year.

[124] Number of mail pieces per year multiplied by weight of envelopes for one mail piece (in pounds) multiplied by disposal cost per ton divided by 2000 (pounds per ton). Details, as shown in Table 1, this section, do not total the exact amount shown due to the effects of rounding.

[125] The total of average annual costs for the two-way option is subtracted from the total of average annual costs of conventional option.

[126] Number of mail piece per year multiplied by weight of envelopes for one mail piece (in pounds) divided by 2000 (pounds per ton).

[127] Disposal costs are reduced because two-ways weigh less than a set of conventional envelopes. Although individual municipal departments would not see disposal savings, the City as a whole saves money when disposal costs are reduced. See the Appendix, this section, for more details.

[128] If an order of two-ways costs $2,908 and stuffing costs are the same, costs for the two systems are approximately equal.

7. HAND DRYERS/PAPER TOWELS – CASE STUDY

Introduction

The SAIC/Tellus team, in consultation with BWPRR and the Department of Citywide Administrative Services (DCAS), selected hand-drying as the focus of one case study due to the large amount of paper toweling used in City government agencies' restrooms. This case study examines the cost and waste stream impacts of the hand-drying alternatives for restrooms in a City office building with 232 employees.[129] The base case analysis assumes no costs for dispenser procurement and installation; this treatment of purchasing and installation costs associated with C-fold dispensers puts the C-fold system in the most favorable light possible. If one considered the costs involved with the C-fold dispensers currently installed, the savings due to using roll towels or hot air dryers would be even greater than those presented below.

The results of the life-span costing analysis of hand-drying alternatives show that roll paper towels have lower overall costs and greater waste-prevention potential than C-folded towels. The costs of roll toweling and hot air drying are similar, but hot air drying prevents all toweling waste. During the course of the product's lifetime, the basic results are that, overall, for each dispenser, using roll toweling would save $8.87 per hand-drying fixture per year and using hot air dryers would save $8.70 per hand-drying fixture per year, compared to the current C-fold towels. Specifically, the analysis shows the following:

- The building would incur $12.60 in average annual costs for the purchase and installation of a roll towel dispenser and $27.11, per dryer, in average annual costs for hot air dryer procurement and installation costs. This assumes no costs for the existing system, C-fold dispensers.
- The building currently has no cost for dispenser maintenance. No maintenance costs are expected for roll towel dispensers. With hot air dryers, $10.48 per dryer per year in maintenance costs are expected.
- The building currently spends approximately $47.17 per dispenser per year in C-fold towel procurement. It would save $20.58 per dispenser per year by switching to roll toweling and would save the full $47.17 per dispenser per year by switching to hot air dryers.
- Towel disposal currently costs $1.68 per dispenser per year; the full amount would be saved by switching to hot air dryers. Using roll toweling would lower disposal costs by $0.90 per dispenser per year.
- No electricity costs are currently incurred; this would not change with a switch to roll toweling. Hot air dryers would cost $2.55 per dryer per year for electricity.

The building that is the setting for this case study has 27 restrooms with one dispenser per restroom.[130] By extrapolating from the above results that show the costs and savings, the analysis shows that:

- Use of roll toweling would result in savings of $239 per year while use of hot air drying would result in savings of $235 per year.[131]

- Switching to roll towels would also avoid disposal of 1,162 pounds per year, while switching to hot air dryers would avoid disposal of 2,182 pounds of paper per year.[132]

The results suggest that the building could minimize life-span costs by using roll towels and minimize waste generation by using hot air dryers. However, this building is currently only about half-occupied; if it were fully occupied, hot air dryers would be the most cost-effective option. Indeed, as explained in the final section, “Sensitivity,” any of several slight changes in the assumptions would make hot-air dryers the most cost-effective option for this building. Therefore, this analysis suggests that hot air dryers are likely to be the most cost-effective option in many settings.

Analysis

This study compares the costs and waste generation from C-folded paper towels, paper towels in roll dispensers (roll paper towels), and hot air dryers used for hand drying in City restrooms. The study focuses on the Department of Sanitation building at 44 Beaver St., New York City. The building manager at 44 Beaver St. and toweling manufacturers were the sources of information for C-fold paper toweling, the system currently in use there. Since the building currently uses C-fold towels, other sources were used for information on the alternatives, roll towels and dryers.

The New York City Comprehensive Solid Waste Management Plan included a case study of switching from folded paper towels to hot air dryers in the bathrooms of a hypothetical 1,000-bed City hospital.[133] This case study and hot air dryer manufacturers are sources of information for hot air dryers. For the current life-span study, the hospital case study was updated to include current DOS costs, modified to focus on an office building, and expanded to include the option of roll toweling.

The City of Cambridge, Massachusetts’ Waste Prevention Action Plan included a case study of switching from folded paper towels to roll paper towels in the bathrooms of all municipal buildings.[134] The Cambridge case study was developed based on observation of the City’s 2,605 employees and in conjunction with a major paper towel manufacturer. This study and subsequent follow-up by Tellus staff with the contributors to the case studies provided information on procurement costs and waste generation figures for roll paper towels and for folded paper towels.

Initial Assumptions and Calculations

The case study began with a review of the relevant literature. In light of this review, the life-span costing analysis focuses on the following categories of associated costs:

- Toweling dispenser and dryer procurement
- Toweling dispenser and dryer maintenance
- Towel procurement
- Electricity use
- Disposal

Table 1 shows the key assumptions for this case study, as well as certain initial calculations, based upon these assumptions. The information provided in Table 1 represents the current best assessment of cost and waste generation characteristics associated with each hand-drying option. This information is used to perform the life-span cost analysis. Table 1 also provides a framework for the development of alternative analyses. Thus, it is possible to change these assumptions and then update the calculations. To repeat the case study for a different type of hand-drying system, such as “no-touch” hot air drying, it is only necessary to replace the information on hot-air dryers shown in Table 1 with similar information for “no-touch” hot-air dryers. See the “Sensitivity” section for more discussion of the estimated lifetimes’ impacts on the results of the analysis.

Table 1 – Key Assumptions and Initial Calculations[135]

Assumptions	C-Fold	Roll Paper	Hot Air	Calculations
BACKGROUND				
Number of Years Before Fixture Replacement[136]	10	5	10	
PROCUREMENT AND INSTALLATION				
Purchase Cost of Fixture[137]	$0.00	$37.49	$209.50	
Number of Hours to Install Fixture[138]	0	1.5	3.625	
Labor Cost per Hour[139]	$17.00	$17.00	$17.00	
Cost of Installation per Fixture	$0.00	$25.50	$61.63	Hours x Labor cost
Total Cost per Fixture	$0.00	$62.99	$271.13	Purchase cost + Installation cost
MAINTENANCE AND OPERATION				
Maintenance Cost of Fixture per Year[140]	$0.00	$0.00	$10.48	
Toweling per Hand Dry (sq. ft.)[141]	1.5278	0.6667	N/A	
Toweling per Case (sq. ft.)[142]	2,444.44	2,800	N/A	
Number of Hand Dries per Case	1,600	4,200	N/A	Toweling per case/ Toweling per dry
Number of Hand Dries per Year per Fixture[143]	5,877.22	5,877.33	5,877.33	
Number of Cases Required per Year per Fixture	3.67	1.40	N/A	Hand dries per year/ Hand dries per case
Cost per Case of Paper Towels[144]	$12.84	$19.00	N/A	
Cost of Paper Towels per Year per Fixture	$47.17	$26.59	N/A	Number of cases x Cost per case
WASTE GENERATION AND MANAGEMENT				
Weight per Case of Paper Towels (pounds)[145]	22	27	N/A	
Pounds of Towel Waste Disposed per Year	80.81	37.78	N/A	Weight per case x Number of cases
Cost per Ton of Towels Disposed[146]	$41.50	$41.50	N/A	
Cost of Disposal per Fixture	$1.68	$0.78	N/A	Pounds disposed/2000 x Cost of disposal

Table 1 – (continued) Key Assumptions and Initial Calculations[135]

Assumptions	C-Fold	Roll Paper	Hot Air	Calculations
ENERGY COSTS				
Wattage of Hot Air Dryer[147]	N/A	N/A	1,300	
Dryer Cycle Time, in Seconds[148]	N/A	N/A	30	
Kilowatt-Hours of Electricity Used per Cycle	N/A	N/A	63.67	(Number of hand dries per year x Wattage of hot air dryers x Dryer cycle in seconds)/(1000 kilowatts per watt/3600 seconds per hour)
Cost per kilowatt-hour[149]	N/A	N/A	$0.04	
Energy Cost per Year per Fixture	N/A	N/A	$2.55	Kilowatt-hours x Cost per kilowatt-hour
SUMMARY FINDINGS				
Total Annual Costs per Fixture	$48.84	$90.36	$281.61	Sum of costs
Average Annual Cost for Life of Fixture[150]	$48.84	$39.97	$40.14	Sum of costs/ Life of fixture

Life-Span Costing

In this case study, the data in Table 1 are used to develop average annual costs for procurement of toweling dispensers, toweling dispenser maintenance, towel procurement, and electricity. The process of converting costs to average annual costs will differ depending on how the costs are originally stated. A couple of examples, using the assumptions presented in the endnotes, will explain the process of annualizing costs.

- Table 1 shows that 5,877.33 hand-dries occur per year per dispenser, and that a C-fold dispenser will provide 1,600 hand-dries per case per year. Since the cost of a case of paper towels is $12.84, the average annual cost of buying C-folded paper towels for one dispenser is $47.17 (5,877.33 hand-dries per year ÷ 1,600 hand-dries per case x $12.84 per case = $47.17).
- Hot air dryers cost $209.50, and are estimated to last 10 years. Thus, the average annual hot air dryer cost is $20.95 ($209.50 ÷ 10 = $20.95).

In general, one year's worth of each cost relevant to the case study must be identified. As the above examples show, what "one year's worth" means may vary considerably, depending on the cost item in question.

Table 2 shows the average annual costs for a single restroom using C-folded towels, roll towels, and hot air. These costs are obtained by annualizing the costs in Table 1. All the calculations necessary for annualizing the costs in Table 1 are explained in the endnotes. Table 3 shows the average annual waste generated by each toweling option. As in Table 2, the waste-generation information from Table 1 is annualized to provide the results shown in Table 3.

Table 2 – Cost Comparison of Hand-Drying Options

Cost Category	C-folded	Roll	Hot Air
Fixture (Dispenser/Dryer) Procurement Cost per Year [151]	$0.00	$7.50	$20.95
Fixture Installation Cost per Year[152]	$0.00	$5.10	$6.16
Subtotal: Average Annual Cost of the Fixture	$0.00	$12.60	$27.11
Average Annual Cost of Maintenance of the Fixture[153]	$0.00	$0.00	$10.48
Average Annual Cost of Towel Procurement[154]	$47.17	$26.59	$0.00
Average Annual Cost of Towel Disposal[155]	$1.68	$0.78	$0.00
Average Annual Cost of Electricity Use [156]	$0.00	$0.00	$2.55
Total of Average Annual Costs	$48.84	$39.97	$40.14

Table 3 – Waste Generation Comparison of Hand-Drying Options

Waste Generation Category	C-folded	Roll	Hot Air
Pounds of Paper Generated per Year [157]	80.81	37.78	0

The hot air dryer has the highest initial costs of the three hand-drying options, but the lowest annual operating costs. The largest operating expenses associated with towel dispensers are the paper towel purchase costs.

The purchase cost of the roll paper towel dispenser is almost double that of the C-folded paper towel dispenser. Roll towel dispensers have a continuous length of toweling on a roll, usually set to dispense only a small quantity of toweling (as little as a 3-inch length) per press of the lever or turn of the crank; users tend to take only as much toweling as they need. The length of a C-fold towel is over 9 inches; therefore, C-fold users may take more toweling than is needed to dry their hands. Because of this difference, roll towel dispensing systems usually require much less toweling to perform the same number of hand-dries. All of these differences are reflected in the data in Table 2.

Results

Basic Results

This analysis indicates that the use of roll paper toweling or hot air dryers would lower the total costs for hand-drying and prevent more waste than C-folded towels. Compared to C-fold toweling:

- Annualized fixture (dispenser or dryer) costs would be $12.60 higher for roll paper and $27.11 higher for hot air. This assumes no cost for the C-fold dispenser, as shown in Table 1. If one considered the costs involved with the C-fold dispensers currently installed, the savings due to using roll towels or hot air dryers would be even greater.

- Fixture maintenance costs are zero currently, are unchanged for roll paper, and are $10.48 higher for hot air.
- Towel purchase costs are $20.58 lower for roll paper. No towel purchases are required when using dryers, a savings of $47.17.
- Towel disposal currently costs $1.68 per dispenser per year; switching to hot air dryers would save the full amount. Using roll toweling would lower disposal costs by $0.90 per dispenser per year.
- Electricity purchase costs are $2.55 higher for hot air; electricity costs are zero for paper towel options.

Overall, the use of roll paper towels saves $8.87 per fixture per year, while the use of hot air saves $8.70 per fixture per year, compared to C-fold use.

Using roll paper towels or hot air dryers generates less waste per fixture than does the use of C-folded towels, a difference of 43.03 pounds of paper per year for roll towels. The entire 80.81 pounds of paper waste per year would be prevented through use of hot air dryers.

By extrapolating from the above results that show the costs and savings, the analysis shows that, for the 27 restrooms in the building:

- Use of roll toweling would result in savings of $239 per year, while use of hot air drying would result in savings of $235 per year.[158]
- Switching to roll towels would also avoid disposal of 1,162 pounds per year, while switching to hot air dryers would avoid disposal of 2,182 pounds of paper per year.[159]

Sensitivity

The results of this analysis, which indicates the cost-effectiveness of using roll paper towels or hot air dryers as compared to C-folded toweling, are sensitive to the some of the assumptions made in the analysis. Our basic analysis shows that rolled towels are most cost-effective, but not by a large margin. Some small changes could shift the balance in favor of hot air dryers. The following discussion presents analyses relating to:

- average towel use,
- number of hand dries per year,
- dispenser/dryer lifespan,
- conversion costs, and
- disposal costs.

Life-span costs for roll towels would be slightly more than those of C-fold towels if a roll towel user averaged about 0.75 square feet of toweling per use; therefore, if this were thought to be true, hot air dryers would be the most cost-effective option. If the purchase cost of a hot air dryer were $200 instead of $209.50, it would have a life-span cost almost exactly equal to that of roll towels; if a hot air dryer cost less than $200, it would be the most cost-effective option. If C-fold dispensers were considered to have costs associated with them (instead of considering costs to be zero because they are currently installed, as was done in the base case), C-fold toweling's costs would be slightly higher, making it an even less attractive option.

The number of hand-dries per year is also an important factor to consider. The building used as the setting for this case study is not currently fully occupied. If there were 500 employees using the 27 restrooms in the building, hot air drying becomes the most cost-effective option.[160] DOS could save over $28 per restroom per year compared to roll toweling (over $62 per restroom per year compared to C-fold) if this were the case. In high-use restrooms, dryers are cost-effective because their operational costs (electricity and possibly maintenance) are low compared to the costs of refilling toweling dispensers.

If the roll towel dispenser were also estimated to have a lifespan of 10 years (equal to the lifetimes of the dryer and the C-fold dispenser), roll towels would be the most cost-effective option, $6.47 less per bathroom per year than hot air drying. If the hot air dryer were estimated to have a lifetime of 11 years, it would be the most cost-effective option. The estimated lifespan of the C-fold towel dispensers has no impact on the results of the study; even if the C-fold dispenser is estimated to have a lifespan of 50 years, C-fold toweling still has the highest life-span costs. This remains true if the C-fold dispensers have the purchase and installation costs of the dispenser associated with them.

It is possible that conversion from C-fold dispensers to roll toweling or dryers conversion costs higher than the installation costs listed in Table 1 and Table 2. If conversion to roll toweling is estimated to cost $68.00 in installation labor (*i.e.*, 4 hours for conversion and installation) per dispenser or if conversion to hot air dryers is estimated to cost $144.50 for installation (*i.e.,* 8.5 hours of labor) per dispenser, then the average annual costs of each of these three options is approximately equal (at about $48 per dispenser per year).[161] If 44 Beaver St. believes that conversion/installation costs would be equal or greater than $68 for roll toweling dispensers or $144.50 for hot air dryers, then the most cost-effective choice is C-fold toweling. However, it should be noted that the City of Cambridge, Massachusetts, found it was possible to convert from C-fold to roll without having to put a new hole in the wall.[162]

At a disposal cost of $41.50 per ton, the inclusion of the impact of disposing a towel dispenser makes a difference of only pennies in the life-span costs; it does not change the results of the analysis.[163] Neither does assuming a $0 cost of disposal per ton change the analysis results; it simply lowers the annual costs of roll toweling by $0.78 per year and costs of C-fold by $1.68 per year.

Endnotes – *Hand drying options*

[129] The model for this case study is 44 Beaver St., New York City, a Department of Sanitation building, in which the Bureau of Waste Prevention, Reuse and Recycling is housed.

[130] Information from Ed Fisher, building manager of 44 Beaver St.

[131] To extrapolate, one simply multiplies the per-dispenser savings—$8.87 for switching to roll toweling or $8.70 for switching to hot air—by the number of dispensers, 27 (one in each restroom).

[132] Since C-folded towels generate 80.81 pounds of paper per restroom per year while roll towels generate 37.78 pounds of paper per year, the building would save 43.03 pounds of paper per year for each of its 27 bathrooms. If using hot air dryers, the building would avoid 80.81 pounds of paper towel generation for each of its 27 restrooms. Again, to extrapolate, one simply multiplies the waste savings per fixture by the number of fixtures in the building.

[133] Section 4.103 of the March 25, 1991, draft of the New York City Comprehensive Solid Waste Management Plan and Generic Environmental Impact Statement (the SWMP). Waste-Tech of Louisiana, Inc. prepared the hospital case study. According to Wally Jordan of Waste-Tech, the hospital case study was not included in the final Plan.

[134] Harris, Gail. A Waste Prevention Action Plan for Cambridge City Government. Submitted to The City of Cambridge, MA., July 1995.

[135] Information sources for Table 1 and calculations are provided in notes to this section.

[136] C-folded: Conversation between Susan Williams and Ed Fisher, building manager, 8/27/96, and conversation with Perkins Paper, 1/21/97. Roll: Conversation between Susan Williams and Jerry Coffey, Perkins Paper, 1/21/97. Perkins Paper is utilized because it was a contributor to the Cambridge study; the author of the Cambridge study recommended Perkins as the most cooperative vendor. Often, manufacturers and vendors consider information proprietary and do not wish to share it. Hot air: Conversations with Nova and World Dryer, air dryer manufacturers.

[137] C-folded: Since C-folded dispensers are currently installed in the building, this study considers there to be no cost associated with them, in effect treating them in the most favorable light possible. Roll: New York City procurement specifications, bid # 9501616, 9/27/95. Hot air: "Paper Towel Replacement Data Sheet," as faxed from Wally Jordan, Waste-Tech of Louisiana, Inc. to Susan Williams, Tellus, 12/21/1995. Waste-Tech developed the case study on paper towel replacement for a hypothetical hospital as part of the SWMP. The data sheet was included as section 4.104 of a draft of the Task 3 report (of the SWMP) dated March 25, 1991. According to Wally Jordan of Waste-Tech, the hospital case study was not included in the final SWMP.

[138] C-folded: Since C-folded dispensers are currently installed in the building, there is no installation cost. Roll: Information from Ed Fisher, building manager, 2/24/97. Hot air: "Paper Towel Replacement Data Sheet." The installation costs for roll and hot air include a half-hour allowance for removal of the existing C-fold dispensers.

[139] Information from Ed Fisher, 2/24/97.

[140] For C-folded and roll: Towels would be replenished by Work Experience Program workers, at no cost to the City. Conversation between Susan Williams and Ed Fisher, building manager at 44 Beaver St., 8/27/96. Hot air: "Paper Towel Replacement Data Sheet."

[141] For C-fold, one hand-dry equals 2.5 towels. This figure has been accepted as a standard average usage by the City of Cambridge and American Dryer, Inc. A C-folded towel is 88 square inches (9.25 x 9.5 inches), or 0.61 square feet. Therefore, one use of C-fold is 1.5278 square feet. The width of roll paper toweling is eight inches. The Cambridge study used 12" per hand-dry (4 pulls of the lever at 3 inches per pull). This is 96 square inches, or 0.6667 square feet of roll toweling per use.

[142] C-fold: Conversation between Susan Williams and Ed Fisher, building manager at 44 Beaver St., 8/27/1996. Roll: "A Waste Prevention Action Plan for Cambridge City Government."

[143] If there are 260 weekdays per year and one must subtract 12 holidays and 20 days of annual leave per employee per year (per tel. conversation between S. Williams, and P. Tobin 8/29/96) and 230 employees (plus 4 part-time, yielding approx. 232 full-time equivalent employees) (Memo from Patty Tobin, BWPRR to Victor Bell, SAIC, 9/13/96) and 3 hand dries per employee per day (assumption taken from “A Waste Prevention Action Plan for Cambridge City Government”), then there are 158,688 hand-dries in the building per year. This number must then be divided by the number of restrooms in the building, 27, to find the number of hand-dries per restroom per year.

[144] C-folded: New York City Department of Citywide Administrative Services, Central Stores, as given by Ed Fisher, building manager, September 1996. Roll: “A Waste Prevention Action Plan for Cambridge City Government.”

[145] “A Waste Prevention Action Plan for Cambridge City Government.”

[146] *New York City Solid Waste Management Plan: Final Update and Plan Modification,* February 15, 1996, pp. 3-26. This is the average cost of disposal in fiscal year 1994 and does not include collection costs.

[147] According to Brian O’Connor, Nova International, hot air dryers on the market today use at least 1300 Watts (2/97).

[148] “Paper Towel Replacement Data Sheet.”

[149] Average cost of electricity for a City agency. Fax from Scott Godsen, New York City Department of Parks and Recreation, to Susan Williams, 1/22/97.

[150] See Table 2, this section, and accompanying discussion for details.

[151] Estimated fixture life/Purchase cost of fixture.

[152] Cost of Installation (see Table 1, this section) / Purchase cost of fixture.

[153] See Table 1, this section.

[154] Cases per year x Cost per case.

[155] Pounds of waste per year (see Table 1, this section) / 2000 x Disposal cost per ton. See DOS Overview.

[156] Cost per kilowatt hour x Total kilowatt hours.

[157] See Table 1, this section.

[158] To extrapolate, one simply multiplies the per-dispenser savings—$8.87 for switching to roll toweling or $8.70 for switching to hot air—by the number of dispensers, 27 (one in each restroom).

[159] Since C-folded towels generate 80.81 pounds of paper per restroom per year while roll towels generate 37.78 pounds of paper per year, the building would save 43.03 pounds of paper per year for each of its 27 bathrooms. If using hot air dryers, the building would avoid 80.81 pounds of paper towel generation for each of its 27 restrooms. Again, to extrapolate, one simply multiplies the waste savings per fixture by the number of fixtures in the building.

[160] This option was analyzed by increasing the number of hand-dries per year from 5,877, as shown in Table 1, this section, to 12,677, the number of hand-dries per year for 500 users.

[161] This uses the $17 per hour figure shown in Table 1, this section.

[162] “A Waste Prevention Action Plan for Cambridge City Government,” p. 26.

[163] Burke Supply, a supplier on New York City requirements contracts, indicated that C-folded dispensers weigh approximately 6 pounds each. 6 pounds is 0.003 tons. Therefore disposing of a dispenser (at $41.50 per ton) costs about 12 cents.

8. MOTOR OIL – CASE STUDY

Introduction

The SAIC/Tellus team, in consultation with BWPRR and the Department of Citywide Administrative Services selected motor oil as the focus of one case study because the City maintains a large vehicle fleet that uses a large amount of motor oil. This case study examines the cost and waste stream impacts of motor oil alternatives for a single bus, and estimates the impacts for the 3,554 fleet of buses run by the Metropolitan Transit Authority (MTA).

The analysis of motor oil alternatives shows that synthetic motor oil has lower overall costs and greater waste-prevention potential than virgin motor oil.[164] The basic results are the following:

- The MTA would save $2.6 million per year by using synthetic motor oil in its buses, rather than virgin oil as it does now.
- Nearly all of the cost savings would come from increased fuel efficiency ($1.23 million per year) and increased engine life ($1.214 million per year).
- Almost $43,000 per year in savings would come from decreased costs of purchasing, installing, and disposing of oil filters.
- An additional $96,555 would come from reduced oil procurement, labor, and disposal costs.
- Use of synthetic motor oil would generate 690,116 fewer pounds (345 tons) of waste oil and 9,169 fewer pounds (close to 5 tons) of used oil filters per year than use of virgin oil.

This case study provides a textbook example of the importance of life-span costing. Synthetic motor oil has a much higher initial cost than virgin oil. However, on a life span basis there are substantial cost savings associated with synthetic oil use.

Analysis

New York City's fleet of 3,554 public transit buses, operated by the Metropolitan Transit Authority, currently uses several brands of virgin 15W-40 motor oil, including Chevron, Mobil, Texaco, and Exxon.[165] This case study examines the effect that using synthetic oil[166] could have on cost of operation and waste generation for New York City public transit buses. It compares cost and waste generation data based on use of synthetic and virgin oil. The MTA provided New York City-specific information on their buses' procurement specifications, maintenance practices, and fuel efficiency.

Since MTA currently uses only virgin motor oil, data from other sources are used for synthetic motor oil. Mobil provided reprints of articles from trade publications that highlighted users' experiences with synthetic oil. The authors of the articles cited are not employees of Mobil. "Synthetic Lubricants Save Fleet Maintenance Dollars," printed in *School Bus Fleet,* was prepared by Charles W. Drake, head mechanic for New York's Ithaca School District.

"Synthetic Lubricants Cut Food Firm's Truck Operation and Maintenance Costs," published in *Food Engineering,* was prepared by Francis Pash and Bill Page of Schwan's Sales Enterprises. The authors were writing about their experiences with Delvac 1 and Mobilube SHC in their trucks, tractors, and refrigerated trailers. These users of synthetic oils, not the Mobil Company itself, are the sources of the information used to develop the analysis. Other information on the cost and performance of synthetic motor oil was developed from case studies by Tellus and SAIC.

Initial Assumptions and Calculations

SAIC/Tellus began the case study by reviewing the relevant literature. The review showed that use of synthetic oil can affect oil filter life, engine life, and fuel consumption, compared to virgin oil. Using re-refined oil does not change oil filter life, engine life, or fuel consumption, compared to virgin oil. Therefore, this analysis is limited to comparing virgin oil and synthetic oil.[167] In light of this review, the life-span costing analysis for motor oil focuses on the following four cost categories:

- Motor oil
- Oil filters
- Engine wear
- Fuel consumption

The cost of motor oil and filters are directly related to the choice of motor oil. Engine wear and fuel consumption are indirectly related.

Table 1 shows the key assumptions for this case study, as well as certain initial calculations that are based upon these assumptions. The information provided in Table 1 represents the current best assessment of waste generation and cost characteristics associated with the choice of motor oil for City buses. This information is used to perform the life-span cost analysis. The details of the life-span analysis are presented in Tables 2 and 3. Assumptions and preliminary calculations required for the life-span analysis are provided in Table 1 and endnotes.

Table 1 – Key Assumptions and Initial Calculations[168]

Assumptions	Synthetic	Virgin	Calculations
BACKGROUND			
Miles traveled per year[169]	30,000	30,000	
Fuel efficiency (mpg)[170]	2.86	2.75	
Miles between engine replacement[171]	225,000	180,000	
Years between engine replacement	7.5	6.0	Miles between replacement/ Total miles traveled
Cost of engine replacement[172]	$10,250	$10,250	
Labor cost per hour[173]	$26.00	$26.00	

Table 1 – (continued) Key Assumptions and Initial Calculations[168]

Assumptions	Synthetic	Virgin	Calculations
Motor Oil			
Miles between oil change[174]	25,000	6,000	
Oil Changes per Year	1.2	5	Total miles traveled/Miles between oil change
Gallons of oil per oil change[175]	7	7	
Oil Filters			
Miles between oil filter change[176]	10,000	6,000	
Oil filter changes per year	3	5	Total miles traveled/Miles between change
PROCUREMENT AND INSTALLATION			
Motor Oil			
Cost per gallon of oil[177]	$13.00	$2.50	
Cost of oil for one change	$91.00	$17.50	Cost per gallon x Gallons per change
Hours to Change Oil[178]	0.5	0.5	
Labor Cost of Oil Change	$13.00	$13.00	Labor cost per hour x Hours to change oil
Oil Filter			
Cost of Oil Filter[179]	$1.59	$1.59	
Hours to Change Oil Filter[180]	0.17	0.17	
Labor Cost of Filter Change	$4.42	$4.42	Labor cost per hour x Hours to change filter
Fuel			
Cost per gallon of diesel fuel[181]	$0.83	$0.83	
Gallons of fuel used per year	10,490	10,909	Total miles traveled/Fuel efficiency
Cost of Fuel per Year	$8,707	$9,504	Cost per gallon x Gallons used per year
WASTE GENERATION AND MANAGEMENT			
Motor Oil			
Gallons of motor oil generated per year	8.4	35.0	Oil changes per year x Gallons per oil change
Weight of gallon of motor oil (pounds)[182]	7.3	7.3	
Pounds of motor oil generated per year	3.87	6.45	Gallons generated per year x pounds per gallon
Disposal cost per gallon of oil[183]	($0.02)	($0.02)	
Disposal Cost for Used Oil per Bus	($0.168)	($0.70)	Gallons per year x Disposal cost

Table 1 – (continued) Key Assumptions and Initial Calculations[168]

Assumptions	Synthetic	Virgin	Calculations
Oil Filters			
Weight of an oil filter (pounds)[184]	1.29	1.29	
Pounds of oil filters generated per bus	3.87	6.45	Weight of filter x Filter changes per year
Disposal Cost Per Ton[185]	$41.50	$41.50	
Disposal Cost Per Bus Per Year	$0.08	$0.13	Pounds generated/2000 x Disposal cost per ton
SUMMARY FINDINGS			
Total of Average Annual Costs	$10,163.26	$10,890.32	See Table 2 and accompanying discussion for details.

Life-Span Costing

The data in Table 1 will be used to develop average annual costs for oil, oil filters, engine wear, and fuel consumption for a bus using each oil option: virgin or synthetic. The sum of average annual costs for all four categories will provide a measure of the difference in life-span costs due to the choice of motor oil.

One might expect a life-span study of motor oil choice for buses to compare costs for two fleets of buses, one using virgin and the other synthetic motor oil, over some number of years. For bus service, comparing average annual costs does exactly that, since the cost over any number of years is simply the average annual cost times the number of years.

The process of converting costs to average annual costs will differ depending on how the costs are originally stated. A few examples will help to explain the process of annualizing costs.

- Based on the data in Table 1, buses using synthetic oil need oil change every ten months. Therefore, buses will need 1.2 oil changes per year. Since the cost of synthetic oil for one oil change is $91.00, the average annual cost of buying synthetic motor oil is $109.20 ($91.00 x 1.2 = $109.20).
- Bus engines cost $10,250. If the bus uses virgin motor oil, the engine will last 6 years. Thus the average annual engine cost for a bus using virgin motor oil is $1,708.33 ($10,250 ÷ 6 = $1,708.33).

In general, one year’s worth of each cost relevant to the case study must be identified. As the above examples show, what “one year’s worth” means may vary considerably, depending on the item in question.

Table 2 shows the average annual costs for a single bus using synthetic or virgin motor oil. These costs are obtained by annualizing the costs in Table 1. All the calculations necessary for annualization are explained in the endnotes. Table 3 shows average annual waste generation associated with each oil option. As in Table 2, the waste-generation information from Table 1 is annualized to provide the results shown in Table 3.

Table 2 – Cost Comparison of a Bus Using Two Motor Oil Options

Cost Category`	Synthetic	Virgin
Procurement Cost of Motor Oil per Year[186]	$109.20	$87.50
Labor Cost to Change Motor Oil per Year[187]	$15.60	$65.00
Disposal Cost of Used Motor Oil per Year[188]	($0.17)	($0.70)
Subtotal: Average Annual Cost of Motor Oil	$124.63	$151.80
Procurement Cost of Oil Filters per Year[189]	$4.77	$7.95
Labor Cost to Change Oil Filters per Year[190]	$13.26	$22.10
Disposal Cost of Used Oil Filters per Year[191]	$0.08	$0.13
Subtotal: Average Annual Cost of Oil Filters	$18.11	$30.18
Average Annual Engine Replacement Cost [192]	$1,366.67	$1,708.33
Average Annual Cost of Diesel Fuel [193]	$8,653.85	$9,000.00
Total of Average Annual Costs	$10,163.26	$10,890.32

Table 3 – Waste Generation Comparison of a Bus Using Two Motor Oil Options

Waste Generation Category	Synthetic	Virgin
Number of pounds of motor oil generated per year [194]	61.32	255.50
Number of pounds of oil filters generated per year[195]	3.87	6.45

Results

Basic Results

This analysis indicates that use of synthetic motor oil in buses would lower overall costs and prevent more waste than virgin motor oil. As shown in Table 2, synthetic motor oil use leads to lower annualized costs per bus than virgin motor oil use in all categories analyzed.

- Motor oil procurement, labor, and disposal costs are reduced by $27.17.
- Oil filter procurement, labor, and disposal costs are reduced by $12.07.
- Engine replacement costs are reduced by $341.66.
- Fuel costs are reduced by $346.15.

Overall, the use of synthetic oil saves $727.06 per bus per year. This is $2,583,978.52 for the entire fleet.

While one might expect that the greatest savings from using synthetic oil would come directly from decreasing the frequency of procurement and disposal of motor oil, this is not the case. Instead, the greatest annualized savings actually come from extending engine life and increasing fuel efficiency. Using synthetic motor oil also generates less waste per bus than does virgin oil—194 fewer pounds of oil and 2.6 fewer pounds of filters.

Sensitivity

The basic result of this analysis—the cost-effectiveness of using synthetic motor oil—is quite robust. The basic results show four separate sources of benefits due to the use of synthetic motor oil in buses. These are reductions in oil-related expenses, oil filter-related expenses, engine replacement costs, and fuel expenditures.

For example, even if a bus' oil must be changed every 6,000 miles, the use of synthetic oil would still result in a savings of $332 per bus per year. Alternatively, if synthetic oil offered no increases in engine life or in fuel efficiency, use of synthetic oil would still save $39 per bus per year.

One variable to consider is the driving conditions under which the vehicles operate. This case study made conservative assumptions assuming city driving conditions to reflect actual conditions of city buses. However, driving conditions that would increase or decrease expected oil lifespan may be taken into account by adjusting the relevant assumptions pertaining to time between oil changes.

Endnotes – *Motor oil*

[164] Virgin mineral motor oil and re-refined mineral oil have the same characteristics, but may differ in purchase price. DOS has a requirements contract available for re-refined motor oil.

[165] Facsimile transmission from Joe Smith, Technical Services & Maintenance Support, Metropolitan Transit Authority, to Susan Williams, Tellus, March 15, 1996.

[166] "Synthetic" motor oil refers to standard synthetic oil such as the Mobil 1™ series.

[167] Re-refined oil may differ in price from virgin oil; in all other aspects, its costs are the same as virgin oil. DOS has re-refined oil available on requirements contracts.

[168] Information sources and calculations are provided in notes to this section.

[169] Fax from Joe Smith, MTA, to Susan Williams, Tellus, March 15, 1996.

[170] Virgin: fax from Joe Smith, MTA, to Susan Williams, Tellus, March 15, 1996. Increase in fuel efficiency for synthetic oil based on "Synthetic lubricants cut food firm's truck operation and maintenance costs," case study supplied by Mobil.

[171] Lifetime of bus engine using virgin oil from fax from Joe Smith, MTA, to Susan Williams, Tellus, March 15, 1996. "Synthetic Lubricants Cut Food Firm's Truck Operation and Maintenance Costs," case study supplied by Mobil, page 1 shows an increase of 25% in engine life from using synthetic oil.

[172] Average cost of an engine replacement based on fax from Joe Smith, MTA, to Susan Williams, Tellus, March 15, 1996. Engine replacement costs between $8,000 and $12,500, depending upon the condition of the engine at replacement.

[173] Telephone conversation between Bill Wallace, NYC Transit, and Susan Williams, Tellus, 4/8/96. This is an approximate labor cost that includes wages and overhead.

[174] Synthetic: "Synthetic Lubricants Save Fleet Maintenance Dollars," case study supplied by Mobil, p. 2. Virgin: fax from Joe Smith, MTA, to Susan Williams, Tellus, March 15, 1996.

[175] Fax from Joe Smith, MTA, to Susan Williams, Tellus, March 15, 1996. City buses require 20-36 quarts of motor oil per oil change. We used the average, 28 quarts, or 7 gallons.

[176] Synthetic: "Synthetic Lubricants Save Fleet Maintenance Dollars," case study supplied by Mobil, p. 2. Virgin: fax from Joe Smith, MTA, to Susan Williams, Tellus, March 15, 1996.

[177] Synthetic: Science Applications International Corporation, "Replace Oil Used in Internal Combustion Engines with Synthetic Oil," p. 1. Virgin: fax from Joe Smith, MTA, to Susan Williams, Tellus, March 15, 1996.

[178] Fax from Joe Smith, MTA, to Susan Williams, Tellus, March 15, 1996.

[179] Tellus Institute, "U.S.P.S. Hartford Vehicle Maintenance Facility Waste Minimization/Pollution Prevention Study," December 1994, unpublished notes.

[180] Fax from Joe Smith, MTA, to Susan Williams, Tellus, March 15, 1996.

[181] Conversation between Susan Williams and Bill Wallace, NYC Transit, 4/8/96.

[182] Mobil Lubricant Support Network (tel: 1-800-662-4525) provided this estimate of a typical weight of a gallon of motor oil to Susan Williams, Tellus, on June 7, 1996.

[183] SAIC study of AARBEE oil's contract with the City. The contract calls for the City to be paid 2¢ per gallon of used motor oil supplied to AARBEE. Thus, the cost of disposal is negative, at -2¢ per gallon.

[184] In an April 8, 1996, draft of its New York City Waste Stream Composition Analysis -Vehicle Associated Products, SAIC estimated that there are approximately 6.34 million oil filters, weighing 4,098 tons in the City waste stream. Therefore, each filter weighs approximately 1.29 pounds (6,340,000 filters divided by 4,098 tons divided by 2000 pounds per ton equals 1.29 pounds per filter).

[185] *New York City Solid Waste Management Plan: Final Update and Plan Modification,* February 15, 1996, pp. 3-26.

[186] Cost of oil required for one oil change multiplied by 12 (months per year) divided by number of months between oil changes.

[187] Labor cost of an oil change multiplied by 12 (months per year) divided by number of months between oil changes.

[188] Cost of disposal per gallon of motor oil, multiplied by gallons of motor oil generated per year. Since revenue is received for motor oil recycling, cost of disposal is negative.

[189] Number of air filter changes required per year multiplied by cost of an oil filter.

[190] Number of air filter changes required per year multiplied by labor cost of an oil filter change.

[191] Number of pounds of oil filters generated per year divided by 2000 (pounds per ton) multiplied the cost of waste disposal per ton. See DOS Overview.

[192] Cost of engine replacement divided by number of years between engine replacements.

[193] Number of gallons of fuel used per year multiplied by cost per gallon of diesel fuel.

[194] See Table 1, this section, for details.

[195] See Table 1, this section, for details.

9. PHOTOCOPIERS – CASE STUDY

Introduction

The SAIC/Tellus team, in consultation with BWPRR and the Department of Citywide Administrative Services, selected copiers as the focus of one case study because the City makes a large number of copies in its copy centers and the City can save money and create less paper waste by duplexing its copies whenever possible. The consultant, in consultation with BWPRR and DCAS, elected to compare buying and using Energy Star copiers with non-Energy Star copiers of the class that are generally found in copy centers. Energy Star is a program run by the United States Environmental Protection Agency and the Department of Energy. Energy Star copiers are designed to conserve energy by automatically shutting off after a certain period of inactivity and by pre-setting high-volume copiers to duplex (double-siding) mode as the default.[196] Because duplex is the default mode on Energy Star copiers, more duplex copies are generally made on them than on conventional copiers. On conventional copiers, users receive single-sided copies unless they choose the "duplex" option. On Energy Star copiers, the opposite is the case; users must choose the "single-sided" option in order not to receive duplex copies.

The City of New York has a number of requirements contracts for copiers. Contracts for purchase of copiers have specified use of Energy Star machines since May 31, 1996. New rental requirements specified the use of Energy Star machines as of April 1, 1997.[197]

Analysis

This case study examines the cost and waste stream impacts of buying and using three copiers that are rated by the manufacturers as capable of copying at least up to 100,000 copies per month: the Canon NP 6060, the Xerox 5065 (both conventional copiers), and the Savin 9650, an Energy Star copier with the duplex default mode.[198] These copiers are not currently available on City requirements contacts.[199] The life-span cost analysis shows the following results:

- The Savin 9650,[200] an Energy Star copier, has lower average annual costs than the two non-Energy Star copiers studied. Using a Savin would save the City $1,998 annually compared to the Canon and $2,547 annually compared to the Xerox.
- In addition to savings in operational costs through the use of less electricity and reduced paper usage, the Savin 9650's purchase price is lower than those of the two other copiers studied. Its purchase price is $6,470 less than the Canon's and $9,770 less than the Xerox's.

This study does not account for staff time due to slower duplex copying or savings due to reduced storage and mailing costs for duplex copies. These costs and benefits are difficult to quantify. However, the results of sensitivity analysis suggest that these costs and benefits are likely to offset each other.

In older technology,[201] a higher duplex rate could lead to increased paper jamming. However, the Savin, and all Energy Star copiers, are designed to be used in duplex mode. While copiers with older technology may have caused more paper jams while duplexing, manufacturers have confronted this issue and believe that no significant increase in paper jamming will occur when Energy Star copiers are running in duplex mode. Therefore, increased duplexing is not expected to result in increased maintenance costs. [202]

Three high-volume copiers, rated to make up to 100,000 copies per month, were selected as the focus of this case study. They are the class of copier typically found in a professional copy center.

Initial Assumptions and Calculations

SAIC/Tellus began the case study by reviewing the relevant literature on high-volume copiers. The review showed that purchase price, maintenance costs, developer and toner costs, electricity costs, and paper disposal costs are factors to consider in a comparison of copiers.

Table 1 shows the key assumptions for this case study, as well as certain initial calculations that are based upon these assumptions. The information provided in Table 1 represents the current best assessment of cost and waste generation characteristics associated with the choice of copier.[203] This information is used to perform the life-span cost analysis. The details of the life-span analysis are presented in Tables 2 and 3 below. Assumptions and preliminary calculations required for the life-span analysis are provided in Table 1 and endnotes.

Among other things, EPA assumes that 67 percent of Energy Star copies will be duplex because that is the default setting; therefore, we have used a 67 percent duplex rate for the Savin. On conventional copiers of this class (the Xerox and Canon in this case) where single siding is the default option, only an estimated 18% of copies are duplex; users of these copiers must specifically elect to receive duplex copies.[204]

Table 1 – Key Assumptions and Initial Calculations[205]

Assumption/Calculation	Canon NP 6060	Xerox 5065	Savin 9650	Calculations
BACKGROUND				
Is Copier Energy Star?[206]	No	No	Yes	
Number of Years before Copier Replacement[207]	5	5	5	
Number of Copies Made per Year[208]	1,200,000	1,200,000	1,200,000	
Duplexing Rate[209]	18%	18%	67%	
Number of Sheets of Paper per Case[210]	5,000	5,000	5,000	
PROCUREMENT AND INSTALLATION				
Purchase Cost of a Copier[211]	$24,300	$27,600	$17,830	
Maintenance Cost per Copier per Year[212]	$10,800	$10,800	$10,800	

Table 1 – (continued) Key Assumptions and Initial Calculations[205]

Assumption/Calculation	Canon NP 6060	Xerox 5065	Savin 9650	Calculations
Paper				
Number of Sheets of Paper Used per Year	1,092,000	1,092,000	798,000	Copies per year x (1-.05 x Duplexing rate)[213]
Number of Cases Required per Year	218.4	218.4	159.6	Sheets used per year/ Sheets per case
Cost per Case of Paper[214]	$35.00	$35.00	$35.00	
Annual Paper Procurement Costs	$7,644	$7,644	$5,586	Cases per year x Cost per case
Toner Cartridges				
Number of Copies per Toner Cartridge[215]	33,000	16,000	38,000	
Number of Toner Cartridges Required per Year[216]	36.4	75.0	31.6	Total copies/Copies per cartridge
Cost per Toner Cartridge[217]	$147.00	$55.60	$182.50	
Annual Cost of Toner Cartridges	$5,351.00	$4,170.00	$5,767	Number of cartridges x Cost per cartridge
Number of Copies per Developer Cartridge[218]	N/A	240,000	120,000	
Number of Developer Cartridges Required	NA	5	10	Total copies/Copies per cartridge
Cost per Developer Cartridge[219]	$0.00	$213.00	$110.00	
Cost for Developer Cartridges	$0.00	$1,065	$1,100	Number of cartridges x Cost per cartridge
WASTE GENERATION AND MANAGEMENT				
Weight of Case of Paper (in pounds)[220]	50	50	50	
Pounds of Paper Disposed per Year[221]	10,920	10,920	7,980	Cases per year x Weight per case
Disposal Cost (per ton)[222]	$41.50	$41.50	$41.50	
Paper Disposal Cost	$226.60	$226.60	$165.59	Pounds per Year/2000 x Disposal cost
ENERGY USE AND COSTS				
Kilowatt Hours of Electricity Used per Year[223]	3,942.0	3,942.0	1,372.4	
Cost per Kilowatt Hour[224]	$0.04	$0.04	$0.04	
Annual Energy Costs per Unit	$157.68	$157.68	$54.90	kWh per year x Cost per kWh
SUMMARY FINDINGS				
Total Average Annual Costs	$29,034	$29,583	$27,036	See Table 2 and accompanying text for details.

Life-Span Costing

The data in Table 1 will be used to develop average annual costs for copier procurement and disposal. The sum of average annual costs will provide a measure of the difference in life-span costs due to the choice of copier.

The process of converting costs to average annual costs will differ depending on how the costs are originally stated. An example will help to explain the process of annualizing costs.

- Table 1 shows that one toner cartridge for the Xerox costs $55.60. Since 75 cartridges are needed per year, the average annual cost of toner cartridges for the Xerox is $4,170 ($55.60 x 75 = $4,170).

In general, one year's worth of each cost relevant to the case study must be identified.

Table 2 shows the average annual costs for copier options. These costs are obtained by annualizing the costs in Table 1. All the calculations necessary for annualization are explained in the endnotes. Table 3 shows average annual waste generation associated with each copier option. As in Table 2, the waste-generation information from Table 1 is annualized to provide the results shown in Table 3.

Table 2 - Cost Comparison of Copiers

Cost Category	Canon NP 6060	Xerox 5065	Savin 9650
Copier Procurement[225]	$4,860	$5,520	$3,566
Copier Maintenance[226]	$10,800	$10,800	$10,800
Paper Procurement[227]	$7,644	$7,644	$5,586
Paper Disposal[228]	$226.59	$226.59	$165.59
Toner Procurement[229]	$5,345.45	$4,170.00	$5,763.16
Developer Procurement[230]	$0.00	$1,065.00	$1,100.00
Electricity Use[231]	$157.79	$157.79	$54.93
Total of Average Annual Costs	$29,034	$29,583	$27,036

The results in Table 2 reflect purchase rather than leasing of a copier. Leasing arrangement can reduce the annual cost of copier procurement. Assuming that leasing affects all three copiers similarly (***i.e.,*** results in the same percentage decrease for all three), the only effect of leasing is to decrease the size of the savings due to choosing the Savin. This Energy Star copier will always be the least cost choice. However, leases can be quite complex and terms may differ for different brands of copiers. However, unless leasing results in additional annual savings of at least $1,998 for the Canon or $2,547 for the Xerox, the Savin will remain the low cost alternative.

Leasing arrangements can easily be compared using the spreadsheets designed for this study. In Table A of the Excel spreadsheet which accompanies this study, corresponding to Table 1 above, one simply enters the average annual lease payment instead of the "Purchase Cost of a Copier" in the second row and the number "1" instead of the "Number of Years before Copier Replacement" in the third row. All other data can be entered just as before, taking due note of lease terms that may affect maintenance costs or other terms. Used in this way, the spreadsheet will accurately compare the costs of leasing copiers.

Table 3 - Waste Generation Comparison of Copiers[232]

Waste Generation Category	Canon NP 6060	Xerox 5065	Savin 650
Pounds of Paper Generated per Year [233]	10,920	10,920	7,980

Results

This analysis indicates that use of the Savin 9650 results in lower overall costs than does the use of Canon NP 6060 or the Xerox 5065.

Basic results

As shown in Table 2, the cost assumptions show that using the Savin:

- Saves $1,294 over the Canon (the closest to it in procurement price) in copier procurement cost per year;
- Saves $2,058 per year over the Canon or Xerox in annual paper procurement costs;
- Saves $61 per year in paper disposal costs (assuming a $41.50 disposal cost per ton; other scenarios are explored in the Sensitivity section which follows.);
- Saves $417 for toner procurement per year compared to the Canon, but costs $1,593.16 more per year for toner procurement than does the Xerox;
- Costs $35 more per year for developer procurement than does the Xerox, but costs $1,100.00 more per year than the Canon, which does not require developer; and
- Saves $102.86 over the Canon or Xerox in annual electricity costs.

Overall, the use of the Savin saves $1,998 annually compared to the Canon and $2,547 compared to the Xerox.

Sensitivity

The results of this case study are quite robust. That is, even if there is some variation in the cost and other assumptions, the Savin copier has the lowest average annual costs. The discussion that follows will help to illustrate this point, providing examples relating to:

- procurement costs,
- disposal costs,
- maintenance costs,

- toner and developer cartridge disposal costs, and
- time associated with duplexing.

For instance, even if all three copiers are procured at the Savin's purchase price of $17,830, the Savin has the lowest average annual costs. Even if the duplex rates were assumed to be the same for all copiers at 67 percent, the Savin is still competitive, having average annual costs $121 higher than those of the Canon, and $429 lower than those of the Xerox.

Paper disposal costs or benefits do not affect the study's results. The Savin still has the lowest average annual costs if paper disposal is assumed to be without cost (disposal cost of $0 per ton) or to generate $5 or $100 per ton from recycling revenues. For example, if paper is assumed to generate $5 per ton through recycling, the Savin costs $1,930 less than the Canon and $2,479 less than the Xerox.

Moreover, even if average annual costs for maintenance are $1,800 lower for the Xerox and the Canon than for the Savin, the Savin copier still has average annual costs that are $198 lower than those of the Canon and $748 lower than the Xerox.

Inclusion of waste disposal costs from toner and developer cartridges do not change the results of the analysis. Used toner cartridges weigh about 2.4 pounds each while used developer cartridges weigh about 5 pounds each. Including the cost of their disposal changes the average annual costs by no more than $5 per year for any copier.[234]

The higher duplexing rate of the Savin saves 588,000 sheets of paper annually, but the increased duplexing will increase copying time. However, a quick analysis shows that the Savin is still the most cost-effective choice. Since the copiers are expected to make 1,200,000 copies per year, this means that they are averaging 9.6 copies per minute during a 40-hour per week period of operation.[235] All three copiers' copying speeds are higher when running (whether making duplex copies or single-sided copies) than this average. Therefore, even with the Savin's increased duplexing (and resulting lower copying speed), it will still be able to make 1,200,000 copies per year[236] and in all likelihood will not create additional labor or machine costs at a copy center.

If all the copies were made by office staff (not copy center staff), then these staff would experience 91.5 hours of additional waiting time at the copier.[237] At $20 per hour in lost labor time, this would add $1,860 in costs to the Savin.[238] However, duplexing also saves a variety of costs including rent for space to store copy paper and files, filing cabinet purchase costs, and mailing costs. These costs are hard to quantify, but researchers at Lawrence Berkeley Laboratories have shown that the cost of filing cabinets is between $0.008 and $0.024 per sheet stored, depending on the style and quality of the filing cabinet. If only 25 percent of copies are filed, the saving on the mid-range cabinet price due to the storage of duplexed material is $2,352.[239] If the filing cabinet lasts ten years, the savings due to reduced filing cabinet purchases with the Savin is $235 per year.[240]

The preceding discussion, while far from complete, does show how the analysis would be affected if additional factors were included. If half of the copies were made by office staff and half by copy center staff, savings from the Savin would be at least $1,068 per year.[241] If, as one might expect for machines of this size, most of the copies were made at copy centers, the benefits due to the Savin would be greater.

The sensitivity analysis suggests that, even if one accepts the likelihood of some additional waiting due to duplexing, and perhaps more conservative assumptions regarding the length of time standard copiers remain on in "high" mode, the benefits still will outweigh the costs.

Endnotes – *Photocopiers*

[196] EPA's brochure, *Purchasing An Energy Star Copier,* July 1995.

[197] Memorandum from Virginia G. Ross, Deputy Commissioner, Department of Citywide Services (formerly Department of General Services), Division of Municipal Supply Services, to Martha K. Hirst, Deputy Commissioner, Department of Sanitation, June 19, 1996.

[198] *Energy Star Office Equipment Database - Copiers,* May 1, 1996, p. 2.

[199] Conversation with Carol Green, DCAS, May 19, 1997.

[200] The Savin 9650 is also sold as the Ricoh FT 6665. According to Phil Bush of Offtech, Ricoh owns Savin. Offtech is a copier distribution agent; it sells copiers and supplies and provides service for copiers.

[201] "Older technology" refers to machines that were not designed to have duplex copying as the default mode.

[202] Conversation between Susan Williams, Tellus, and Allison Watkins, Lawrence Berkeley Laboratories, Washington, DC, February 5, 1997. Paper specifications are also important in paper jams. Some manufacturers have very specific guidelines for the paper to be used; in general, high-quality recycled content paper can be used.

[203] The sources for this information are fully explained in the endnotes, this section.

[204] The difference in duplexing rates reflects the characteristics of the equipment being compared. On the Energy Star machine, the user has to change the machine setting to get a single-sided copy; on the other two machines, the user has to change the settings to duplex.

[205] Information sources and calculations are provided in notes to this section.

[206] *Energy Star Office Equipment Database - Copiers,* May 1, 1996.

[207] Buyers Laboratory Inc., *BLI Copier Specification Guide,* Spring 1995.

[208] Buyers Laboratory Inc., *BLI Copier Specification Guide,* Spring 1995. Each of the copiers listed is rated to copy up to 100,000 copies per month—1,200,000 copies per year.

[209] According to the INFORM report, *Reducing Office Paper Waste* by Robert Graff and Bette Fishbein, copiers in this class (Class 4) have a duplex rate of approximately 18 percent. In its *Purchasing An Energy Star Copier* brochure, EPA assumes a duplex rate of two-thirds for Energy Star copiers.

[210] *BLI Copier Specification Guide.*

[211] Buyers Laboratory Inc., *BLI Copier Specification Guide,* Spring 1995.

[212] Philip Bush of Offtech provided a rough estimate for copier maintenance of $0.009 per copy. At 1,200,000 copies per year, this per-copy cost would result in a $10,800 maintenance cost per year.

[213] Copies per year x (1 - 0.5 x Row 6). This calculation applies the formula developed for the INFORM report, *Reducing Office Paper Waste.*

[214] *BLI Copier Specification Guide.*

[215] *BLI Copier Specification Guide.*

[216] *BLI Copier Specification Guide.*

[217] For the Canon and Xerox copiers, prices were obtained from the *BLI Copier Specification Guide.* For the Savin copier, price for toner was provided by Philip Bush of Offtech in a telephone conversation on June 18, 1996.

[218] *BLI Copier Specification Guide.* The Canon does not require developer.

[219] For the Canon and Xerox copiers, prices were obtained from the *BLI Copier Specification Guide.* For the Savin copier, price for toner was provided by Philip Bush of Offtech in a telephone conversation on June 18, 1996.

[220] *BLI Copier Specification Guide.*

[221] Although all paper used in a year will not be discarded in that year, this analysis assumes a steady state relationship, over time, between purchases and discards.

[222] *New York City Solid Waste Management Plan: Final Update and Plan Modification,* February 15, 1996, pp. 3-26.

[223] According to EPA's *Purchasing An Energy Star Copier,* conventional and Energy Star copiers in this class use 450 Watts in High mode. Because of their auto-off mode, Energy Star copiers are assumed to be in High mode 8 hours per day while non-Energy Star copiers are assumed to be in High mode 24 hours per day.

[224] According to EPA's *Purchasing An Energy Star Copier,* a typical kilowatt hour rate is 8 cents.

[225] Purchase Cost of a Copier /Number of Years Before Copier Replacement.

[226] See Table 1, this section, for details.

[227] Number of Cases Required per Year x Cost per Case of Paper.

[228] Pounds of Paper Disposed per Year x Cost per Ton of Paper Disposed / 2000. See DOS Overview.

[229] Number of Toner Cartridges Required per Year x Cost per Toner Cartridge.

[230] Number of Developer Cartridges Required per Year x Cost of Developer Cartridge.

[231] Kilowatt-hours of Electricity Used per Year x Cost per Kilowatt-Hour.

[232] The impact of toner and cartridge waste is addressed in the following section, "Sensitivity."

[233] Number of Cases Required per Year x Weight of Case of Paper in Pounds.

[234] Tellus staff weighed a used Xerox toner on a postal scale. Its weight was 2.4 pounds. It is assumed that the weights of the other toner cartridges are similar. Jim Lane of Copy Cop (Boston, MA) said that the developer cartridges weigh approximately 6 pounds when full. Therefore, it is reasonable to assume that they weigh no more than 5 pounds when empty.

[235] Copiers that make 1,200,000 copies per year make an average of 9.6 copies per minute of the work week: 52 weeks per year x 5 days per week x 8 hours per day x 60 minutes per hour = 124,000 minutes of working time per year. If the copy center is open more than 8 hours per day, then the average number of copies made per minute is even lower.

[236] This is still assuming a 40-hour work week.

[237] The Savin saves 588,000 copies per year because its duplex rate is 49 percentage points higher than the duplex rate of the Xerox and the Canon (as shown in Table 1). If, as shown in Table 1, all copiers make 1.2 million copies per year, then: 0.49 x 1,200,000 = 588,000 copies. According to BLI Copier Specification Guide, the Xerox makes single-sided copies from single-sided originals at a rate of 49 copies (images) per minute while the Canon performs the same action at a rate of 55 copies per minute. Therefore, their average single-siding copying speed is 52 copies per minute. According to BLI Copier Specification Guide, the Savin makes double-sided copies from single-sided originals at a rate of 35 copies (images) per minute. Because of the Savin's higher duplexing rate, it will require longer to produce the copies that would have been single-sided on the Xerox or Canon. The Savin will require 91.5 additional hours of copying time because: (1/35 -1/52) x 588,000/60 = 91.5 hours.

[238] 91.5 hours x $20/hour = $1,830.

[239] Since each sheet not stored saves between $0.008 and $0.024, the per-sheet savings with an average priced filing cabinet is $0.016 because: ($0.008 + $0.024)/2 = $0.016. $0.016 per sheet stored x 25/100 percent of all copies that are stored x 588,000 fewer sheets produced with Savin through higher duplexing = $2,352.

[240] This assumes just one year of storage per filed sheet of paper.

[241] The Savin saves $1,998 per year in total average annual costs compared to the Canon (and more compared to the Xerox). Therefore, the savings should be: $1,998 – ($1,860/2) = $1,068. Savings compared to the Xerox are even greater.

10. REPLACEMENT SLATS FOR PARK BENCHES – CASE STUDY

Introduction

The SAIC/Tellus team, in consultation with BWPRR and the Department of Citywide Administrative Services, selected the slats in park benches as one of the case studies because two options, with differing cost and waste generation characteristics, are available.

This case study examines the cost and waste stream impacts of buying and using wooden and recycled plastic slats (*i.e.,* boards) for park benches in the New York City Department of Parks and Recreation ("Parks"). The City spends a significant amount of money each year to replace worn and vandalized wooden slats with new wooden replacement slats. The City also has at least three styles of benches that require slats of differing dimensions. The City also buys several types of wood, each with its own life span and price ranges. It is necessary to compare plastic slats to a specific type of wooden slat. Burrell Studs wooden slats are the focus of this case study because they are available in dimensions that could be replaced one-for-one by plastic lumber.

The basic result of this analysis is that, for each bench that used slats made of recycled plastic instead of Burrell Studs wood, the City would save $2.81 per bench each year.[242] Specifically, each year, the City would:

- Save $0.91 in slat procurement costs, but spend an additional $1.25 per bench on procurement costs for bracing the plastic lumber;
- Save $1.87 in labor costs;
- Save $0.75 on paint, but spend $0.13 on paint thinner instead; and
- Prevent about 32 pounds of waste and save $0.66 in disposal costs.

Based on 1997 purchases of Burrell Studs slats, on an annual basis, the City would save $5,331 and prevent 60,495 pounds of waste by changing from the Burrell Studs wooden slats to plastic slats.[243] The way these savings were calculated (*i.e.,* through the application of life-span costing) is fully explained in the Analysis and Life-Span Costing Sections of this case study.

Recycled plastic bench slats differ significantly from wooden bench slats in their expected life spans. Using life-span costs to compare the two products ensures an accurate analysis of the overall cost for bench slats.

It should be noted that the life-span analysis framework developed in this case study can be used to analyze slats made from other types of wood. In addition, the framework can be used to analyze other types of products in which wood could be replaced with recycled plastic lumber, such as picnic table sets or park signs. The City may be able to save an additional amount by changing its other types and uses of wood to plastic lumber.

Analysis

Slats in the park benches managed by the New York City Department of Parks and Recreation are the focus of this case study. The NYC Department of Parks and Recreation provided information on the characteristics of the systems in place and labor maintenance requirements. This information was supplemented by cost, lifetime, and other information provided by the plastic lumber manufacturers and distributors.

Initial Assumptions and Calculations

SAIC/Tellus began the case study by gathering background information on park benches and plastic lumber. This review showed that purchase price, maintenance costs, frequency of park bench slat replacement, and costs of disposal were relevant to the analysis.

Table 1 and the endnotes show the key assumptions for this case study, as well as certain initial calculations that are based upon these assumptions. The information provided in Table 1 represents the current best assessment of cost and waste generation characteristics associated with the choice of material used for park bench slats.[244] This information is used to perform the life-span cost analysis. The results of the life-span analysis are presented in Tables 2 and 3. The impact of variations from the base case assumptions on the costs and characteristics is explored in the final section of this case study, "Sensitivity."

Table 1 – Key Assumptions and Initial Calculations for Options for a Park Bench[245]

Assumption/Calculation	Wood	Plastic	Calculations
BACKGROUND			
Number of Slats per Bench[246]	4	4	
Average Life-Span of Bench Slats[247]	6	50	
Average Life-Span of Bracing[248]	50	50	
PROCUREMENT AND INSTALLATION			
Price of a Bench Slat[249]	$3.67	$19.20	
Price of Bracing[250]	$0.00	$62.50	
Costs of Slats for One Bench	$14.68	$76.80	Price of slat x Number of slats per bench
Labor Hours to Install Slats for One Bench[251]	0.75	0.75	
Labor Cost per Hour[252]	$17.00	$17.00	
Labor Cost of Installing Slats for One Bench	$12.75	$12.75	Labor cost per hour x Labor hours required
MAINTENANCE			
Average Annual Cost of Painting[253]	$0.75	$0.00	See endnote for calculations.
Average Annual Cost of Graffiti Removal[254]	$0.00	$0.13	See endnote for calculations.

Table 1 – Key Assumptions and Initial Calculations for Options for a Park Bench[245]

Assumption/Calculation	Wood	Plastic	Calculations
WASTE GENERATION AND MANAGEMENT			
Weight of Slats for One Bench (in Pounds)[255]	216	205	
Cost of Disposal (per Ton)[256]	$41.50	$41.50	
Disposal Cost for One Bench	$0.75	$0.09	Weight of slats in pounds/2000 x Cost per ton for disposal/ Avg. lifespan of slats
SUMMARY FINDINGS			
Total Average Annual Costs per Bench	$6.07	$3.26	See Table 2 and accompanying discussion for details.

Life-Span Costing

The data presented above in Table 1 will be used to develop average annual costs for bench slat procurement and disposal. The sum of average annual costs will provide a measure of the difference in life-span costs due to the choice of bench slat.

An example will help to explain the process of annualizing costs.

- Table 1 shows that wooden slats for one bench cost $14.68 and last 6 years. Therefore, the average annual purchase cost of wooden slats for one bench is $2.45 ($14.68 / 6 = $2.45).

In general, one year’s worth of each cost relevant to the case study must be identified.

Table 2 shows the average annual costs for bench slat options. These costs are obtained by annualizing the costs in Table 1. All the calculations necessary for annualization are explained in the endnotes. Table 3 shows average annual waste generation associated with each bench slat option. As in Table 2, the waste-generation information from Table 1 is annualized to provide the results shown in Table 3.

Table 2 – Cost Comparison of Bench Slat Options for One Park Bench[257]

Cost Category	Wood	Plastic
Average Annual Purchase Cost of Bench Slats[258]	$2.45	$1.54
Average Annual Cost of Labor to Install Slats[259]	$2.13	$0.26
Average Annual Costs of Bracing[260]	$0.00	$1.25
Average Annual Cost of Painting[261]	$0.75	$0.00
Average Annual Cost of Graffiti Removal[262]	$0.00	$0.13
Average Annual Cost of Disposal[263]	$0.75	$0.09
Total Average Annual Costs Per Bench	$6.07	$3.26
Savings of Plastic Option Compared to Wood Option[264]	$2.81	N/A

Table 3 – Waste Generation Comparison of Bench Slat Options for One Park Bench

Waste Generation Category	Wood	Plastic
Pounds of Lumber Generated Per Bench Per Year[265]	36.00	4.11

Results

Basic results

The basic result of this analysis is that, for each bench that used slats made of recycled plastic instead of Burrell Studs wood, the City would save $2.81 each year.[266] For each bench, the City would:

- Save $0.91 in slat procurement costs, but spend an additional $1.25 per bench on procurement costs for bracing the plastic lumber;
- Save $1.87 in labor costs;
- Save $0.75 on paint, but spend $0.13 on paint thinner instead; and
- Prevent about 32 pounds of waste and save $0.66 in disposal costs.

Based on 1997 purchases of Burrell Studs slats, on an annual basis, the City would save $5,331 and prevent 60,495 pounds of waste by changing from the Burrell Studs wooden slats to plastic slats.[267]

Table 2 shows that, on an annualized basis, most of the savings associated with the plastic slats comes from avoided labor costs: installing new plastic slats every 50 years rather than new wooden ones every 6 years. The impact of avoided painting is not as significant because the benches are currently painted by those in the Work Experience Program, at no cost to the City. If the Work Experience Program were no longer available, the City would experience additional labor savings from switching to plastic slats, as noted in the “Sensitivity” section.

Sensitivity

The cost-effectiveness of using plastic slats for park benches is sensitive to some of the assumptions made in the analysis. These include:

- the estimated lifespan of bench slats and
- labor costs for painting and graffiti removal.

The lifetime used for the plastic and wooden bench slats may have the most significant effect on the analysis’s outcome. If the lifetime of the plastic slats is reduced to 26 years, plastic costs about equal those of the wood. However, tests conducted by Trex and other manufacturers of plastic lumber indicate that a life expectancy of greater than 26 years for new generations of plastic lumber is realistic.

The lifetime of wooden slats and other cost assumptions have less effect on the study's results. Wood's lifetime was estimated as ranging from 3 to 10 years. If wood lasted only 3 years compared to the 50-year lifetime estimated for plastic, wood's cost would increase to $11.39, compared to plastic's $3.26 per bench. If wood lasted 10 years, the wooden slats would still be more expensive than the plastic ones, at $3.94 per bench. If a plastic slat cost $54 rather than $19.20, or if the bracing for the plastic cost $203 instead of $62.50, the costs of the two materials would be equal. The cost of graffiti removal would have to be $2.94 per bench rather than $0.13 for the costs of wood and plastic to be equal.

This analysis reflects the current arrangements for maintenance personnel at Parks; Work Experience Program workers are used to paint the benches, at no cost to the City. It is assumed that these workers would also remove graffiti from plastic slats with paint thinner at no labor cost. However, if these workers were no longer available at no cost, the City would see increased labor costs associated with park bench slat maintenance. If one assumes that these workers would earn $10 per hour and that painting a bench would take 15 minutes, the average cost of wooden slats would increase by $2.50 per bench annually, for a total of $8.57. Of course, removing graffiti from plastic slats would also have a cost in this case. However, since graffiti removal addresses only the defaced area while the entire bench must be painted, graffiti removal is likely to be less time-consuming than painting. Assuming that these workers would earn $10 per hour and that removing graffiti took half as long as painting, the cost of plastic slats would increase by $1.25, for a total of $4.51 per bench annually. This is a savings of $4.06 per bench per year.

Endnotes – *Replacement slats for park benches*

[242] Average annual costs of a bench with wooden slats is $6.07. The cost of a bench with plastic slats is $3.26, an overall savings of $2.81 per bench.

[243] Parks spent $27,852 on Burrell Studs wooden slats in FY 1997. Fax from Scott Godsen, NYC Department of Parks and Recreation, 3/25/97. No more bench slat purchases were planned in FY 1997. As will be explained in the body of the case study, the four slats needed for one bench cost $14.68. This means that the slats for 1,897 benches were replaced, since $27,852 ($14.68 = 1,897 benches. 1,897 benches x $2.81 = $5,331. 1,897 benches x 31.89 pounds = 60,495 pounds.

[244] The sources for this information are explained in the notes to Table 1, this section.

[245] Information sources and calculations are provided in notes to this section.

[246] Conversation with Bernadette Grullon, Parks. Parks has more than one type of bench. Other benches require more slats that are not as wide as these. This style of bench was chosen for the study because Grullon said that Parks believed these slats could be replaced one-for-one with plastic lumber.

[247] Wood: Conversation with Greg Monahan. Monahan estimated that wooden slats may last from 3 to 10 years, depending on a variety of factors, including location, weather, and quality of the wood. Plastic: Since plastic does not decompose and graffiti damage to plastic is repairable, plastic lumber's lifetime is indefinite. The 50-year estimated lifetime is based on the warranty from Earth Care products, a plastic lumber manufacturer.

[248] Bracing is estimated to last 50 years, since the materials are likely to be either galvanized steel or plastic lumber. The bracing would become part of the bench structure. The structure of the bench lasts indefinitely; the only part of the bench that requires periodic replacement is the slat.

[249] The price for wooden slats is the average paid for Burrell Studs wood by the New York City Department of Parks and Recreation for FY 1997, according to fax from Scott Godsen, Assistant to the Commissioner for Citywide

Services, Parks. Burrell Studs is one of several types of wood that Parks purchases for use as bench slats. Each type of wood has different cost and life-span characteristics. American EcoBoard, a plastic lumber distributor, provided its government price list, which has been used for the plastic slat price. American EcoBoard's prices were used because Parks has been in discussion with them about the potential use of plastic lumber for bench slats (Parks has also discussed using plastic lumber with other distributors). The bench slats considered in this study are 8 feet long, 3 inches thick, and 8 inches wide. American EcoBoard lists prices by the foot. It is assumed that Parks would order green plastic slats, which would cost $2.40 per foot ($2.40 x 8 = $19.20). Other colors are available from American EcoBoard for $2 per foot.

[250] Conversation with Tom Moyer, All City Play Equipment, a local NYC distributor of plastic lumber. Moyer estimated that a support would cost between $50 and $75 per bench; $62.50 is the midpoint of this range.

[251] Conversation with Greg Monahan, Borough of Queens, Parks. Monahan estimated the approximate labor time to install slats in one bench as "under an hour."

[252] Conversation with Greg Monahan, Borough of Queens, Parks.

[253] Participants in the Work Experience Program paint the benches at no cost to Parks. Parks buys its paint for $6.10 per gallon. Each gallon should cover about 400 square feet of surface area. A park bench has about 50 square feet of surface area, excluding the bottom side of the slats that provide the seat of the bench (which is assumed not to be painted); a gallon will cover approximately 8 benches. Therefore, it costs about $0.75 to paint one bench ($6.10 / 8 = $0.75). Details may not calculate exactly due to rounding.

[254] Conversation with Ron Kwaikowski, American EcoBoard. Their plastic lumber is "graffiti-proof;" that is, graffiti is easily removable. Kwaikowski recommended cleaning the slats with paint thinner and steel wool. Paint thinner costs about $2 per gallon retail. This analysis assumes that a gallon of paint thinner can be used on twice as many benches as a gallon of paint, although it seems likely that the paint thinner would go even further. Therefore, it costs about $0.13 per bench to remove graffiti ($2 / 16 = $0.13).

[255] Wood: Mench Lumber Yard, NYC Parks supplier of wooden slats. Each slat weighs 54 pounds, so the 4 slats used in one bench weigh 216 pounds. Plastic: American EcoBoard Government Price List. A 12-foot long 3 x 8 board weighs 77 pounds. This is about 6.4 pounds per foot. Therefore, an 8-foot slat weighs about 51.3 pounds, and, together, the 4 slats used for one bench weigh 205 pounds.

[256] *New York City Solid Waste Management Plan: Final Update and Plan Modification,* February 15, 1996, pp. 3-26, indicates that disposal by landfilling costs $41.50 per ton. See DOS Overview.

[257] Columns may not sum exactly due to rounding in spreadsheet program.

[258] Costs of slats for one bench divided by average life-span of bench slats.

[259] Labor cost of installing slats for one bench divided by average life-span of bench slats.

[260] Price of bracing divided by average life-span of bracing.

[261] See note 254.

[262] See note 255.

[263] Weight of bench slats for one bench (in pounds) / 2000 / divided by average life-span of bench slats x cost of disposal per ton.

[264] The total of average annual costs for the plastic option is subtracted from the total of average annual costs of wood option.

[265] Weight of bench slats for one bench (in pounds) / by average life-span of bench slats.

[266] The average annual cost of a bench with wooden slats is $6.07. The cost of a bench with plastic slats is $3.26; resulting in an overall savings of $2.81 per bench.

[267] Parks spent $27,852 on Burrell Studs wooden slats in FY 1997. Fax from Scott Godsen, NYC Department of Parks and Recreation, 3/25/97. No more bench slat purchases were planned in FY 1997. The four slats needed for one bench cost $14.68. This means that the slats for 1,900 benches were replaced, since $27,852 ÷ $14.68 = 1,897 benches. 1,897 benches x $2.81 = $5,331. 1,897 benches x 32 pounds = 60,495 pounds.

11. SORBENTS – CASE STUDY

Introduction

SAIC/Tellus, in conjunction with BWPRR and the Department of Citywide Administrative Services, selected sorbents as the focus of one case study because the City uses a large amount of sorbent to absorb motor oil spatterings and spillages in its garages. This case study examines the cost and waste stream impacts of using three loose sorbent alternatives to absorb motor oil: Sorbitol, DOS's current sorbent, Dri Zorb, DOS's previous sorbent, and PetroSorb EZ Sweep, a wood cellulose sorbent.[268]

The basic results of the analysis[269] indicate that:

- DOS has saved $3,448 through its switch from Dri Zorb to Sorbitol; although the per-pound price of the two sorbents is identical, the City has used less sorbent since its switch to Sorbitol.
- DOS has avoided the generation of almost 9 tons of waste.
- DOS may be able to save close to an additional $5,230 per year through a switch to PetroSorb, if PetroSorb meets its stated sorbency and if users do not apply more PetroSorb than is necessary to absorb a spill.

This analysis treats used sorbent as municipal solid waste. Used sorbent that does not contain free-flowing oil or any characteristic hazardous materials can be managed as solid waste under New York State regulations. If it is necessary to treat used sorbent as hazardous waste, waste disposal will make a more concentrated sorbent such as PetroSorb more cost-effective.[270]

The results of the analysis may also change due to:

- Different sorbent capacities for different spilled liquids;
- User application of sorbent; if workers use more sorbent than the stated sorbent capacity, then the cost-effectiveness of sorbents changes.

Research conducted for this analysis shows that any or all of these factors may be important to the analysis.

Analysis

New York City Department of Sanitation currently uses a sorbent product called Sorbitol, which is made of reprocessed cellulose pulp.[271] The City had previously used a sorbent called Dri Zorb which was made of ground corncobs, but changed due to complaints from users that Dri Zorb did not adequately pick up spills; some DOS workers appeared to be unsatisfied with the sorbent capacity of Dri Zorb.[272] This case study examines the effect that using alternative sorbents could have on costs and waste generation. Sorbitol and Dri Zorb are compared with PetroSorb EZ Sweep, a sorbent product made of recycled wood cellulose. The study compares cost and waste generation data. The Department of Sanitation as well as manufacturers and sales representatives of each of the sorbents provided information on each product's performance and cost.

Initial Assumptions and Calculations

SAIC/Tellus began the case study by reviewing the relevant literature on sorbent. The review showed that price, absorbency, liquid to be absorbed, and disposal cost were important to consider in a comparison of sorbent alternatives.

Table 1 shows the key assumptions for this case study, as well as certain initial calculations that are based upon these assumptions. It is important to note that this study compares the cost-effectiveness of sorbents for cleaning up motor oil. The sorbent capacity of each product differs depending on the type of spill to be cleaned up. The absorbencies for Sorbitol and PetroSorb were obtained from each product's manufacturer and/or distributor. For Dri Zorb, an empirical, NYC-specific, absorbency was calculated. The absorbency used for Dri Zorb is simply the actual amount purchased divided by the amount of liquid to be absorbed. Although Dri Zorb reported a higher absorbency than did Sorbitol, DOS used more Dri Zorb than Sorbitol, instead of less, as one would expect.[273]

The information provided in Table 1 represents the current best assessment of cost and waste generation characteristics associated with the choice of sorbent. This information is used to perform the life-span cost analysis. The details of the life-span analysis are presented in Tables 2 and 3. Assumptions and preliminary calculations required for the life-span analysis are provided in Table 1 and endnotes.

Table 1 – Key Assumptions and Initial Calculations[274]

Assumption/Calculation	Sorbitol	Dri Zorb	PetroSorb
BACKGROUND			
Actual Number of Bags of Current Product Used per Year[275]	1,560	2,000	N/A
Number of Bags of Sorbent Needed per Year[276]	1,560	2,000	1,219
PROCUREMENT AND USE			
Price per Bag of Sorbent[277]	$6.87	$6.90	$5.15
Pounds per Bag of Sorbent[278]	40	40	20
Cost per Year	$10,712	$13,800	$6,278
WASTE GENERATION AND MANAGEMENT			
Amount of Liquid Absorbed by One Bag of Sorbent (Gallons)[279]	5	3.9	6.4
Weight of One Gallon of Liquid (Pounds)[280]	7.3	7.3	7.3
Weight of Waste from One Bag's Use (Pounds)[281]	76.50	68.47	66.72
Cost of Waste Disposal (per Ton)[282]	$41.50	$41.50	$41.50
Annual Disposal Cost[283]	$2,476	$2,842	$1,688
SUMMARY FINDINGS			
Total of Average Annual Costs[284]	$13,193.51	$16,641.51	$7,963.85

Life-Span Costing

The data in Table 1 will be used to develop average annual costs for sorbent procurement and disposal. The sum of average annual costs will provide a measure of the difference in life-span costs due to the choice of sorbent.

Table 2 shows the average annual costs for sorbent options. These costs are obtained by annualizing the costs in Table 1. All the calculations necessary for annualization are explained in the endnotes. Table 3 shows average annual waste generation associated with each sorbent option. As in Table 2, the waste-generation information from Table 1 is annualized to provide the results shown in Table 3.

Table 2 – Cost Comparison of Sorbents

Cost Category	Sorbitol	Dri Zorb	PetroSorb
Procurement Cost of Sorbent Procurement per Year[285]	$10,717.20	$13,800.00	$6,276.56
Disposal Cost of Used Sorbent per Year[286]	$2,476.31	$2,841.51	$1,687.29
Total of Average Annual Costs[287]	$13,193.51	$16,641.51	$7,963.85

Table 3 – Waste Generation Comparison of Sorbents

Waste Generation Category	Sorbitol	Dri Zorb	PetroSorb
Pounds of Used Sorbent Generated per Year[288]	119,340	136,940	81,315

Results

This analysis indicates that use of Sorbitol is more cost-effective and produces less waste than does use of Dri Zorb. In addition, DOS may be able to save even more money and produce less waste through use of PetroSorb.

Basic results

As shown in Table 2, the cost assumptions show that:

- Using Sorbitol saves $3,083 in procurement costs compared to Dri Zorb.
- Using PetroSorb would save an additional $4,441 in procurement costs compared to Sorbitol.
- Using Sorbitol has saved DOS $365 in disposal costs.
- Using Sorbitol has prevented the generation of 17,600 pounds (almost 9 tons) of waste on an annual basis compared to Dri Zorb.
- Switching to PetroSorb would be expected to save the City an additional $789 in disposal costs compared to Sorbitol.

- Switching to PetroSorb would be expected to prevent the generation of an additional 38,025 pounds (19 tons) of waste on an annual basis compared to Sorbitol.
- If the used sorbent is required to be disposed of as hazardous waste (at a much higher cost), use of PetroSorb would result in even greater savings.

Overall, the use of Sorbitol saves $3,448 annually compared to Dri Zorb. Use of PetroSorb is expected to save an additional $5,230 compared to Sorbitol.

Sensitivity

The results of this analysis are sensitive to some of the assumptions made in the analysis. That is, changes in some of the initial inputs to the study may change the results of the analysis. Assumptions to consider include:

- the quantity of sorbent used relative to manufacturer recommendations,
- the price of the sorbent, and
- the regulatory status of sorbent containing used oil.

The overuse of sorbent product may be important to this study; workers may use more sorbent than is necessary to absorb spillages. In an effort to ensure that an entire spill is absorbed, workers may use more sorbent than the manufacturer recommends. This may occur because a sorbent is perceived as inefficient or because a sorbent is more efficient (absorbent) than what users are accustomed to. However, the analysis indicates that 65 percent more PetroSorb than the manufacturer recommends would have to be used for PetroSorb's average annual costs to approximately equal those of Sorbitol.

The price of PetroSorb clearly impacts the result of the analysis. At the single bag price of $8.95, PetroSorb has slightly higher average annual procurement costs than does Sorbitol. In contrast, the pallet-based price used in the basic analysis shows procurement savings of over $5,000 compared to Sorbitol.[289] PetroSorb's price is important to consider because the prices of Sorbitol and Dri Zorb are the actual prices paid by DOS, but PetroSorb's price is simply that cited by the manufacturer. If the City (and/or DOS) were to receive a bid for PetroSorb, its actual cost may be even lower.[290]

The final factor that is key to the life-span cost analysis of sorbent alternatives is the determination of whether the used oil-soaked sorbent must be disposed of as hazardous material, or whether it can be treated as solid waste. Under New York State regulations, used sorbent that does not contain free-flowing oil or any characteristic hazardous materials can be managed as solid waste.[291] DOS is currently managing its sorbent as solid waste.[292] Sorbent distributors, however, often assume that sorbent will be treated as hazardous waste. If all used sorbents are disposed as hazardous waste at a cost of $4,520 per ton, then a highly concentrated sorbent, such as PetroSorb, is clearly the best option.[293] Even if only 25 percent of the sorbent required disposal as hazardous waste, PetroSorb or other concentrated sorbents are clearly the best option.

Endnotes – *Sorbents*

[268] Other forms of sorbent were not examined for this analysis. However, sorbent options include pads, socks, and sponges. It was not feasible within the scope of this study to compare these alternatives to the loose sorbent currently used by DOS. However, these products may be a viable sorbent option for some applications and may have significant waste reduction impacts.

[269] As will be explained in the body of the report, this is based on assuming that motor oil is the liquid absorbed and that the amount of motor oil to be absorbed remains approximately constant.

[270] New York State Department of Environmental Conservation, Division of Solid & Hazardous Materials, Fact Sheet Sorbents Contaminated with Used Oil, April 1996.

[271] Conversation between Lou DiMartino, Deputy Director, Bureau of Motor Equipment, Department of Sanitation, and Susan Williams, December 16, 1996.

[272] Telephone conversation between Carole Belle, Science Applications International Corporation, and Susan Williams, Tellus on June 3, 1996. In Ms. Bell's visits to DOS garages, some workers told her that Dri Zorb did not work very well.

[273] This assumes that the volume and types of spillages remained the same during the time DOS was using Sorbitol and Dri Zorb.

[274] Information sources and calculations are provided in notes to this section.

[275] Information provided by Lou DiMartino, DOS, December 16, 1996, and March 4, 1997.

[276] For Sorbitol and Dri Zorb, products actually used by DOS, this line is the same as the previous line. For PetroSorb, the per bag absorbency of Sorbitol multiplied by number of bags of Sorbitol divided by per-bag absorbency of PetroSorb.

[277] Lou DiMartino, Deputy Director, Bureau of Motor Equipment, Department of Sanitation, provided price information for Dri Zorb on March 4, 1997. DiMartino provided price information for Sorbitol on December 16, 1997. A PetroSorb customer service representative provided price information on EZ-Sweep General Purpose Industrial Absorbent ("PetroSorb") on May 31, 1996. PetroSorb costs $8.95 per bag. A pallet of 50 bags costs $257.50 for a per-bag cost of $5.15.

[278] Sorbitol: Lou DiMartino provided bag size information on December 16, 1996. Dri Zorb: The manufacturer, the Andersons Industrial Products Division of Maumee, OH, provided information on the size of a bag of Dri Zorb on June 3, 1996. Lou DiMartino confirmed the bag size purchased by NYC on March 4, 1997. PetroSorb: Bag size taken from PetroSorb EZ-Sweep information sheet provided by the manufacturer.

[279] Sorbitol: The manufacturer, DMS & Associates of Ocean, NJ, said that one bag of Sorbitol absorbs 5 gallons of motor oil on February 20, 1997. Dri Zorb: Information received from the manufacturer on June 11, 1996, indicated that one bag of Dri Zorb would absorb about 6.3 gallons of oil. However, this information is not consistent with the data available on actual DOS usage of Dri Zorb. It is reasonable to assume that the annual volume of oil spillage treated with sorbents by DOS is approximately constant. Usage of 1,560 bags of Sorbitol, at 5 gallons per bag, implies spillage of 7,800 gallons per year. Use of 2,000 bags of Dri Zorb to treat this level of spillage implies an absorbency of 3.9 gallons per bag in DOS applications. Reducing Dri Zorb absorbency is consistent with the DOS staff comment that Dri Zorb "didn't work well" (*i.e.,* was less effective in absorbing spills than anticipated). PetroSorb: A customer representative at PetroSorb said that 1 20-pound bag absorbs 6.4 gallons on May 31, 1996. The pallet-based price is used since the analysis shows that DOS would use over 1,219 bags per year. The actual price paid by DOS may be lower or higher.

[280] Mobil Lubricant Support Network provided information on the typical weight of motor oil on June 7, 1996.

[281] Number of gallons absorbed by a bag multiplied by the weight of a gallon, plus weight of bag of unused sorbent.

[282] *New York City Solid Waste Management Plan: Final Update and Plan Modification,* February 15, 1996, pp. 3-26. The "base case" of this study uses the cost of disposal of sorbent as solid waste. If disposed as hazardous waste, the cost would be significantly higher. See DOS Overview.

[283] Number of bags used per year x Weight in pounds of waste from one bag / 2000 x Cost per ton for disposal.

[284] See Table 2, this section, and accompanying discussion for details.

[285] Purchase cost of a bag of sorbent multiplied by number of bags of sorbent needed.

[286] Weight in pounds of one bag's worth of used sorbent x Number of bags of sorbent needed / 2000 x Cost of waste disposal per ton.

[287] Sum of annual costs.

[288] Weight of waste from one bag's use in pounds multiplied by number of bags of sorbent needed.

[289] A PetroSorb customer service representative provided price information on May 31, 1996. PetroSorb costs $8.95 per bag. A pallet of 50 bags costs $257.50 for a per-bag cost of $5.15.

[290] Of course, there is no guarantee that the City would receive a lower price. Indeed, the price paid by the City could be higher.

[291] New York State Department of Environmental Conservation, Division of Solid & Hazardous Materials, Fact Sheet Sorbents Contaminated with Used Oil, April 1996.

[292] Telephone Conversation between Carole Bell, SAIC, and Susan Williams, Tellus, on June 3, 1996. In Ms. Bell's visits to Department of Sanitation garages, she observed DOS employees treating oil-soaked sorbent as solid waste.

[293] According to Green Stuff Absorbent Products, Inc. of Cuyahoga Falls, Ohio, the average cost for disposal of oil-type hazardous waste was $2.26 per pound ($4,520 per ton) in 1992. This is based on a cost to the generator of $475 per drum for waste collection and disposal. Green Stuff based this "average" cost on disposal costs in California, but disposal costs vary widely, depending on degree of contamination and disposal method (*i.e.,* landfilling, fuel blending, incineration). However, the important point to note is that disposal as hazardous waste is much more costly than disposal as (non-hazardous) solid waste.

12. TOILET TISSUE – CASE STUDY

Introduction

The SAIC/Tellus team, in consultation with BWPRR and the Department of Citywide Administrative Services, selected toilet tissue as one of the case studies because several toilet tissue dispensing options, with differing cost and waste generation characteristics, are available. This case study examines the cost and waste generation characteristics of a potential switch from conventional toilet tissue dispensing system to a controlled dispensing toilet tissue system. The analysis shows that switching to controlled dispensing toilet tissue could save money and reduce waste.[294] The basic results of the study are that, through a Citywide switch to a controlled dispensing system, the City could save an average of about $106,000 annually.

Analysis

The City buys at least 500 cases of 1,000-sheet, single-ply toilet tissue each week for use in the numerous restrooms in government buildings and public areas in the City. This is about 2.5 million rolls of toilet tissue per year.[295] However, use of conventional, household-sized toilet tissue rolls in a non-residential setting can result in a great deal of waste. Therefore, the City has expressed interest in exploring the procurement of larger rolls of toilet tissue. The waste from the household-sized rolls results from two sources: theft and “stub rolls.” Since 1,000-sheet rolls can be used in household toilet tissue dispensers, some of the City’s toilet tissue may be pilfered for use at home. In addition, “stub rolls” are created when a new roll of toilet tissue is used before the last roll is completely gone. When users have access to a fresh roll, they often prefer to draw from that one rather than a partially used roll. In addition, maintenance workers often put a fresh roll in the dispenser when some tissue remains in order to avoid a situation where no toilet paper is available for users.

To reduce the amount of toilet tissue wasted, a controlled dispensing system is needed. While many such systems may exist, this analysis focuses on the Cormatic system developed by Georgia Pacific. In the Cormatic system, 2,000-sheet rolls are used, dispensers can hold 2 or 3 rolls, and the user has no access to fresh rolls until the last sheet of the current roll has been used. When the current roll is completely used, the paperboard core drops into a receptacle area, allowing the fresh roll to slide down, ready for use. Since the paperboard cores are larger than those used in the household and users have no access to spare rolls, pilferage is minimized. Since the fresh roll will not drop into place until the last sheet of the current roll has been used, creation of stub rolls is eliminated. At the same time, users may still pull as much tissue from the roll as desired; usage reductions are derived from minimized theft and waste. The Cormatic dispensers can hold either two or three rolls, or 4,000 to 6,000 sheets, compared to the 2,000 sheets contained in conventional double-roll dispensers.

Choosing a two-roll dispenser enables users that already have two-roll systems to convert dispensers without remodeling, since the Cormatic dispenser fits into the same space as conventional two-roll dispensers. Either two-roll or three-roll dispensers would be included in the price of any agreement on Cormatic tissue procurement, such that the City would incur no additional costs beyond tissue procurement if it chose to use two-roll dispensers.

Initial Assumptions and Calculations

Table 1 shows the key assumptions for this case study, as well as certain initial calculations that are based upon these assumptions. The information provided in Table 1 represents the current best assessment of cost and waste generation characteristics associated with the choice of toilet tissue. The City and Georgia Pacific, a maker of both conventional and controlled-dispensing toilet tissue, supplied the bulk of the information for this case study, as documented in the notes to Table 1. The analysis presented in Table 1 assumes that the City would opt for two-roll dispensers rather than three-roll dispensers, thus avoiding remodeling costs. The primary benefit of a three-roll dispenser is the reduction of labor time needed to change the rolls. However, since workers in the Work Experience Program currently perform these tasks at no labor cost to the City, using a three-roll dispenser would be of little benefit to the City.

This information in Table 1 is used to perform the life-span cost analysis. The details of the life-span analysis are presented in Tables 2 and 3. Assumptions and preliminary calculations required for the life-span analysis are provided in Table 1 and endnotes.

Table 1 – Key Assumptions and Initial Calculations[296]

Assumption/Calculation	Conventional Double Roll	Controlled Dispensing System	Calculations
BACKGROUND			
Cases of Tissue Currently Bought Per Year[297]	26,000	N/A	
Current Rolls Per Case[298]	96	N/A	
Current Sheets Per Roll of Tissue[299]	1,000	N/A	
Sheets of Tissue Currently Bought Per Year	2,496,000,000	N/A	Number of cases x Rolls per case x Sheets per roll
Estimated Percentage Stolen or Wasted[300]	35%	N/A	
Number of Sheets Actually Used Per Year in Current System (Adjusting for Theft and Waste)	1,622,400,000	N/A	Number of sheets purchased less number of sheets wasted or stolen (65% x Total number of sheets)
Number of Rolls Per Case For Alternative[301]	N/A	36	
Number of Sheets Per Roll For Alternative[302]	N/A	2,000	
Estimated Percentage of Alternative Stolen or Wasted[303]	N/A	0	
Number of Sheets Needed Per Year, Accounting for Theft and Waste	2,496,000,000	1,622,400,000	“Conventional” estimate is from total purchased in current scenario and “controlled” estimate is based on quantity actually used under current scenario, assuming no waste in controlled system.

Table 1 – (continued) Key Assumptions and Initial Calculations[296]

Assumption/Calculation	Conventional Double Roll	Controlled Dispensing System	Calculations
PROCUREMENT			
Number of Cases Needed Per Year, Accounting for Theft and Waste	26,000	22,533	Total number of sheets needed/Sheets per roll/ Rolls per case
Cost of One Case of Tissue[304]	$ 34.33	$ 35.00	
Annual Procurement Costs	$892,580	$788,655	Total cases per year x Cost per case
WASTE GENERATION AND MANAGEMENT			
Weight of a Case of Toilet Tissue and Associated Packaging (Pounds)[305]	48.00	36.00	See note for explanation.
Pounds of Toilet Tissue and Associated Packaging Generated per Year	1,248,000	811,200	Cases per year x Weight per case
Percentage of Toilet Tissue and Associated Packaging Disposed as Solid Waste[306]	10%	2%	
Pounds of Toilet Tissue and Associated Packaging Disposed as Solid Waste	124,800	16,224	Total generation x Percent disposed
Cost per Ton of Disposal as Solid Waste[307]	$41.50	$41.50	
Annual Waste Disposal Costs	$2,590	$337	Total pounds of associated waste/2000 x Cost per ton for disposal.
SUMMARY FINDINGS			
Total of Average Annual Costs	$895,170	$789,003	See Table 2 and accompanying discussion for details.

Spreadsheet-based Calculations

Tables 1, 2, and 3 of this document are reproduced as Tables A, B, and C, respectively, of a single Microsoft Excel spreadsheet that accompanies this case study. Using this spreadsheet, users can easily change the assumptions in Table A to update the calculations. Whenever users enter a new assumption, all three tables will update themselves automatically. To examine a different toilet tissue dispensing option, one would simply replace the relevant data in Table A with the data on the toilet tissue dispensing options under consideration.

Life-Span Costing

The data in Table 1 will be used to develop average annual costs for toilet tissue procurement and disposal. The sum of average annual costs will provide a measure of the difference in life-span costs due to the choice of toilet tissue.

An example will help to explain the process of annualizing costs.

- Table 1 shows that the cost of a case of conventional toilet tissue is $34.33. Since 26,000 cases are bought per year, the average annual cost of toilet tissue for the City is $892,580 ($34.33 x 26,000 = $892,580).

In general, one year's worth of each cost relevant to the case study must be identified.

Analysis

Table 2 shows the average annual costs for toilet tissue options. These costs are obtained by annualizing the costs in Table 1. All the calculations necessary for annualization are explained in the endnotes. Table 3 shows average annual waste generation associated with each toilet tissue option. As in Table 2, the waste-generation information from Table 1 is annualized to provide the results shown in Table 3.

Table 2 – Cost Comparison of Toilet Tissue Options

Cost Category	Conventional Double Roll	Controlled Dispensing System
Annual Cost of Toilet Tissue Procurement[308]	$892,580	$788,667
Annual Cost of Disposal[309]	$2,590	$337
Total Annual Costs	$895,170	$789,003
Savings of Controlled Dispensing System Option Compared to the Conventional Double Roll Option[310]	$106,167	

Table 3 – Waste Generation Comparison of Toilet Tissue Options

Waste Generation Category	Conventional Double Roll	Controlled Dispensing System
Pounds of Toilet Tissue and Associated Packaging Disposed as Solid Waste Per Year	124,800	16,224

Results

Basic results

The basic results of the analysis show that using controlled dispensing toilet tissue would save money and reduce waste.

As shown in Table 2, the cost assumptions illustrate that, by switching from conventional toilet tissue to controlled dispensing toilet tissue, each year the City could save:

- $103,913 on toilet tissue procurement; and
- $2,253 on solid waste disposal costs.

It should be noted that this analysis assumes no labor savings from switching to controlled dispensing system, although maintenance workers would not need to refill the dispensers as frequently. No savings are included because the City incurs no cost for this maintenance activity because it is performed by workers in the Work Experience Program. If the Work Experience Program workers were no longer available, the City would realize additional savings from switching to the controlled dispensing system.

Sensitivity

The cost-effectiveness of the two toilet tissue options is sensitive to some of the assumptions made in the analysis, specifically the quantity of tissue wasted or stolen.

This analysis is most sensitive to the amount of toilet tissue wasted or stolen and the price of the controlled dispensing tissue option. The price of the Cormatic toilet tissue is, as estimated by Georgia Pacific, based on the minimum number of rolls required in a bid for the City's toilet tissue. The estimated amount wasted or stolen was based on conversations with a Georgia Pacific representative. The representative estimated that from 25 percent to over 50 percent of the toilet tissue in a 96-roll case (such as the cases that the City buys) are lost due to theft or early roll-changing by maintenance workers. He estimates a 35 percent reduction in usage from switching to Cormatic tissue. It should be noted that the company is willing to provide a one-month, no-cost trial of the toilet tissue and dispensers—allowing the City or other potential customers to observe actual reduction in usage and associated costs before committing to buy the product. If the current loss were between 26 and 27 percent, costs for both systems would be approximately equal, while the controlled dispensing system would provide waste reduction benefits.

Endnotes – *Toilet Tissue*

[294] The methodology for these calculations is fully explained in the body of the case study.

[295] New York City Summary of Award for Paper; Toilet Tissue, Rolls, Bid No. 09501979.

[296] Information sources and calculations are provided in notes to this section.

[297] New York City Summary of Award for Paper; Toilet Tissue, Rolls, Bid No. 09501979. The City requires at least 500 cases per week, or 26,000 cases per year (500 x 52 weeks/year = 26,000).

[298] New York City Summary of Award for Paper; Toilet Tissue, Rolls, Bid No. 09501979.

[299] New York City Summary of Award for Paper; Toilet Tissue, Rolls, Bid No. 09501979.

[300] Conversation with Dana Wright, Georgia Pacific, January 15, 1998. In a typical 96-roll carton, the equivalent of 25 to 50 full rolls of tissue are typically wasted or stolen with conventional toilet tissue dispensing systems. Thirty-five percent is the average for waste and theft. Contacts in the City were unable to provide another estimate of theft and waste.

[301] Conversation with Dana Wright, Georgia Pacific, January 15, 1998.

[302] Conversation with Dana Wright, Georgia Pacific, January 15, 1998.

[303] Conversation with Dana Wright, Georgia Pacific, January 15, 1998.

[304] Conventional: New York City Summary of Award for Paper; Toilet Tissue, Rolls, Bid No. 09501979. Controlled dispensing: Conversation with Dana Wright, Georgia Pacific, January 15, 1998. The actual price the City would pay

for Cormatic tissue may differ from this estimate, which was based on the expected level of City-wide usage, since this price is not the result of a bid and this toilet tissue is not currently on City requirements contracts.

[305] Tellus staff weighed conventional 1,000-sheet toilet tissue on a postal scale. It weighs approximately 8 ounces. 8 ounces x 96 rolls / 16 ounces / pound = 48 pounds for a case of conventional tissue. No samples of the controlled dispensing tissue were available, but its weight should be approximately double, since there are 2,000 sheets per roll. The weight of the core itself is insignificant and such small differences are not captured well on the available scale. At 16 ounces, or 1 pound, per roll, a case of 36 rolls will weigh 36 pounds.

[306] Some of the "wasted" conventional toilet tissue is stolen while the other part consists of discarded stub rolls. In addition, a minor amount of waste is created by the paperboard cores and the wrapping. The amount of toilet tissue disposed as solid waste is a matter of judgment. This study assumes that 10 percent of the conventional tissue is disposed of as solid waste. In addition, some small amount of the controlled tissue will be disposed of as solid waste—the wrappings and cores. This study assumes that 2 percent of the control tissue will be disposed as solid waste. Using a relatively low percentage for conventional tissue and a relatively high percentage for controlled dispensing tissue (considering the amount of waste expected) ensures that the savings due to avoided solid waste disposal is not overestimated.

[307] *New York City Solid Waste Management Plan: Final Update and Plan Modification,* February 15, 1996, pp. 3-26, indicates that disposal by landfilling costs $41.50 per ton. See DOS Overview.

[308] Total number of cases required, from Table 1, this section, multiplied by cost per case.

[309] Waste generation from Table 1, this section, (in pounds)/ 2000 x Disposal cost per ton.

[310] The total of average annual costs for the controlled dispensing option is subtracted from the total of average annual costs of the conventional double roll option to determine the savings.