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Attached for filing in the above-referenced undocketed matter are the comments of the Integrated Waste Services Association.

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INTEGRATED
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ASSOCIATION

Comments of the Integrated Waste Services Association
Florida PSC Renewable Portfolio Standard Workshop
December 21, 2007

The following comments are submitted by the Integrated Waste Services Association (IWSA). IWSA is the national trade association representing the nation's waste-to-energy industry and municipalities. Waste-to-energy facilities produce clean, renewable energy through the combustion of municipal solid waste in specially designed power plants equipped with the most modern pollution control equipment to clean emissions. Trash volume is reduced by 90% and the remaining residue is safely reused or disposed in landfills. There are 87 waste-to-energy plants operating in 25 states managing about 13 percent of America's trash, or about 95,000 tons each day. Waste-to-energy generates about 2,700 megawatts of electricity to meet the power needs of nearly 2.3 million homes while serving the trash disposal needs of more than 36 million people. In Florida, 11 WTE plants process over 18,000 tons per day of municipal solid waste, and 514 megawatts of electricity.

Waste to Energy benefits in relation to Greenhouse Gases:

In response to recent discussions regarding greenhouse gases at the workshop, IWSA would like to point out that a number of studies have shown that waste-to-energy is better than "carbon neutral." Use of waste-to-energy avoids emissions from fossil fuel-fired electric generation, fugitive methane emissions from decomposing trash in landfills and avoidance of emissions from production of new iron and steel by recovery and recycling of ferrous metals from the ash residue. In short, waste-to-energy facilities have negative greenhouse gas emissions. We have attached to this filing, two of these studies.

Response to questions:

IWSA submits the following responses to certain questions posed in the December 6 FL PSC RPS Workshop Agenda regarding Renewable Portfolio Standards (RPS).

Q: Which resources should be eligible?

A: Eligible resources should be "Florida renewable energy resources" as defined in F. S. 366.92 (2) i.e. "renewable energy, as defined in s. 377.803, that is produced in Florida." 366.92 also specifically notes, "It is the intent of the legislature to promote renewable energy; protect the economic viability of Florida's existing renewable energy facilities...", thus the question of including new and existing facilities has already been addressed by the legislature, which has made it clear it wishes new and existing sources to be included. Waste-to-energy plants are included in this definition.

Q: What approach, multipliers or Tiered Goals?

A. IWSA strongly supports an RPS system which achieves the public policy goals that (1) incent continued operation of existing renewable power facilities, and (2) promote the development of new renewable power facilities. These goals reflect the Legislature's intent as set forth in 366.92.

A tiered RPS structure is the best way to reach the goals set by the Legislature. Representatives from the solar community have already commented in this proceeding that multiplier programs have not been successful in promoting renewables development. Multiplier programs can also be complex to administer and track.

The simplest way to achieve these goals can be accomplished through a "two tier" system with "tiers" as follows:

Tier 1. New solar and wind sources

Tier 2. Existing and new renewable sources as defined in F. S. 377.803, except wind and solar sources

Electric utilities in Florida would be required to purchase a set percentage of their load from each of these tiers. For example, in a given year, electric utilities would be required to provide 15% of their electric sales from Tier II, and 5% of their electric sales from Tier I sources, making a total renewable energy requirement for that year 20% (these numbers are hypothetical—actual numbers would have to be developed following a comprehensive analysis of existing and potential new renewable sources in Florida).

The purchase requirement of Tier II energy or credits should be set at the percentage of total Florida electric sales provided by existing renewable resources, as defined in the statute, at the time of implementation of the RPS Rule. Furthermore, to meet the above mentioned goals, it is essential that electric utilities that fail to comply with the requirements for either tier pay an Alternative Compliance Payment (ACP) that is sufficient to incentivize the utility to attempt to acquire the actual energy or credits from renewable sources.

Q. Can excess compliance in "policy preferred" tier be used to meet goals in other tiers?

A. There can be no crediting from one tier to another, as this would dilute the incentive for any tiers which are "shared" and defeat the purpose of separate tiers. The separation of the tiers ensures that incentives for one fuel type are not harmful to another fuel type. This tiered system eliminates controversy surrounding "multipliers" for certain fuel types, and reduces discrimination of certain fuel types, while still ensuring desired incentives for specific fuel types, like solar and wind.

Q. What Financial compliance mechanisms are needed?

A. An Alternative Compliance Payment (ACP) mechanism is needed. ACP is a commonly used method to ensure compliance in the event there is a shortage of renewable resources. A properly functioning RPS program sets annual renewable energy requirements at a level that will clearly encourage the development of new renewable energy sources. Having an option to make an ACP should there not be enough in-state renewables available, particularly at the beginning of the RPS program, is a sound policy that should be pursued. The initial value of the ACP must be initially set high enough (per megawatt hour), to ensure that IOUs purchase energy or RECs from existing renewable resources, and act as an incentive for IOUs to seek out new in-state renewable energy projects.

Consideration should be given to having ACP payments flow into a Renewable Energy Fund administrated by the PSC or its designee. These funds could be used to spur investment in renewable power development, and/or contribute to cost of administering the RPS program. It must be clear that the monies collected under the ACP can only be used to support the development of more in-state renewable energy production, from new or existing projects.

Q. How should financial compliance mechanisms be set?

A. The initial value of the ACP, in dollars per megawatt-hour, must be set high enough to ensure that IOUs purchase RECs from existing renewable resources, and provide a financial incentive for IOUs to seek out new in-state renewable energy projects. The PSC should realize that the value of the ACP will essentially set the ceiling price for renewable energy credits since there will be no incentive for a utility to pursue the purchase of renewable energy that costs more than the ACP. Therefore, the ACP should be set at a price that can provide an incentive for new development and provide financial support for existing renewable generators. RECs can be created on a scale of 1 REC per megawatt hour.

Q. Cost recovery for IOUs:

A. IOUs should be able to recover cost recovery for ACP payments, ***within limits of prudency reviews. The prudency review is critical.*** This ensures that when renewable energy or RECs are available, IOUs are incented through the prudency process to pay for the actual energy or REC, thus stimulating demand for renewable power. Prudency review is needed to ensure a vibrant market for renewable energy exists, and to discourage ACP payments when the energy or RECs are reasonably available. Put simply, failure to purchase renewable resources when available will reduce demand for renewable energy and defeat the goal of incenting development of renewable power. Therefore, purchase of renewable resources by an IOU needs to be defined as prudent in the RPS program, and failure of an IOU to purchase renewable resources *when reasonably available* must conversely be defined in the RPS program as imprudent. Alternatively, the RPS program could be set up in such as way is to simply state that ACP payments made when renewable resources were reasonably available are simply not recoverable by the IOU.

It is important for the PSC to understand whether any ACP payments have been made during a period when renewable resources were available for purchase by an IOU. In order to make this determination, part of the administrative monitoring function must be able to track and link the availability of energy or RECs with ACP payments made by IOUs. Only in this way, when the availability of renewable resources are reviewed in conjunction with ACP payments at particular points in time, will the PSC be able to determine if an ACP payment was made properly.

Q. How should compliance be tracked and verified?

A. As a matter of sound public policy, it is clear that entities subject to enforcement penalties in an RPS regime, should not be the same entities tracking and determining if an entity is in compliance.

In an RPS regime, electric utilities or IOUs will have requirements to purchase a certain amount of renewable energy or RECs in order to be in compliance. Therefore, there needs to be a central "clearinghouse" which oversees the accounting for this process. IWSA recommends that the PSC or a third party designated by the PSC handle this function as it is the appropriate regulatory body to do so. (The third party methodology is currently used successfully in the New England ISO and PJM.)

The PSC will likely need to use data obtained from FRCC in order to determine how much retail sales (in Megawatt-hours) each responsible party serves, and therefore an accurate determination of how much RECs each responsible party needs to purchase.

All reporting of RPS compliance activities, such as the purchase of RECs and the payment of compliance payments, when necessary, should be done in a public fashion, to allow observers to be able to track each party's compliance with the RPS mandates. Reporting of REC and ACP activity by each party can be posted on the Web by PSC or the third party administrator.

It is important for the PSC to understand if any ACP payments have been made during a period when RECs were available to an IOU (see answer on IOU cost recovery above). In order to make this determination, part of the administrative monitoring function must be able to track the timeframe of available RECs with the ACP payments made by IOUs. Only in this way will the PSC be able to determine if an ACP payment was made improperly.

Utilities would be required to report quantities of renewables purchased (in megawatt-hours), and ACP payments made to the PSC and/or third party administering the program. These reported quantities need to be audited annually as part of the annual review process referred to above. This reporting should include documentation to support any decisions to make ACP payments in lieu of purchasing RECs as discussed in detail above.

Q. Should self-service generation be counted toward goals?

A. Yes. This provides the proper incentive for entities to produce their own power.

Q. Should energy efficiency count towards goals?

While energy efficiency is a laudable public policy goal, it is not appropriate in the context of a renewable portfolio standard, the goal of which is the development of renewable power sources. If an RPS purchase requirement is met through the use of energy efficiency measures, no incentive will be created for the development of reneweable resources, nor will there be any policy benefit towards the goal of fuel diversity.

That is not to mean IWSA opposes energy efficiency measures; far from it. It is however, appropriate for those measures to be incented elsewhere, separate and apart from the RPS program.

Conclusion

In closing, IWSA would like to remind the PSC of the two key statutory goals set forth in section 366.92(1) as it considers implementing a RPS in Florida

1. Incent continued operation of existing renewable power facilities
2. Promote the development of new renewable power facilities

IWSA and its members welcome the opportunity to work further with the Florida PSC on this important policy matter.

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Application of the U.S. Decision Support Tool for Materials and Waste Management

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Abstract

The U.S. Environmental Protection Agency (EPA) launched the Resource Conservation Challenge in 2002 to help reduce waste and move towards more sustainable resource consumption. The RCC hopes to help communities, industries, and the public think in terms of materials management rather than waste disposal. Reducing cost, finding more efficient and effective strategies to manage municipal waste, and thinking in terms of materials management, requires a holistic approach that considers life-cycle environmental tradeoffs. The EPA's National Risk Management Research Laboratory (NRMRL) has led the development of a municipal solid waste decision support tool (MSW-DST). The computer software can be used to calculate life-cycle environmental tradeoffs and full costs of different waste management plans or recycling programs. The environmental methodology is based on the use of life-cycle assessment (LCA) and the cost methodology is based on the use of full-cost accounting (FCA). Life-cycle inventory (LCI) environmental impacts and costs are calculated from the point of collection, handling, transport, treatment, and disposal. For any materials that are recovered for recycling, offsets are calculated to reflect potential emissions savings from use of virgin materials. The use of the MSW-DST provides a standardized format and consistent basis to compare alternatives. This paper provides an illustration of how the MSW- DST can be used by evaluating ten management strategies for a hypothetical medium-sized community to compare the life-cycle environmental and cost tradeoffs. The LCI results from the MSW- DST are then used as inputs into another EPA tool, the Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI), to convert the LCI results into impact indicators. The goal of this paper is to demonstrate how the MSW-DST can be used to identify and balance multiple criteria (costs and environmental impacts) when evaluating options for materials and waste management. This type of approach is needed in identifying strategies that lead to reduced waste and more sustainable resource consumption. This helps to meet the goals established in EPA's Resource Conservation Challenge.

Keywords: Decision Support for Strategic Waste Management Planning, Resource Conservation and Recovery, Sustainability, Materials Recovery, Waste Disposal

1. Introduction and Background

The need for credible and science-based information for making more informed waste management decisions precipitated the development of a decision-support tool for municipal waste. Often decision makers are faced with conflicting and incomplete information that can have major economic and environmental implications. In the U.S., more than 214 million metric tons of municipal solid waste (MSW) was generated in 2003 and more than $40 billion dollars was spent on its management. (EPA, 2003a) Finding more efficient options can help reduce cost and reduce environmental burdens.

The U.S. EPA recognizes the need for finding flexible, yet protective, ways to conserve national resources. The Resource Conservation Challenge (RCC) was launched in 2002 to help the U.S. move away from solid waste to materials management (EPA, 2003c and 2004). This is to be done through: (1) pollution prevention, recycling, and reuse of materials; (2) reduction of the use of toxic chemicals; and (3) conservation of energy and materials. The objectives are to encourage more sustainable resource use and to minimize waste. The MSW-DST helps support the goals for the RCC by identifying materials/waste management strategies that balance resource consumption, environmental burdens, and cost. The MSW-DST can also be used to identify the "best" management option for individual materials. (Thorneloe, et al., 2001, 2003, 2004).

With the transition from waste management to materials management, it is even more important to have tools available that consider life-cycle environmental tradeoffs. Determining the best means to manage solid waste is not straightforward. Questions that arise include: Should food waste be composted or landfilled? Should newsprint be recycled, landfilled, or combusted? What is the environmental benefit or burden from increasing the recycling rate in a community or adopting a curbside recycling program? What about increased air pollution from waste collection and transport? Is it better to export waste to a larger regional facility or continue use of an existing near-by facility that may not have the same degree of environmental controls? Are there changes within a community's existing infrastructure that could improve efficiency and reduce cost and environmental burdens?

The economics of solid waste management are also becoming increasingly important as communities face higher energy costs, and competing priorities. To address budgetary concerns, recycling programs are often targeted for reduction and even elimination, which occurred in New York City (it was later restored). Are there potential savings from finding more regional solutions to solid waste management? If so, then what are the actual savings in terms of reduced costs and environmental burdens?

The MSW-DST was developed through a partnership between Federal, state, and local government, private sector, and environmental interest groups. The goal of this research was to develop information and a computer program and supporting database to evaluate the relative cost and environmental performance of integrated MSW management strategies. The primary audience for the outputs is local government and solid waste planners. However, the outputs are also of value to Federal agencies, environmental and solid waste consultants, industry, LCA practitioners, and environmental advocacy organizations.

Over 80 stakeholders were active participants in the development of the process models and tool. Funding for the research was provided by the U.S. EPA and the U.S. Department of Energy. The work was conducted through a cooperative agreement between EPA's National Risk Management Research Laboratory (NRMRL) and RTI International. (Thorneloe, et al., 1999a, 2001 and 2003) The research team included North Carolina State University (NCSU) who had a major role in the development of the LCI and cost models as well as MSW-DST. The University of Wisconsin was responsible for development of the life-cycle inventory (LCI) data and process models for mixed MSW and yard waste composting (Ham, et al., 2003). Funding was also provided by the Environmental Research and Education Foundation (EREF) for the development of LCI data and process models for municipal solid waste landfills (Ecobalance, 1999). The methodology, process models, MSW-DST, and documentation went through extensive review including that of stakeholders, series of external peer-reviews, in addition to peer, quality assurance, and EPA administrative review.

To account for differences in environmental benefits for recycling different MSW components, research was also conducted to develop LCI data sets for aluminium, glass, plastic, paper, and steel. RTI International worked in cooperation with private-sector partners, environmental interest groups, Franklin Associates, and Roy F. Weston to develop the LCI datasets. Each industry sector provided review and/or LCI data. Extensive effort was put into ensuring comparability of the LCI data. Environmental interest groups were also active participants in the development and review of LCI data including Environmental Defense and the Natural Resources Defense Council. (Weitz, 2003; and Thorneloe, et al., 2003)

Figure 1 provides an illustration of the MSW life-cycle. All activities are considered from the point of collection to its ultimate disposition, whether that be in a landfill, compost that is applied to the land, energy that is recovered from combustion, or materials that are recovered and reprocessed into new products. The computer software can track up to 26 components (e.g., yard waste, food waste, paper, plastic, metals, and glass) from residential, multi-family dwellings, and commercial sectors. Differences in MSW composition and management can be tracked for these different sectors helping to identify where they may offer more environmental benefit or cost savings from expanding recycling programs or making improvements to existing waste management programs.

The MSW-DST provides a standard approach for evaluating the life-cycle environmental tradeoffs and full costs of MSW management. Over 40 unit processes have been modeled covering waste collection, transportation, materials recovery, transfer stations, treatment, and disposal. An illustration of a unit process is provided in Figure 2. A list of the unit processes is provided in Table 1. The process models calculate the cost, energy consumption and LCI emissions for 32 pollutants from each solid waste unit operation based on the quantity and composition of waste processed. Each process model contains peer-reviewed default values that can be adjusted to reflect site-specific data. The allocation of cost, resource and energy consumption, and environmental releases for individual MSW components is described in Table 1 for each unit process.

Over 50 applications of the tool have been conducted on community, state, and national basis. (Thorneloe, et al., 2001, 2003, 2004). The tool was recently used in a study for the State of California to compare waste conversion technologies. Several other studies are underway currently in helping communities develop solid waste management plans and improving the environmental benefit or cost of recycling programs. Studies have varied from just comparing different options for waste collection and transportation to identifying options that help maximize recycling targets. Some studies have been conducted that evaluate the relationship between waste management and greenhouse gas emissions (Weitz, et al., 2002). A study was conducted to compare the life-cycle environmental burdens between disposal and combustion of CCA-treated wood (Jambeck, et al., in press). The MSW-DST is available through either RTI International or NCSU for conducting studies. A web accessible version of the MSW-DST (which is a simplified version) is under development. It is expected to be released in 2007 once final reviews have been completed.

Different materials (i.e., aluminum cans, green glass, newsprint, office paper, PET beverage containers, steel cans, and yard trimmings) have different LCI burdens depending upon extraction of raw materials, materials processing, manufacturing, use, and waste management. Accounting for these differences help communities identify which components to target for recycling programs to help maximize environmental and economic benefits. The MSW-DST provides the methodology, LCI data, and other information for making these evaluations through a comprehensive mathematical model that accounts for cost, energy, and environmental emissions. The model is implemented through an interactive decision support system (Harrison et al., 2001). This type of analysis helps communities to identify more sustainable solutions that minimize environmental burdens and maximize resource conservation and recovery. (Coleman et al., 2003; McDougall et al., 2001; White et al., 1995)

The purpose of this paper is to illustrate the use of the MSW-DST for evaluating different MSW management strategies. The scenarios, identified in Table 2, were selected to help illustrate the change in LCI environmental tradeoffs with increased materials recovery, differences in landfill gas capture and control, waste combustion with energy recovery, and differences in waste transport. The scenario analysis also helps to document environmental improvements from strategies that are now more typical in the U.S. (Scenarios 5 through 10) versus what was more typical in the 1970s (Scenario 1) with minimal recycling and control of landfill gas. The scenarios were calculated for a medium size community with a population of 750,000 and a waste generation rate of approximately 1.6 kg (3.5 lbs) per person per day (EPA, 2003a and b).

2. MSW Management Scenarios and MSW-DST Input Data

Using information available from EPA's Office of Solid Waste, ten scenarios were developed to help illustrate the types of management strategies that are typical in the U.S. As of 2003, the amount of municipal waste generated in the U.S. was 214 million metric tons or 2 kg/person/day (Figure 3, EPA 2003a). Statistics on waste composition are also available as are recycling rates for individual MSW components (Figure 4; EPA, 2003a). Paper is the largest component in municipal waste with 37% (or 79 million metric tons). Of the paper that is collected, 45% is recycled (or 40 million metric tons). Yard waste represents 12% of the total waste. Of the yard waste that is collected, 57% is composted (or 15 million metric tons). The national average recycling rate which includes composting is 30% (Figure 5, EPA 2003a). The Resource Conservation Challenge has identified a recycling goal of 35% for the U.S. by 2005 (EPA, 2004). Statistics are not yet available to determine if this has been met. However, individual communities and states have reported recycling rates of 40%.

Ten scenarios were defined to help compare environmental and economic tradeoffs between different waste management strategies. These are summarized in Table 2. The first 4 scenarios illustrate the transition between minimal recycling as was done in the 1970s versus increasing recycling to 40%. This will capture different MSW components as identified in Figure 6. The fifth scenario is typical of most U.S. cities with a 30% recycling rate and residuals being landfilled. Landfill gas is controlled and flared. The next two scenarios were selected to quantify the benefit of landfill gas recovery to produce electricity (Scenario 6) and to offset fuel oil in nearby industrial plant (Scenario 7). Approximately 14% (or 29,000 million metric tons) of MSW in the U.S. is combusted with energy recovery. Scenario 8 represents a typical "waste to energy" (WTE) facility in the U.S. which recovers any metals in the ash and meets stringent Clean Air Act requirements. The last two scenarios were chosen to help illustrate the differences in environmental impacts when waste is long hauled using semi-tractor trucks (Scenario 9) or rail (Scenario 10). These scenarios are identical to Scenario 5 except that the waste is hauled to a transfer station prior to transport 800 kilometers to a landfill. This operation is becoming more frequent in the U.S. with the closing of smaller, older landfills and the use of larger, more modern, regional landfills. These scenarios do not account for all of the diversity that exists in different geographical regions of the U.S. They also do not account for differences that exist between urban, suburban, and rural communities. However, these scenarios are thought to help illustrate the differences in waste or materials management strategies that are thought to have the greatest impact on life-cycle environmental tradeoffs or costs.

The same quantity of solid waste was used for each scenario (437,000 metric tons/year), which is considered to be a medium-sized community in the U.S. with a population of 750,000. Weekly collection of waste and recyclables was assumed, with all items collected on the same day from residential, multi-family dwellings, and commercial sectors. The waste composition is based on national averages (Figure 4). Costs were calculated using model defaults, which reflect national and regional averages. Key assumptions for each process model are identified in Table 3.

The diversion rates in each scenario were met through a combination of recycling and yard waste composting. The MSW-DST uses linear optimization software to find the most efficient solution based on minimum cost or environmental objective (e.g., minimum release of greenhouse gases) (Solano, et al., 2002a and 2002b). Multiple criteria can be used which could combine cost and environmental objectives to find more efficient solutions for waste and materials management. For this analysis, cost was used in identifying which mix of components would meet the diversion goals set in each scenario (i.e., we solved for the least cost mix that would meet scenario goals). The analysis did not try to maximize resource conservation and recovery although this has been done in previous publications (Barlaz, et al., 1999b; Harrison, 2001). Therefore, this will be sensitive to the market value for recyclables. When used for a site-specific analysis or in solid waste management planning, different values can be used to reflect current prices and to evaluate market impacts on management practices.

The mix of materials that were captured by the 10, 20, 30, and 40 percent recycling goals is presented in Figure 6. The 10 percent diversion rate was met by using recycling only (i.e., no yard waste composting). The recycling consisted of commingled recyclables from residential and multi- family housing and presorted recyclables from commercial entities. To reach the 20, 30, and 40 percent diversion rates (or recycling goals), the model included both recycling and yard waste composting from the residential sector. Note that for reaching a 40% recycling target, there is almost 100% capture of metals.

Modeling of energy has been found to have a significant impact on the life-cycle environmental tradeoffs (Finnveden et al., 2002). Energy emissions include extraction, production, consumption, and offsets for energy conservation. In the U.S. the marginal energy source to be displaced is typically coal-fired power plants (Weitz et al., 2002). Therefore, the energy offsets that were used for Scenarios 6 and 8 are for coal combustion. For Scenario 7, the most likely offset is fuel oil which was used in calculating the energy offset.

Assumptions regarding landfill gas control can also have a significant impact (Ecobalance, 1999; Barlaz et al., 1999a). For the scenarios with landfill gas control (i.e., Scenarios 4, 5, 7, 8, 9, and 10), a landfill gas collection efficiency of 75% was assumed. This is consistent with EPA's guidelines for developing emission inventories (EPA, 1997). However, some sites will obtain greater capture efficiency while some sites may have less. Most large landfills in the U.S. (i.e., greater than 2.5 million tons of waste) collect and control landfill gas. However, some sites exist that are below the size threshold for the Clean Air Act gas control requirements (i.e., they do not have gas control). However, the trend in the U.S. is towards larger, regional landfills with gas control. About 300 U.S. landfills have energy recovery (Thorneloe, et al., 2001). Life-cycle environmental emissions and costs were calculated over a 100-year time frame. More detail on the life-cycle landfill model is provided in a report that was prepared for the Environmental Research and Education Foundation (Ecobalance, 1999).

More detailed descriptions of how individual waste management processes are modeled have been provided in previous publications (Barlaz et al., 1999 a and b; Ham and Komolois, 2003; Harrison et al., 2001; Thorneloe and Weitz, 2001 and 2003; and Weitz, 2003). Key process model assumptions and allocation procedures are summarized in Table 2.

3. Results and Discussion

The standard output of the MSW-DST is annualized cost, energy consumption, and life-cycle environmental emissions for 32 pollutants. (Solano et al., 2002a and 2002b). The life-cycle emissions data were used as inputs to EPA's Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI, Version 2.0) (Bare, 2002 and Bare et al., 2003). TRACI is computer software that allows storage of inventory data, classification of stressors, and characterization of impact categories within various life-cycle stages. Impact categories include climate change, acidification, eutrophication, trospospheric ozone, and human and ecosystem health.

3.1 Cost

The cost results generated by the MSW-DST are based on a full cost accounting (FCA) approach. This is a systematic approach for accounting for past and future costs, overhead (oversight and support services) costs, and operating costs. Historically, cash flow accounting has been used by local government to track the flow of financial resources regardless of when the money is spent. This does not reflect the time value of money which is needed to compare waste management alternatives or any option where there are past and future costs to be accounted for.

Waste management can involve significant expenditures both before and after the operating life of management facilities. Focusing solely on the use of current financial resources will misrepresent the actual cost of MSW management. For example, a landfill includes the cost of permitting, design, construction, operation, and long-term monitoring. In full cost accounting, all of these costs are included when calculating the net annualized costs. (Ecobalance, 1999)

Another advantage is that system-wide costs are being compared (collection, transport, materials recovery facility, treatment, and disposal). In addition, the market value of recyclables is also factored in. Many of these parameters can vary over time and within different geographical regions. The defaults in the tool can be adjusted to account for site-specific values such as labor rates, land values, regional market prices for recyclables and energy, and any special permit requirements for licensing a facility. The information can also be used to benchmark the costs to compare to similar communities or norms.

Figure 7 provides a comparison of the total net (i.e., cost minus revenues from the sale of materials and/or energy) annual cost for the 10 scenarios analyzed. The lowest cost scenario is scenario 2 at 20% recycling and the remainder is landfilled. As recycling is increased to 30% and 40% in scenarios 3 and 4, the cost increases by 42% and 69%, respectively, because it becomes more difficult and costly to recover the marginal recyclable (given a fixed infrastructure). Similarly, when the rate of recycling is reduced to 10% in scenario one, the cost increases. This suggests that there are cost benefits of increasing recycling levels past 10% but diminishing returns somewhere in the 20-30% range (assuming fixed infrastructure, recycling program participation, and separation efficiencies). The highest cost management option is the WTE scenario (scenario 8).

3.2 Energy Consumption

The results for total net energy consumption are shown in Figure 8. All scenarios show a net negative energy consumption which highlights the significance of materials recycling in terms of energy consumption. Even recycling at the 10% level in scenario one results in a net energy savings over the total system. As shown in Figure 8, the energy savings are largest with the higher recycling level (40% for scenario four) and where energy recovery is greatest (in the scenario 8 WTE). The large jump in energy savings between the 30% and 40% recycling scenarios is due largely to the addition of metals recycling in scenario 4 to meet the 40% rate. Metals' recycling has a high energy savings potential compared to most other recyclables. If another material (or mix of materials) had been used to meet the 40% recycling rate, the energy savings likely would not have increased as much. The specific material that the MSW-DST selects for inclusion in recycling portion was based on a minimum cost criterion. Therefore, the least cost items to recycle are selected first to meet the recycling target. The higher cost of metals recycling is likely due to the longer distances for transporting metals to remanufacturing facilities as compared to the other materials.

3.3 Climate Change

Figure 9 presents a comparison of the net carbon emissions using MSW-DST life-cycle emissions results for methane and carbon dioxide as inputs to TRACI. The results from TRACI are in units of grams of CO_2 equivalent. These units were converted to kilograms of CO_2 equivalent for presentation in Figure 9. Previous research shows that as waste management technologies have evolved, greenhouse gas (GHG) emissions have been reduced (Weitz et al., 2002). This study shows similar results. The first four scenarios illustrate recycling benefits increasing from 10 to 40% recovery with no residuals being landfilled. For these four scenarios, no landfill gas control was assumed. The transition between these scenarios and scenario 5 helps illustrate the importance of landfill gas control. A significant reduction in greenhouse gases can be achieved through increased recycling and control of landfill gas. About 300 U.S. landfills have energy recovery (Thorneloe, et al., 2001).

The most attractive strategy from a GHG perspective is Scenario 8. The negative offset is due to energy conservation, increased metals recovery, and absence of landfilling any biodegradable waste (only residual being landfilled is combustion ash).

Scenarios 9 and 10 provide the GHG impact of long hauling using either semi-tractor trailers or rail. In the U.S., there is an increasing trend towards transporting waste over long-distances. Typical distances vary from 480 to 800 km (300 to 500 miles). As smaller, older landfills reach capacity and are closed, communities are often transporting waste over longer distances. Typically, waste is collected and transported to a transfer station where the waste is compacted for long haul using either semi-tractor trailers or rail. For the rail-haul, typically there is a transfer station at both ends of the rail line. For this analysis, a long-haul distance of 800 km (500 miles) was assumed. The results show a slight increase in GHG emissions for long-haul transport as compared to Scenario 5 where waste is transported to near-by landfill.

3.4 Acidification

The pollutants calculated by the MSW-DST that contribute to acidification include SOx, NOx, ammonia, and HCl. These pollutants are tied to (1) fuel combustion, and (2) electrical energy production and consumption (including mining of coal or raw materials extraction). The results in Figure 10 for acidification increase or decrease from scenario to scenario depending on how much fuel and electrical energy are consumed. TRACI was used to model acidification based on moles of H+ equivalents. The results for all scenarios are negative indicating a net savings or avoidance of acidification related pollutants for each scenario. The negative values are directly tied to materials and/or energy recovery from the scenarios.

The WTE scenario (scenario 8) shows the greatest offset of acidification-related pollutants primarily because it results in the largest energy offset. One might expect that the 40% recycling scenario, which had the greatest net energy offset, would also have the greatest acidification offset. However, it appears that while the addition of metals recycling saves a significant amount of energy, it does not necessarily save as much in terms of acid precursors. This may be due to the longer transportation distances for metals remanufacturing and/or emissions during the remanufacturing processes. There is also an increase in the offset of acidification that results from landfill gas to energy projects (see scenario 5 versus scenarios 6 and 7). Scenarios 9 and 10 show the negative affects that long-hauling waste have in terms of acidification.

3.5 Eutrophication

Eutrophication results based on grams of nitrogen equivalents using TRACI indicate a net savings or avoidance of eutrophication related pollutants for each scenario. The pollutants that contribute to acidification include NOx and ammonia air emissions. Waterborne pollutants that contribute to eutrophication include ammonia, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and phosphate. Phosphate releases appear to be the most significant and are predominately tied to materials remanufacturing. Thus, the results for eutrophication will generally increase or decrease from scenario to scenario depending on the quantity and type of material recycled.

Paper production and remanufacturing appear to be the key material driving the eutrophication results. Paper recycling is increased significantly from scenario one (10% recycling) to scenario two (20% recycling) and then remains relatively constant through the remaining scenarios and thus the eutrophication results also follow this pattern.

3.6 Trospospheric Ozone (or smog)

TRACI's model for smog is based on grams of NOx equivalents. The results presented in Figure 12 indicate a net reduction or avoidance of smog related pollutants for each scenario. The pollutants that contribute to smog formation include NOx, carbon monoxide and methane with NOx being the most potent of the smog forming pollutants. NOx and carbon monoxide emissions are generally tied to the combustion of fuels while methane emissions are largely tied to the degradation of organic material in landfills. Although methane emissions from landfills are quite large, their smog equivalent is relatively low. This is illustrated when comparing scenario 3 (where landfill gas is vented) to scenarios 5 through 7 (where landfill gas is controlled). The results for smog are most significantly governed by transportation related activities and materials recycling (in general). Thus, an increase or decrease from scenario to scenario will depend on how much fuel and electrical energy are consumed. The negative values are directly tied to materials and/or electrical energy recovery from the scenarios.

The WTE scenario (scenario 8) shows the greatest offset of smog related pollutants because it offsets the most electrical energy. One might expect that the 40% recycling scenario, which had the greatest net energy offset, would also have the greatest smog offset. However, it appears that while the addition of metals recycling saves a significant amount of energy, it does not necessarily save as much in terms of smog related gases. There is also a slight increase in the offset of smog that results from landfill gas to energy projects (see scenario 5 versus scenarios 6 and 7). Scenarios 9 and 10 show the negative affects that long-hauling waste have in terms of smog production.

3.7 Human Health

Human health impacts are modeled in TRACI for cancer, non-cancer, and criteria pollutant categories. The indicator used for each of these categories is as follows (1) cancer: grams of benzene equivalent; (2) non-cancer: grams of toluene equivalent; and (3) criteria: grams PM2.5 equivalent. For presentation purposes, TRACI results were converted to kilograms of respective equivalent. The results for the three human health categories are shown in Figures 13 through 15.

The key pollutants reported by the MSW-DST to model cancer impacts include lead releases to the air and water and arsenic and cadmium releases to water. Of these pollutants, arsenic is the most potent cancer agent. However, it is insignificant relative to lead and cadmium releases. Figure 13 indicates relatively little difference between the scenarios for cancer related health effects except for Scenario 10 which transports waste using long-haul by rail. This is related to higher cadmium and lead water releases associated with the production and combustion of fuel for rail engines.

For non-cancer human health impacts (Figure 14), the results are negative for all scenarios because of a net offset of non-cancer related pollutants. The non-cancer pollutants reported by the MSW-DST and used in the non-cancer TRACI model include air releases of ammonia, HCl, and lead and water releases of iron, ammonia, copper, cadmium, arsenic, mercury, selenium, lead, and zinc. The pollutant that appears to drive this non-cancer category is zinc through water releases. In reviewing the LCI results, zinc releases (or in this case offset of releases) result from materials remanufacturing operations and thus the results are tied to materials recycling. Specifically, paper recycling is driving the non-cancer health results. As paper recycling increases from scenario 1 to 2, the non-cancer health offset increases but as paper recycling remains steady for the remaining scenarios, the non-cancer results also remain steady.

For criteria pollutants, the TRACI model converts U.S. EPA criteria air pollutants to PM 2.5 equivalents. Figure 15 shows the criteria pollutant human health results for this study based on life-cycle emission results from the MSW-DST for PM, SOx, and NOx. All results are negative indicating that there is a net savings or avoidance of criteria air emissions for all scenarios. In reviewing the LCI results, these air emissions (or in this case offset of releases) result from materials remanufacturing operations as well as electrical energy consumption/production and thus the results are generally tied to these two activities. The WTE scenario (scenario 8) has the highest offset due to its 30% recycling and high recovery of electrical energy from the remaining portion of the waste stream. Scenario 1 has the lowest net offset because it has the lowest level of recycling.

3.8 Ecological Toxicity Results

For ecological toxicity, TRACI converts specific pollutants (air and water) to grams of 2,4-D equivalents. The results presented in Figure 16 are reported in kilograms. All scenarios indicate a net offset of eco-tox related pollutants. The eco-toxicity pollutants reported by the MSW-DST and used as inputs in the TRACI model include (1) ammonia, HCl, and lead for air releases and (2) iron, ammonia, copper, cadmium, arsenic, mercury, and selenium for water releases.

In reviewing the TRACI equivalency factors and results, it appears that zinc releases to the water are the driving pollutant for eco-tox and thus the results are directly tied to this pollutant. In reviewing the LCI results, zinc releases (or in this case offset of releases) result from materials remanufacturing operations and thus the results are tied to materials recycling. Specifically, paper recycling is driving the non-cancer health results. As paper recycling increases from scenario 1 to 2, the eco-tox offset increases but as paper recycling remains steady for the remaining scenarios, the non-cancer results also remain steady.

4. Conclusion

With EPA's Resource Conservation Challenge there is increased interest in finding more sustainable solutions for waste management. This paper provides an evaluation of scenarios to illustrate the tradeoffs in life-cycle emissions, energy consumption, and micro-economic costs between different strategies for waste and materials management. The results are based on a medium-sized community using national or average defaults. Cost results capture the full-costs of managing the defined tonnage of waste through its life (varies by waste management operation). Environmental results capture the full life cycle burdens and benefits of waste and materials management. Although actual results for a specific community will vary, the general trends are thought to be realistic. The use of MSW-DST in evaluating management strategies can help a community identify site-specific strategies that maximize environmental benefits and minimize cost.

Multi-criteria analysis did not result in any clear winner. For example, WTE appears to be the most attractive option in terms of net carbon emissions, acidification, and smog. However, this option had a higher cost as compared to the other options using landfills. The option with the lowest cost is Scenario 2 which had a 20% recycling rate. The option with the most attractive net energy consumption is the option with a 40% recycling target. This is due to offsets from primary production which includes extraction and mining environmental burdens.

In general the recovery of materials and energy helps to reduce environmental impacts as illustrated by the results. Criteria based on improving environmental and economic performance would have to be developed on a site-specific basis to help determine which scenario is preferred depending upon a community's objectives and constraints. Some communities may have greater concern over water quality issues whereas others may value air quality concerns more. Constraints to consider include whether there is sufficient waste to fuel a WTE plant or available land to build a landfill. Uncertainty is also a factor and important in decision making (Özge Kaplan et al., 2005) to be considered in future analysis. In a cursory review of the results, Scenario 6 (30% recycling, residual landfilled, and landfill gas recovered to produce electricity using IC engines) might be viewed as preferred because of its mid-range cost, 30% recycling rate, and life-cycle environmental performance. However, if environmental performance was given more weight than cost, then one might prefer Scenario 8 (30% recycling rate and residual managed using WTE facility).

How might this analysis change for a given community? The results could be quite different when model defaults for land values, labor rates, facility costs, and environmental burdens are adjusted to represent site-specific values. The results presented in this paper are based on a limited number of pollutants. For some options, metals, hazardous air pollutants, and toxics, are calculated for some options (e.g., combustion and landfills) but not for all because there is no consistent data across all options. Also, the remanufacturing numbers seem to dominate the impact results. It would be interesting (perhaps in a future paper) to separate the impacts from waste activities from those associated with energy and materials production.

Next steps include conducting further applications of the MSW-DST for regional and local decision making. Work on a web-accessible version of the MSW-DST is also progressing. Once reviews are complete, a web-accessible version will be released (planned for 2007) providing easier access and more wide-spread use. The web accessible version is to include TRACI for allowing impact assessment for comparing materials and waste management strategies. Updates will be conducted as newer data and information become available. For further information about the MSW-DST, refer to the project web site at www.rti.org (or Keith Weitz at kaw@rti.org).

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Table 1. Process Model Assumptions and Allocation Procedures

	Key Assumptions and Design Properties	Allocation Procedures[a]
Collection	Location specific information (e.g., population, generation rate, capture rate) is model input.	Environmental releases are allocated based on mass. Cost is based on volume and mass.
Transfer Station	User selects between several default design options based on how the MSW is collected.	Same as collection
Materials Recovery Facility (MRF)	Design of the MRF depends on the collection type (mixed waste, commingled recyclables, etc.) and the recyclables mix. Eight different designs are available.	Same as collection. Also includes revenue from the sale of recyclables.
Combustion (with and without energy recovery)	The default design is a new facility assumed to meet the most recent U.S. regulations governing combustion of MSW. Designs to model older facilities are also available.	Environmental releases are allocated based on mass and stoichiometry. Cost is based on mass and includes revenue from sale of metal scrap and electricity (based on Btu value of the waste and the heat rate of the facility).
Refuse-Derived Fuel (RDF) and Processed-Refuse Fuel (PRF)	Traditional RDF and PRF design options are available. The facilities are designed to meet the U.S. Clean Air Act regulations for MSW combustion.	Same as combustion.
Composting (both yard and mixed MSW)	A low and high quality mixed MSW and yard waste compost facilities are included. All use the aerated windrow composting process as the default design.	Same as MRFs. However, no revenue was assumed for sale of compost for this analysis.
Landfill (traditional, bioreactor, and ash)	The default design meets U.S. federal requirements (i.e., RCRA Subtitle D and Clean Air Act). Process model also includes design for wet/bioreactor landfills (with leachate recirculation) and ash (monofills).	Cost and emissions for operations, closure, and post-closure are allocated equally over the mass of refuse buried. Landfill gas and leachate are allocated to MSW items.
Electrical Energy	Regional electrical energy grids are used for waste management processes; national grid for upstream processes.	Environmental releases are based on the fuel source used by regional or national electricity grids. Regional grids are used for waste management operations; National grid used for manufacturing operations. Cost is not considered.
Inter-Unit Process Transportation	Distances between different unit operations are key input variables.	Environmental releases are based on mass. Cost is based on volume and mass, and is considered only for transportation necessary for waste management.
Materials Production	Primary (virgin) and Secondary (recycled) closed-loop production processes are included.	Environmental releases are based on mass. Cost is not considered.

[a] Allocation of costs, resource and energy consumption, and environmental releases to individual MSW components

Table 2. Description of Scenarios Used to Illustrate Potential Environmental and Economic Tradeoffs

Scenario	Description
1	10% recycling, 90% landfilled with no gas collection and control
2	20% recycling, 80% landfilled with no gas collection and control
3	30% recycling, 70% landfilled with no gas collection and control
4	40% recycling, 60% landfilled with no gas collection and control
5	30% recycling, 70% landfilled; landfill gas is collected and combusted using flare
6	30% recycling, 70% landfilled; landfill gas is combusted using internal combustion engines to produce electricity
7	30% recycling, 70% landfilled; landfill gas is piped to nearby industrial facility and combusted in boiler (displacing fuel oil)
8	30% recycling, 70% combusted using waste to energy facility (generating electricity and recovery of metals)
9	Same as Scenario 5 except waste is collected and transported to transfer station, and then long-hauled 800 kilometers (500 miles) to landfill using semi-tractor truck
10	Same as Scenario 9 except waste is long-hauled to landfill by rail

Table 3. Summary of Key Assumptions Used in This Study

Parameter	**Assumption**
General	
Waste Generation	437,000 metric tons/year
Waste Composition	National average[a]
Collection Frequency	1 time per week
Transportation Distances	
Collection to Transfer Station	16 kilometers one way
Collection to MRF	16 kilometers one way
Collection to Compost	16 kilometers one way
Collection to WTE	16 kilometers one way
Collection to Landfill	16 kilometers one way
Transfer Station to Landfill	800 kilometers one way (used in long-haul scenarios)
Materials Recycling Facility	
Basic Design	Semi-automated, commingled recyclables
Equipment	Magnet, eddy-current separator, glass crusher
Separation Efficiency	90% for all materials
Compost Facility	
Basic Design	Yard waste, windrow
Windrow Turning Frequency	2,270 kg/week
Compost Residence Time	168 days
Compost Curing Time	90 days
WTE Facility	
Basic Design	Mass burn
Heat Rate	18,600 kJ/kWhr
Waste Input Heating Value	Varies by waste constituent
Ferrous Metal Recovery Rate	90%
Utility Sector Offset	Baseload coal
Landfill	
Basic Design	Subtitle D
Time Period for Calculating Emissions	100 years
Landfill Gas Collection Efficiency	75%
Landfill Gas Management	Varied (vent, flare, and energy recovery)
Utility Sector Offset	Baseload coal (for ICE) or fuel oil (for boiler).

[a] From EPA's Office of Solid Waste (http://www.epa.gov/msw/msw99.htm)

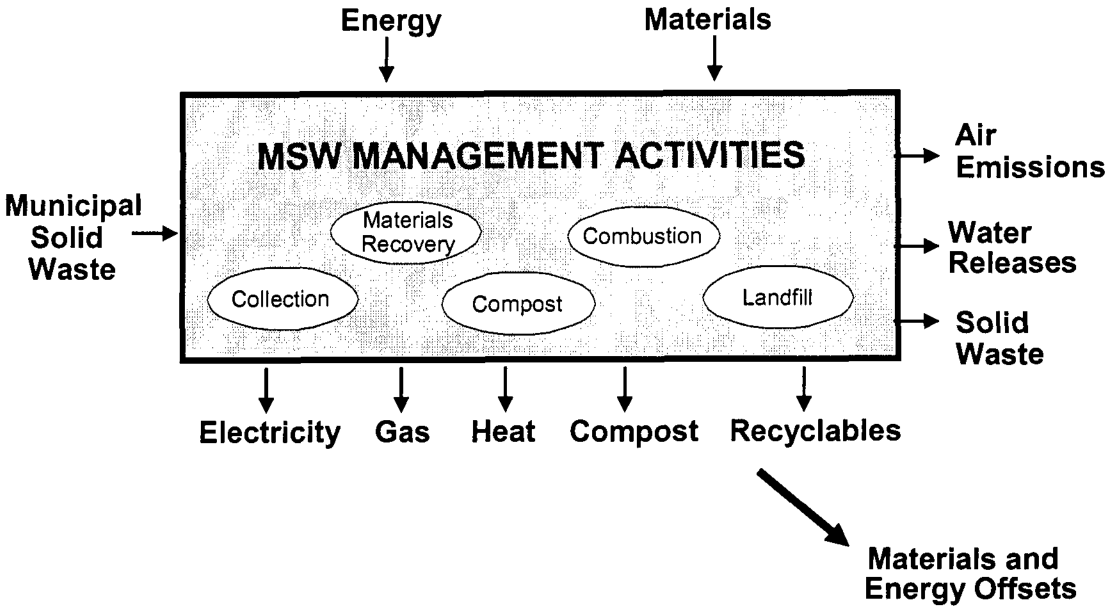


Figure 1. Illustration of MSW Life-Cycle

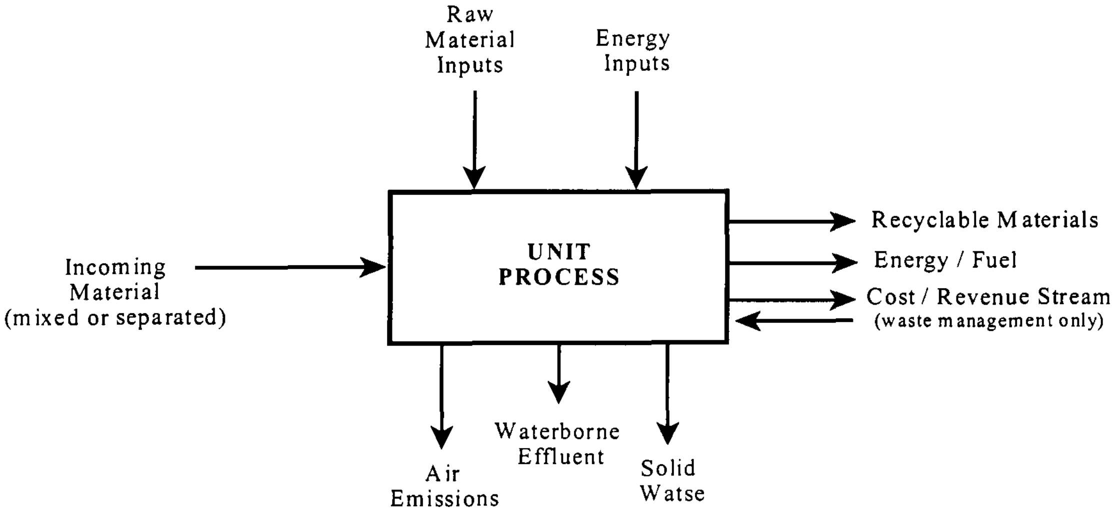


Figure 2. Illustration of a Unit Process
A given quantity and composition of material flows into each unit process. Default facility designs and operating conditions are used to estimate the energy and resource use, environmental releases, and cost (or revenue) for each unit process. These values are then partitioned to individual MSW components using the allocation provided in Table 2.

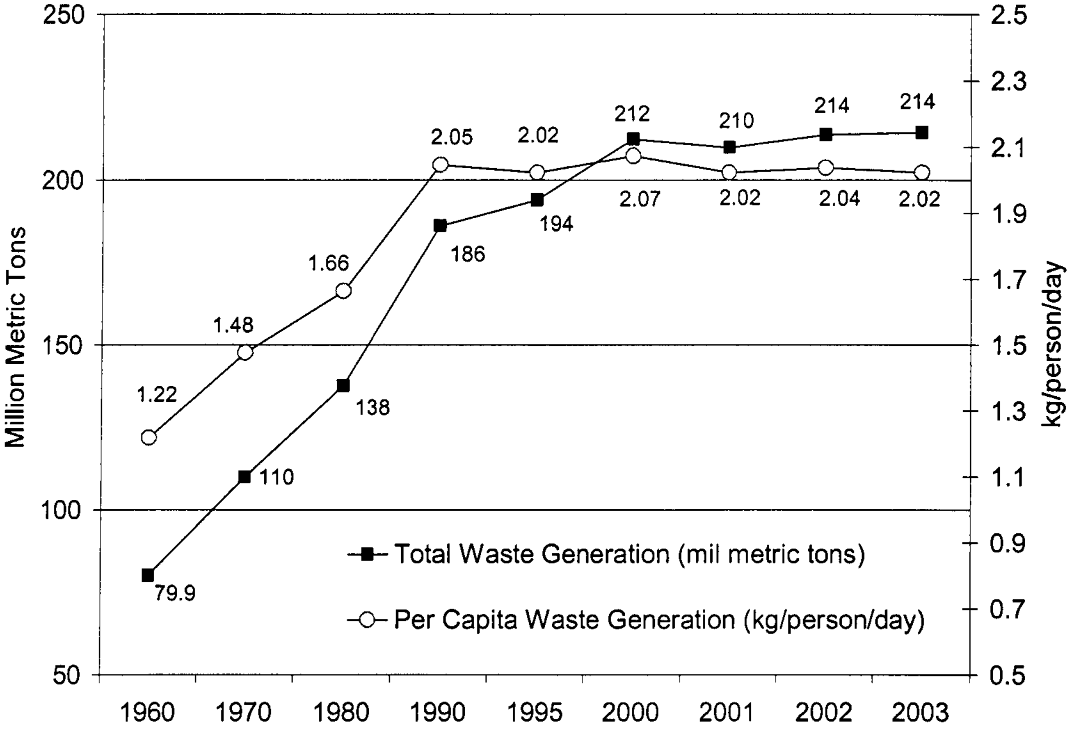


Figure 3. Trends in U.S. MSW Generation (EPA, 2003a, b)

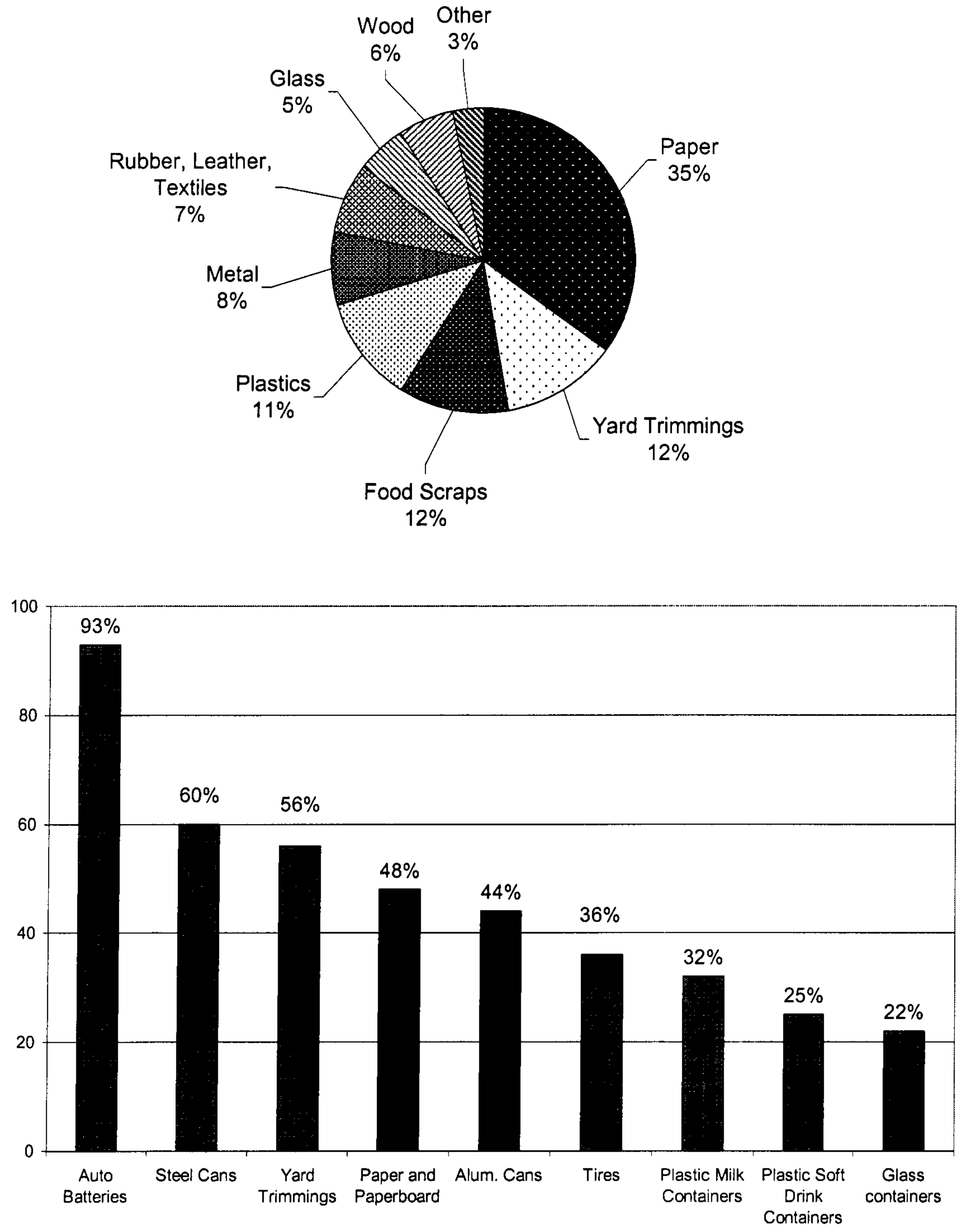


Figure 4. Composition of MSW in the U.S. and Selected Recycling Rates (EPA 2003a)

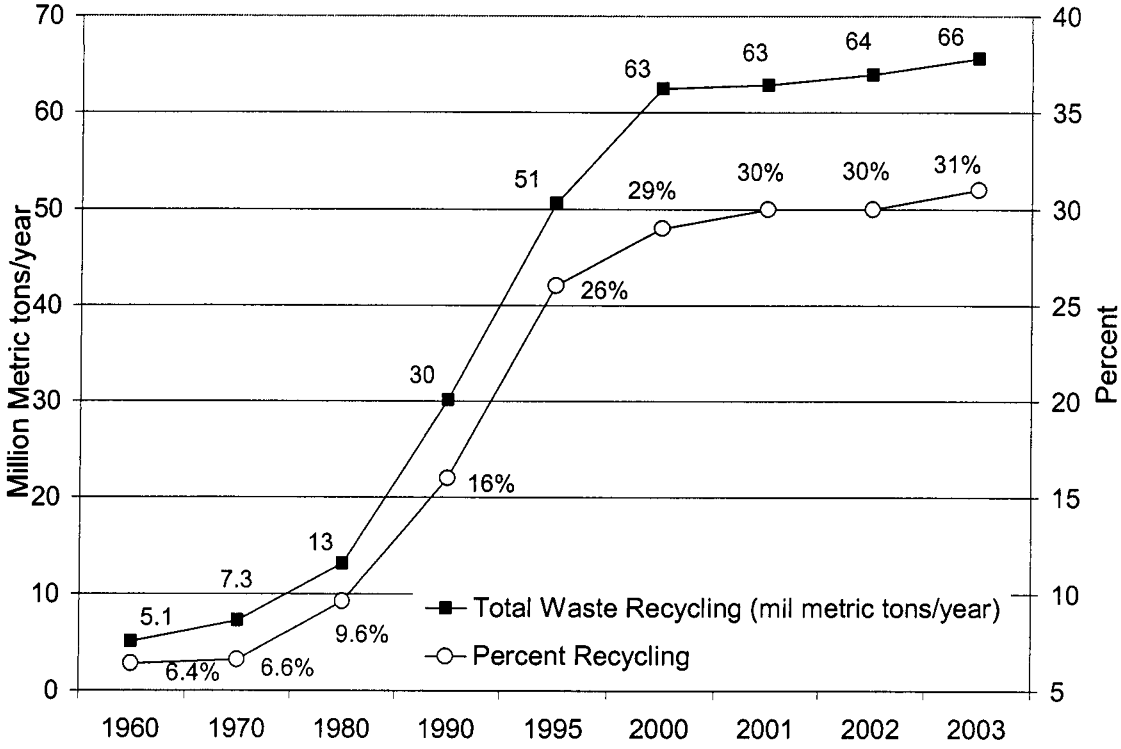


Figure 5. U.S. Waste Recycling Rates 1960-2001 (EPA 2003a)

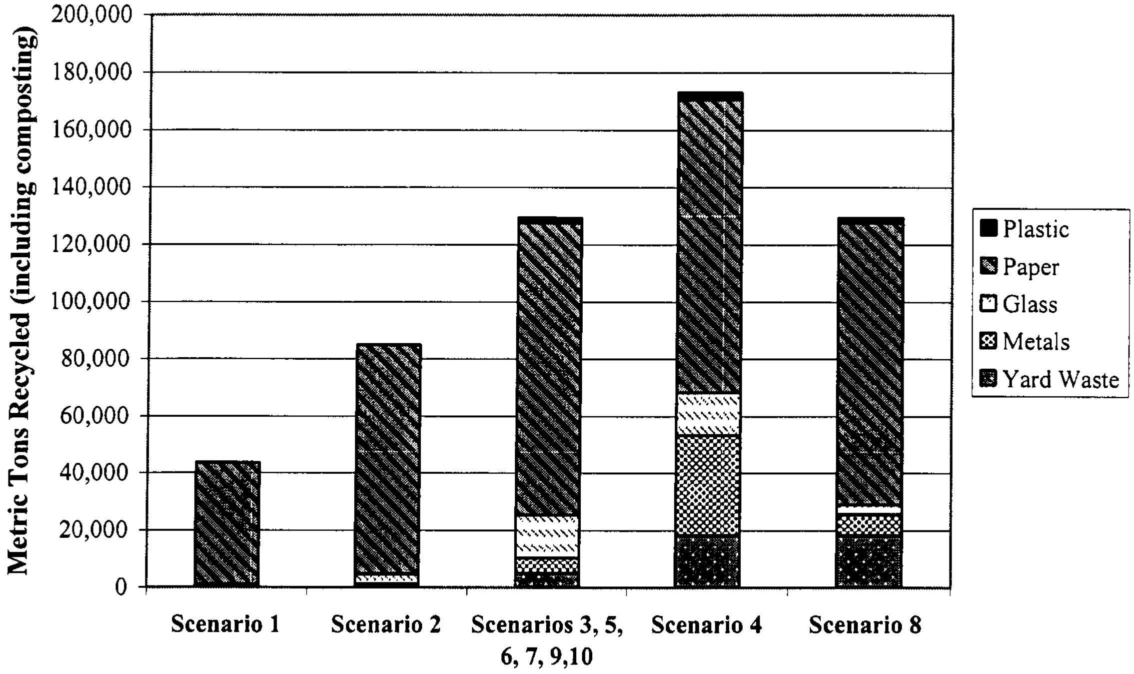


Figure 6. Composition of Materials Captured by Tonnage for Management Scenarios

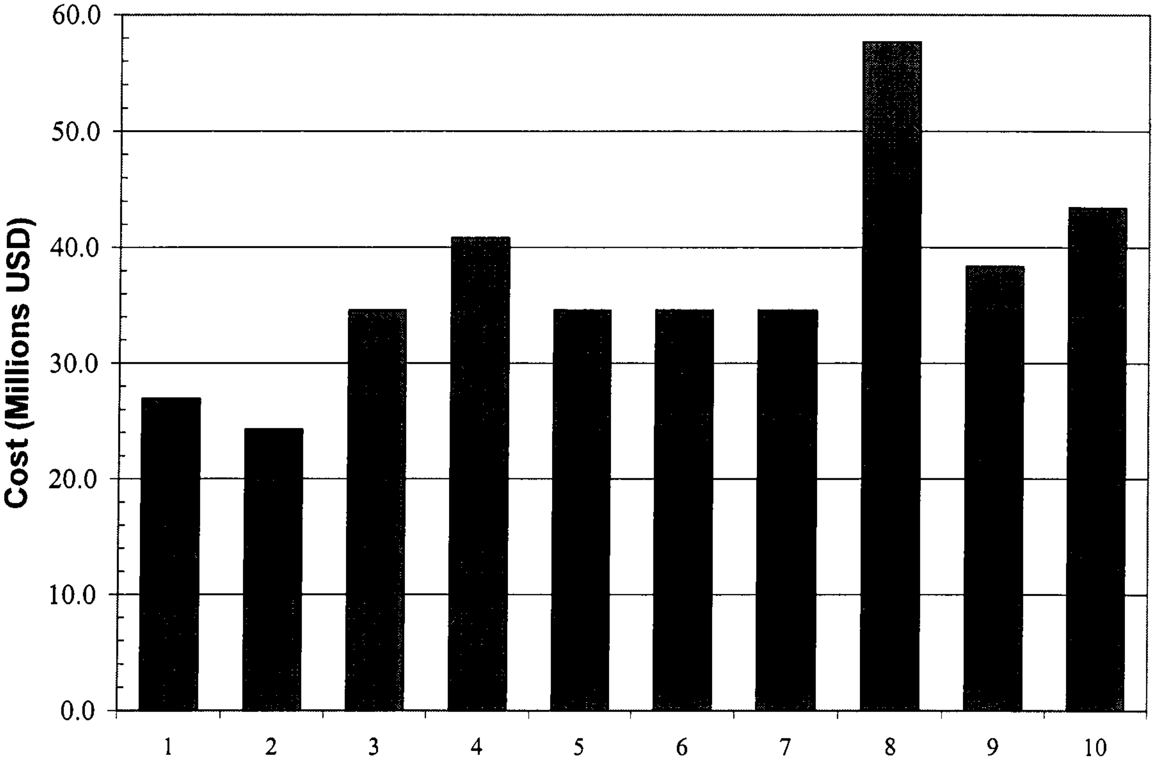


Figure 7. Net Annualized Cost by Scenario

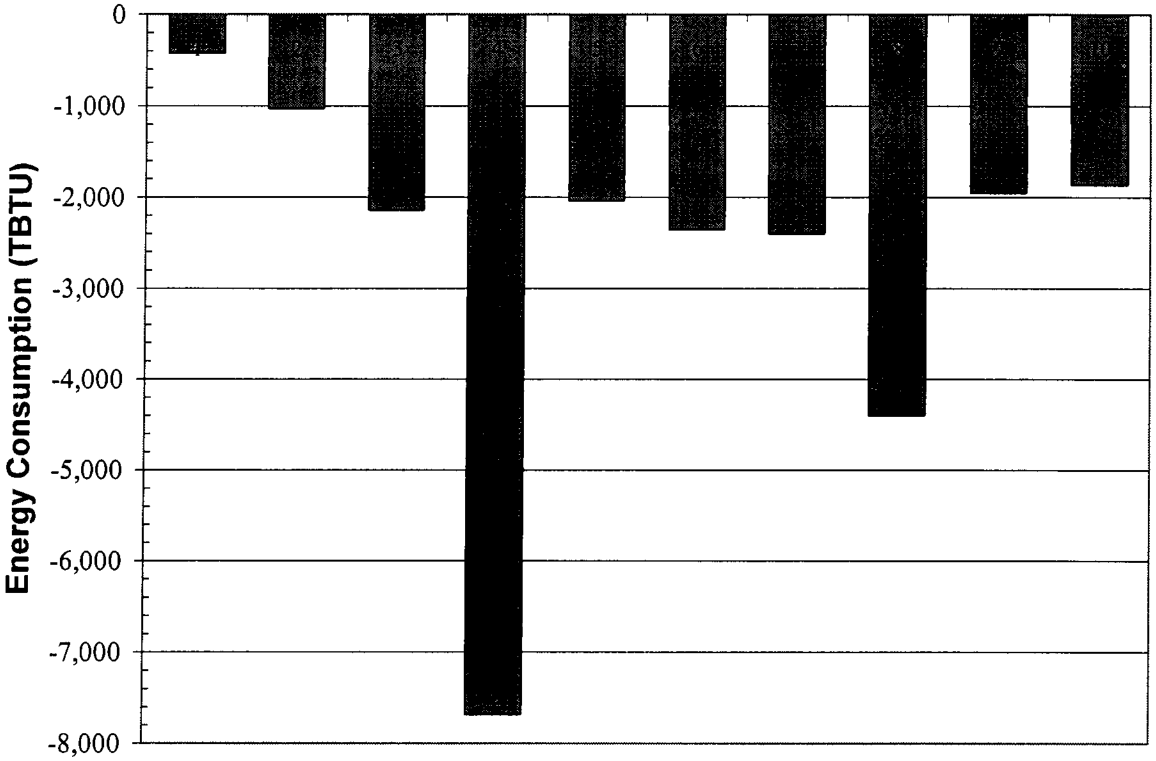


Figure 8. Net Energy Consumption by Scenario

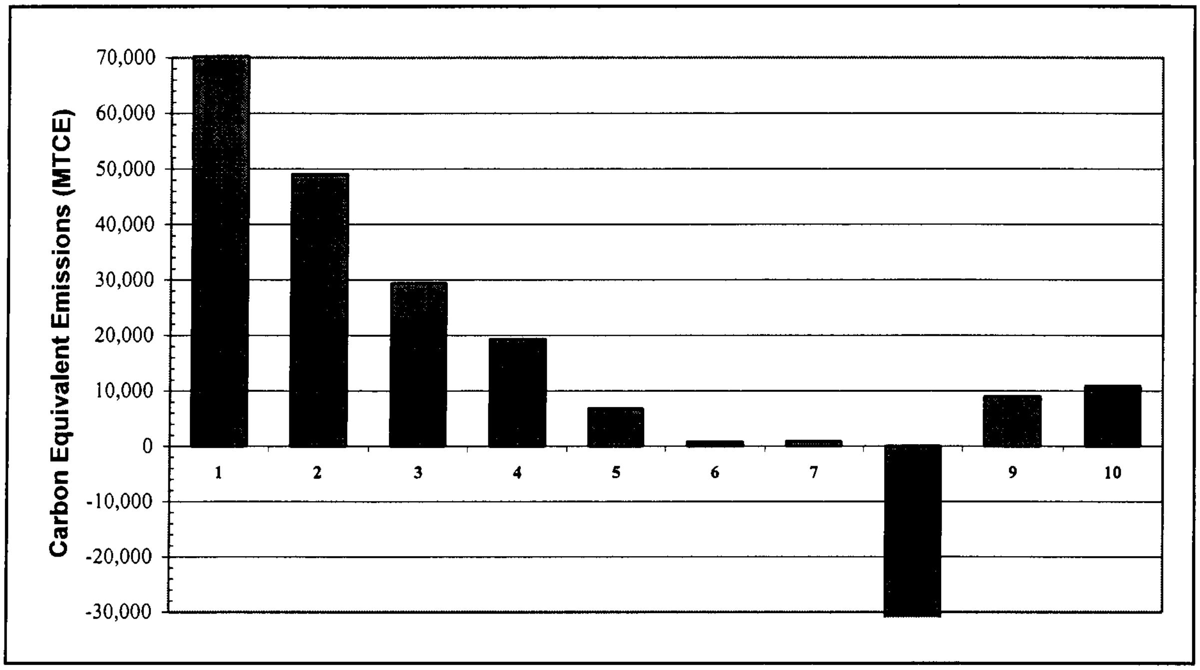


Figure 9. Net Global Climate Change Emissions by Scenario

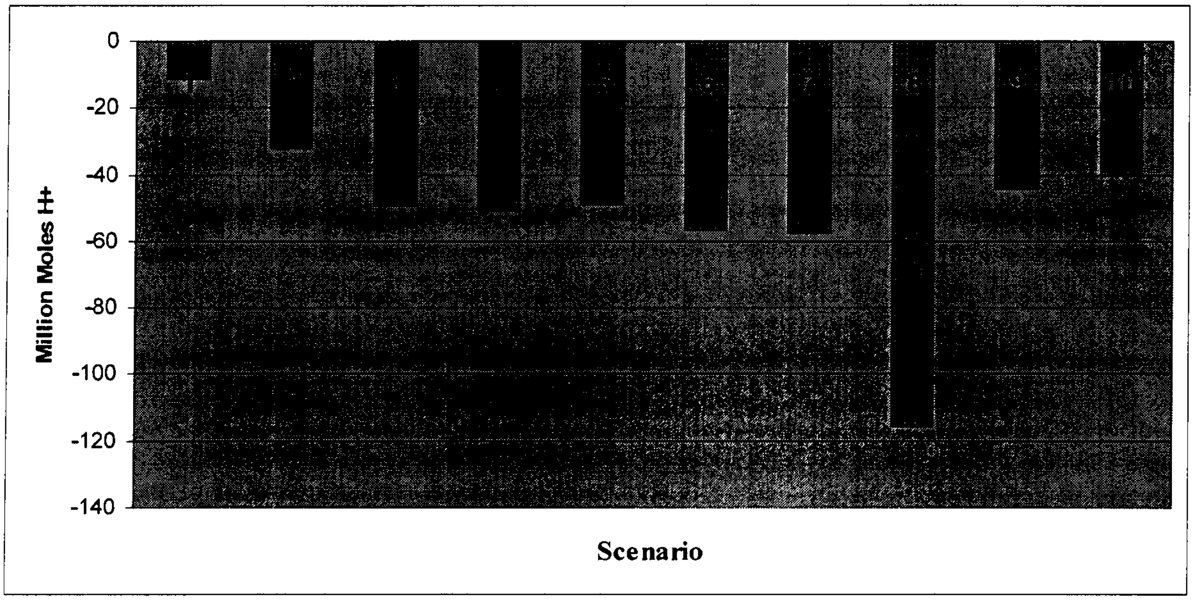


Figure 10. Acidification Results by Scenario

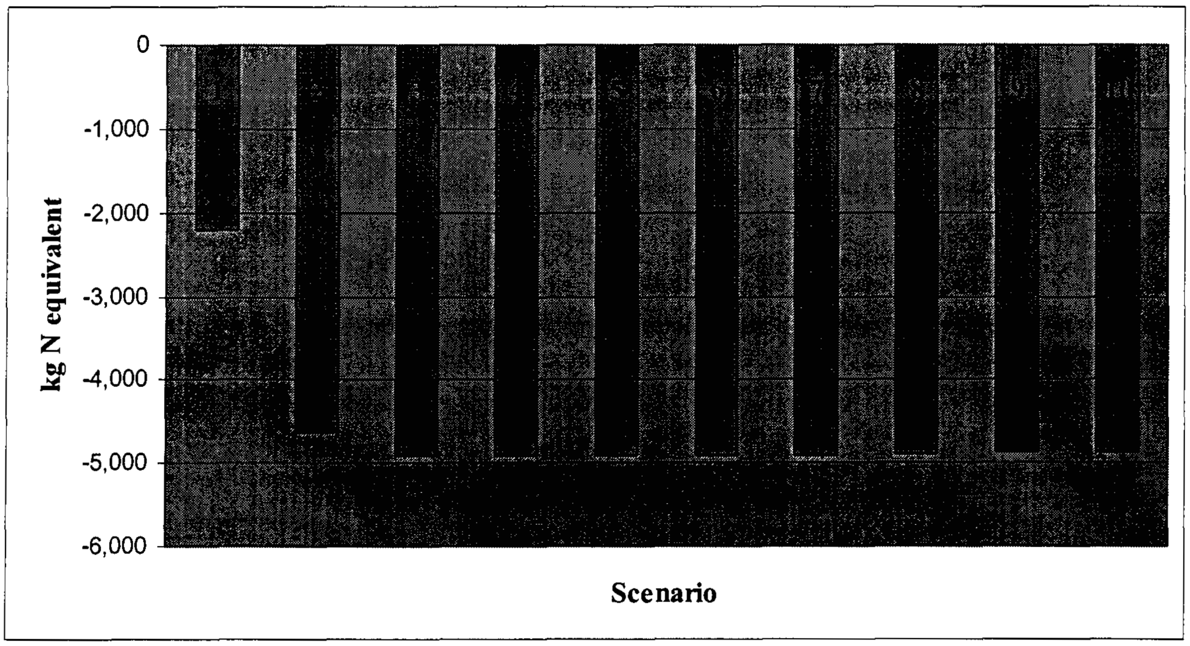


Figure 11. Eutrophication Results by Scenario

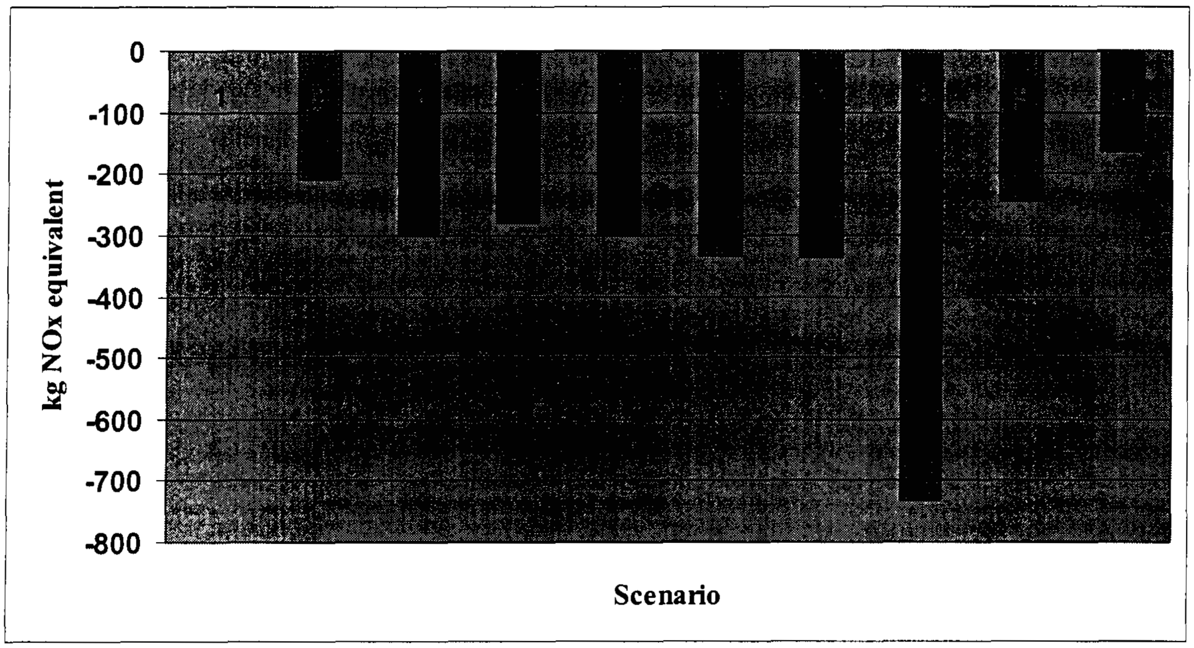


Figure 12. Smog Results by Scenario

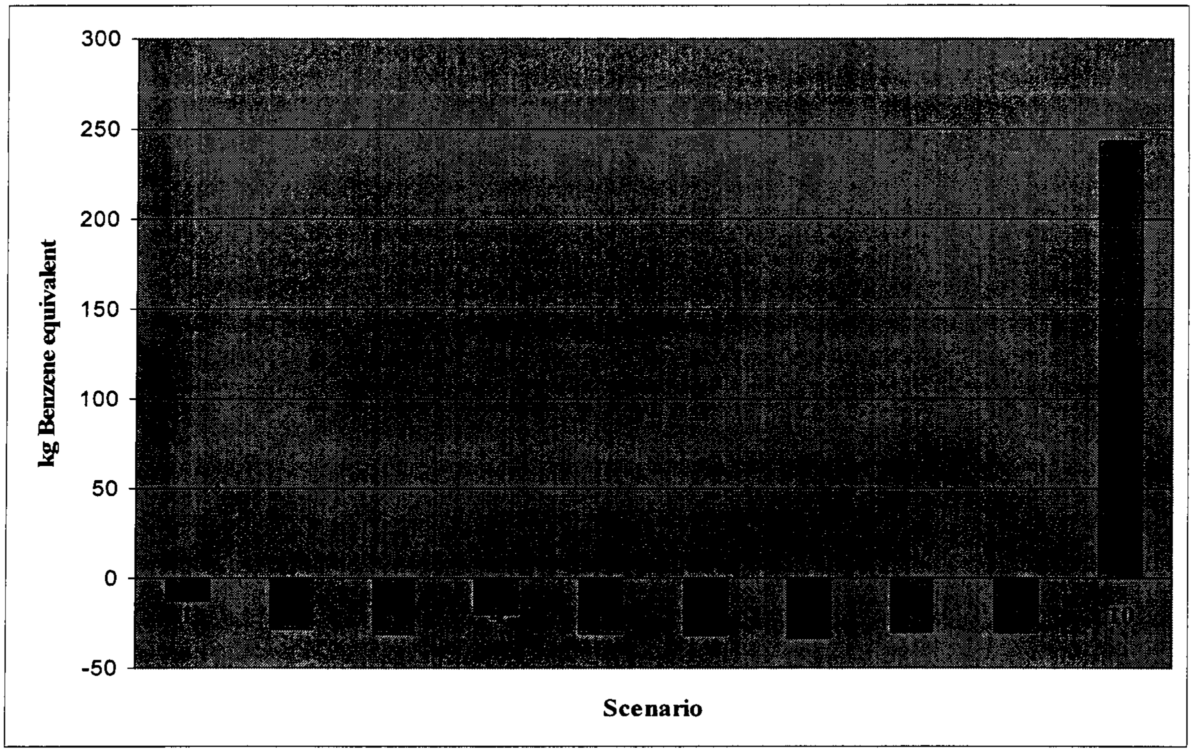


Figure 13. Human Health Cancer Results

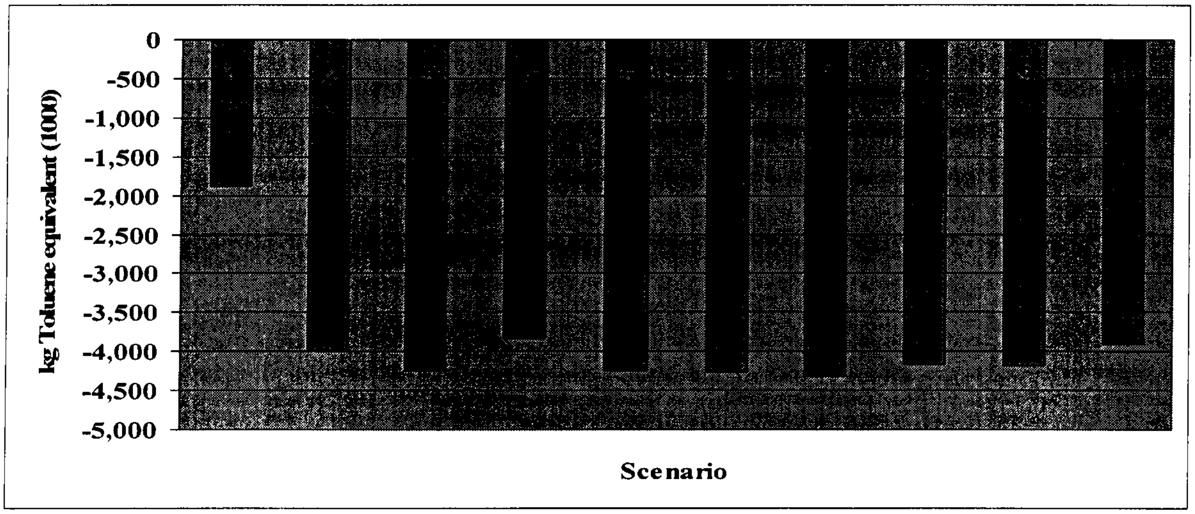


Figure 14. Human Health Non-Cancer Results

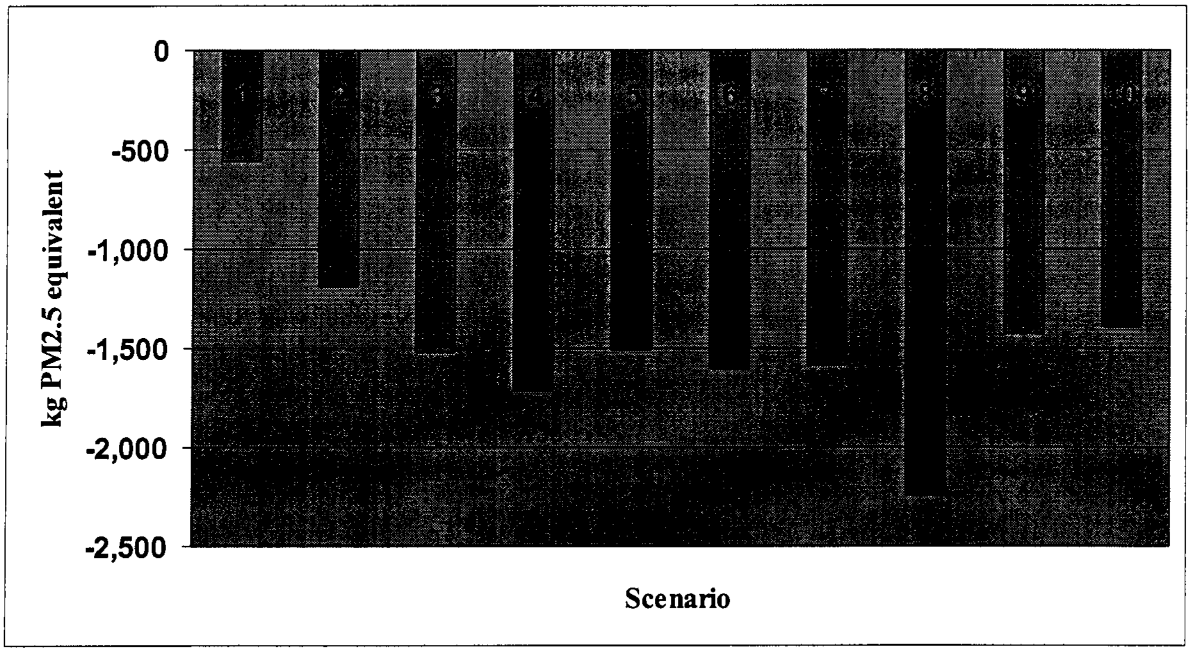


Figure 15. Human Health Criteria Air Pollutant Results

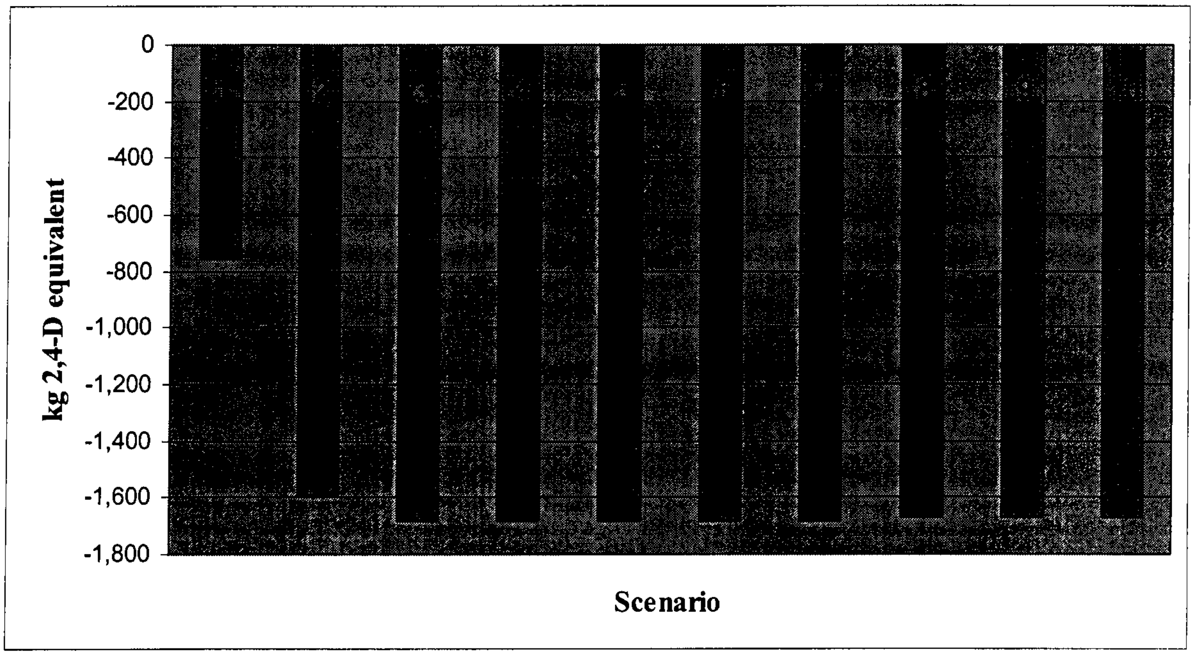


Figure 16. Ecological Toxicity Results

Greenhouse Gas Reductions From The Wheelabrator Saugus Waste-to-Energy Facility

October 14, 2003

Greenhouse Gas Reductions From Waste-to-Energy: A Case Example Using Saugus, MA Facility Data

Background

Greenhouse gas (GHG) emissions, expressed as emissions of carbon equivalents, are associated with many aspects of municipal solid waste (MSW) management including the production of fuels and electrical energy, combustion of fuels in vehicles and equipment, combustion of waste, and the decomposition of waste (e.g., compost or landfill). GHG emissions can be reduced or avoided by adopting various MSW management practices. For example, diverting recycling materials from the waste stream displaces virgin materials production and thus avoids GHG emissions from virgin material production. Similarly, recovering energy from waste displaces electrical energy production in the utility sector and thus avoids GHG emissions associated with electrical energy production. Table 1 includes a listing of the various sources of GHG emissions from MSW management and related activities, as well as activities related to waste-to-energy that avoid the release of GHG emissions.

Objective

The goal of this analysis is to calculate the quantity of GHG emissions generated and avoided through the use of the waste-to-energy facility in Saugus, Massachusetts.

Method and Results

For this exercise, the Wheelabrator waste-to-energy facility located in Saugus, Massachusetts (Saugus) was chosen. The Saugus facility was the first successful commercial waste-to-energy facility in the United States, having begun operation in 1975. The facility processes up to 1500 tons of MSW per day from communities north of Boston, and is equipped with state-of-the-art emissions control technologies.

GHG emission estimates were calculated using the MSW decision support tool (MSW DST) developed by RTI International in cooperation with the U.S. Environmental Protection Agency. Background information about the MSW DST is provided in Attachment A.

Using site-specific data, the MSW DST was used to quantify the difference in GHG emissions for waste managed at the Saugus waste-to-energy facility versus GHG emissions that would result if the waste was disposed of at a landfill and the electricity was generated by a local utility. Based on discussions with local MSW management officials, a landfill was identified where the waste would most likely be sent to if the waste is not managed at the Saugus facility. The Saugus waste-to-energy facility manages more than 400,000 tons of waste per year. This waste would be rail hauled to a landfill in Lee County, South Carolina if not managed locally at the

Saugus facility. The South Carolina landfill is approximately 870 miles from the waste collection in Eastern Massachusetts.

Table 1. Sources of GHG Emissions From MSW Management and Potential Areas Where GHG Emissions May Be Avoided

Waste Management or Related Activity	Sources of GHG Emissions	Potential Areas Where GHG Emissions May Be Avoided
Collection	Combustion of fuels in trucks Production of fuels and electricity	
Combustion	Combustion of waste Combustion of fuels in equipment Production of fuels and electricity	Displacement of electrical energy Ferrous recycling Avoided land disposal
Landfill	Decomposition of waste Combustion of fuels in equipment Production of fuels and electricity	Displacement of electrical energy (where landfill gas is collected and used for energy recovery)
Transportation	Combustion of fuels in trucks Production of fuels	

The electrical energy that is produced at the Saugus facility is part of the base load capacity purchased and/or generated by the local utility and displaces coal and oil produced electrical energy. As a result, GHG emissions are avoided through fossil fuel conservation and reduction of carbon dioxide emissions at the power plant. Because of the reliability in energy production of waste-to-energy facilities, this energy more often displaces power generated from older fossil-fuel power plants. In addition to GHG emissions being reduced, particulate, and sulfur dioxide emissions are also reduced.

Key assumptions used to conduct the scenario analysis are presented in Table 2. The results for this analysis are illustrated graphically in Figures 1 and 2.

Interpretation of Results

As shown in Figure 1, the Saugus waste-to-energy facility avoids the release of GHG emissions by displacing electrical energy production in the utility sector, displacing virgin steel production, and avoiding the quantity of waste being disposed of in a landfill. The avoided GHG emissions far outweigh emissions generated through waste collection, combustion, and ash disposal . The net GHG emissions (expressed as metric tons of carbon equivalent or MTCE) for the waste-to-energy scenario (including offsets) are estimated to be a negative 73,000 MTCE per year. The negative value means that a net 73,000 MTCE per year are avoided through the use of the Saugus waste-to-energy facility as compared to the disposal of waste at the South Carolina landfill, generation of electricity at a local utility, and production of virgin steel.

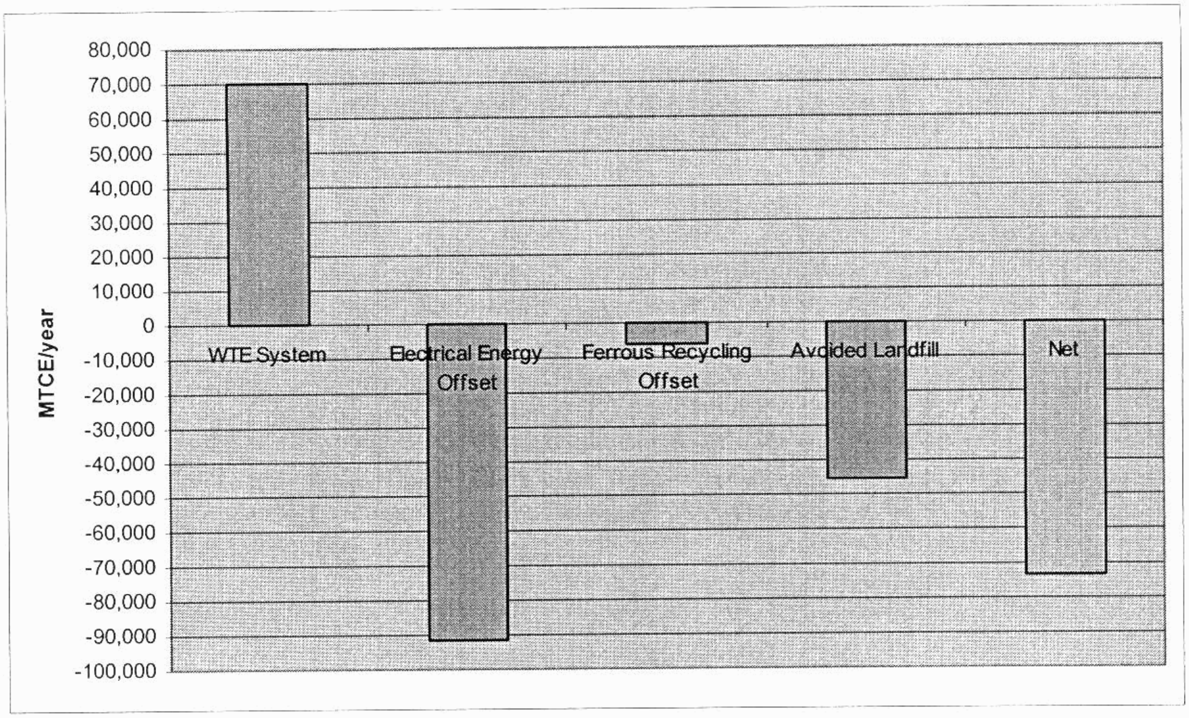
Table 2. Key Assumptions

Parameter	Assumption
General	
Waste Generation	440,000 tons/year
Waste Composition	National Average (based on U.S. EPA data)
Residential Population	450,000
Residential Waste Generation Rate	5.4 lb/person/day
Residents Per Household	2.8
WTE Facility	
Basic Design	Mass Burn
Heat Rate	18,000 BTU/kWh
Waste Input Heating Value	Varies by waste constituent
Ferrous Recovery Rate from Ash	90%
Utility Sector Offset	Coal and oil fired utility boilers
Landfill	
Basic Design	Subtitle D
Time Period for Calculating Emissions	100 years
Landfill Gas Collection Efficiency	58%
Landfill Gas Management	Gas collection and flaring
Local Utility	
Basic Design	Utility boiler
Fuel Use	Coal and oil
Heat Rate	10,402 Btu/lb coal and 149,700 Btu/gal oil
Generation Efficiency	33% for coal and 33% for oil

Conclusion

This analysis shows that the Saugus WTE facility is responsible for indirect reductions of 73,000 MTCE per year due to avoided landfill emissions, ferrous metals recycling, and displacement of fossil-fuel electricity generation.

Figure 1. Total Net GHG Emissions from WTE Versus South Carolina Landfill Option.



Attachment A
Background Information About the MSW DST

The MSW DST was developed through a cooperative agreement between the U.S. EPA's Office of Research and Development and RTI's Center for Environmental Analysis to assist communities and other waste planners in conducting cost and environmental modeling of MSW management systems. Users can evaluate the numerous MSW management strategies that are feasible within a community or region and identify the alternatives that are economically and environmentally efficient, making tradeoffs if necessary.

The MSW DST allows users to analyze existing waste management systems and proposed future systems based on user-specified information (e.g., waste generation levels, waste composition, diversion rates, infrastructure). The current components included in the MSW DST are waste collection, transfer stations, material recovery facilities (MRFs), mixed MSW and yard waste composting, combustion and refuse-derived fuel production, and conventional or bioreactor landfills. Existing facilities and/or equipment can be incorporated as model constraints to ensure that previous capital expenditures are not negated by the model solution.

As illustrated in Figure A-1, the MSW DST consists of several components, including process models, waste flow equations, an optimization module, and a graphic user interface (GUI). The process models consist of a set of spreadsheets developed in Microsoft Excel. These spreadsheets use a combination of default and user-supplied data to calculate the cost and life-cycle coefficients on a per unit mass basis for each of the 39 MSW components being modeled for each solid waste management unit process (collection, transfer, etc.). Each process model describes and represents the essential activities that take place during the processing of waste items. For example, the collection model includes parameters for waste collection frequency, collection vehicle type and capacity, number of crewmembers, and number of houses served at each stop. Although national average default values are included in the MSW DST for such parameters, users can override the default values with site-specific information. These operational details, which are input by the user to represent an MSW management system, are then synthesized in the process model to estimate the cost of processing as a function of the quantity and composition of the waste entering that process. The resulting cost coefficients from each waste management process model are then used to estimate the cost of that option.

The MSW DST also contains models for ancillary processes that may be used by different waste management processes. These models calculate emissions for fuels and electrical energy production, materials production, and transportation. Electricity, for example, is used in every waste management process. Based on the user-specified design information and the emissions associated with generating electricity from each fuel type, the MSW DST calculates coefficients for emissions related to the use of a kilowatt-hour of electricity. These emissions are then assigned to waste stream components for each facility that uses electricity and through which the mass flows. For example, MRFs use electricity for conveyors and facility lighting. The emissions associated with electricity generation would be assigned to the mass that flowed through that facility. Users can specify whether the emissions associated with generating electrical energy are based on a national, regional, or user-defined mix of fuel.

The optimization module is implemented using a commercial linear programming solver called CPLEX. The model is constrained by mass flow equations that are based on the quantity and composition of waste entering each unit process and that intricately link the different unit processes in the waste management system (i.e., collection, recycling, treatment, and disposal options). These mass flow constraints preclude impossible or nonsensical model solutions. For example, these mass flow constraints will exclude the possibility of removing aluminum from the waste stream via a mixed waste MRF and then sending the recovered aluminum to a landfill. The optimization module uses linear programming techniques to determine the optimum solution consistent with the user-specified objective and mass flow, and user-specified constraints. Examples of user-specified constraints are the use of existing equipment/facilities and a minimum recycling percentage requirement.

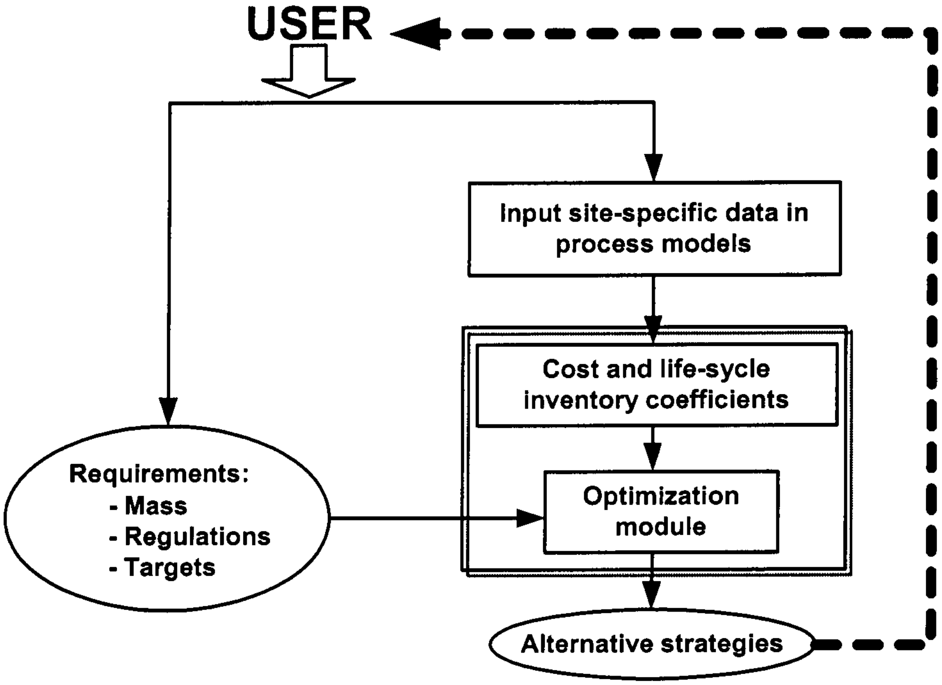


Figure A-1. Conceptual Framework for the MSW DST.

The environmental aspects associated with a defined MSW management strategy are estimated in terms of annual net cost, energy consumption, and environmental releases (air, water, solid waste). For example, waste collection vehicles consume fuel and release several types of air pollutants in their exhaust. The collection process model of the MSW DST uses information about the quantity and composition of waste generated and a host of collection route parameters to estimate the amount of fuel consumed and air emissions by waste constituent collected. In addition, the environmental burdens associated with producing the fuel used in the collection vehicles are calculated and included in the collection results. All process modules in the MSW

DST operate in a similar manner and express results as a function of the quantity and composition of the waste entering each process.

In some waste management processes, cost, energy, and emission offsets may occur. For example, diverting recycling materials from the waste stream results in a revenue stream and can displace energy consumption and emissions associated with virgin materials production. Similarly, waste management processes that recover energy (e.g., WTE, landfill gas utilization) will displace energy production in the utility sector and thereby avoid fossil fuel production- and combustion-related emissions. In applying the MSW DST, any materials or energy recovery-related benefits are netted out of the results for each process.

In terms of GHGs, the MSW DST accounts for CO_2 and methane emissions. Although there are other potential GHGs, CO_2 and methane are the main emissions associated with waste management. CO_2 emissions from fossil and non-fossil sources are tracked separately. This is because CO_2 emissions from non-fossil sources are typically given a "zero" weighting when converted to GHG equivalents. In addition to reporting emissions of CO_2 and methane, the MSW DST converts these emissions into an aggregate greenhouse gas equivalent (GHE) value using metric tons of carbon equivalent (MTCE) emitted per year as the reporting unit.

In addition to modeling GHG emissions for each scenario, we used a feature of the MSW DST that allows users to identify an objective (such as "minimize cost") for each run of the model. Here, for each model run, we specified the objective of identifying waste management options that would minimize GHG emissions. We then conducted iterative runs of the model, at each pass seeking the waste management solution that minimizes GHG emissions within the constraints of the scenario.

Table A-1 includes a list of the various stakeholders that participated in the development of the MSW DST. Annual stakeholder workshops and smaller stakeholder working group meetings were held and stakeholders provided input to and review of the specific modules (e.g., combustion, landfill) of the MSW DST.

Table A-1. MSW DST Stakeholders

American Forest and Paper Association
American Iron and Steel Institute
American Plastics Council
American Public Works Association
American Society of Mechanical Engineers
Association of County Commissioners for Georgia
Association of State and Territorial Solid Waste Management Officials
Audubon
Bes-Pack, Inc.
Browning-Ferris Industries, Inc.
Can Manufacturers Institute
Chemical Manufacturers Association
City of Austin
City of Los Angeles
City of Madison, WI
City of Philadelphia
City of Portland
City of San Jose
Corporations Supporting Recycling
County Waste Management Division, Santa Barbara California
Delaware Solid Waste Authority
E. Tseng & Associates
Electronic Industries Association
Electro-Prolysis, Inc.
Energy Answers Corporation, Inc.
Environment Canada
Environmental Defense Fund
Environmental Industry Associations
Glass Manufacturing Industry Council
Glass Packaging Institute
Indiana Institute of Recycling
Institute of Scrap Recycling Industries, Inc.
Integrated Waste Services Association
International City/County Management Association
International Joint Commission
Keep American Beautiful
Lucas County Solid Waste Management District
Minnesota Office of Environmental Assistance
Monterey Regional Waste Management District
MSW Management
National Association of Counties
National Conference of State Legislatures
National Council of the Paper Industry for Air & Stream Improvements, Inc.
National Recycling Coalition
National Solid Waste Management Association
New York City Department of Sanitation
New York State Energy Research and Development Authority
North Carolina Department of Environment and Natural Resources
Ogden Martin
Owens-Illinois, Inc
Procter & Gamble Company
Resource Recycling
Resource Recycling Systems, Inc.
SITA (UK)
Solid Waste Association of North American
Sound Resource Management Group
South Carolina Institute for Energy
State of Florida
State of Georgia
State of Iowa
State of New Hampshire
State of Pennsylvania
State of Wisconsin
Steel Recycling Institute
The Aluminum Association
The City of San Diego
The Coca-Cola Company
Union Carbide
U.S. Conference of Mayors
U.S. Navy
Virginia Association of Counties
Waste Industries, Inc.
Waste Management, Inc.