U.S. Case Studies Using Municipal Solid Waste Decision Support Tool

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SUMMARY: The recently completed municipal solid waste decision support tool (MSW-DST) is being used in communities across the United States. The methodology that the tool is based on incorporates both life-cycle inventory (LCI) analysis and full-cost accounting. The results of this tool are helping communities to make decisions that will result in more efficient environmental management. This paper provides an overview of some of the case studies that the tool has been used for to help illustrate the variety of potential applications.

1. INTRODUCTION

As presented in prior Sardinia conferences, the United States Environmental Protection Agency (U.S. EPA) has led the development of tools and data collection that can help communities make more informed decisions regarding municipal solid waste (MSW) management. Often there is conflicting information or a lack of data that prevents a credible evaluation of options. Through funding by the U.S. EPA, a MSW decision support tool (MSW-DST) and life-cycle inventory (LCI) database for North America have been developed. The collection and development of LCI data, methodology and two software products, were the result of more than 6 years of research including detailed data collection and software development.

This research was conducted with the cooperation of representatives from state and local government, solid waste industry, the aluminum, glass, paper, plastic, and steel industries, environmental interest groups, academia, and others. Over 80 stakeholders were included in this interactive process which included workshops, working groups, and annual meetings. A rigorous review of the methodology, data, process models, and software products was conducted by the stakeholders. In addition, a series of three external program peer reviews were conducted with internationally recognized experts in life-cycle assessment and solid waste management (SWM). The final set of reviews, which is still being completed, will include EPA's review process (i.e., peer, quality assurance, editorial, and administrative reviews). The goal was to develop a credible, objective, state-of-the-art tool that can be used to make more informed choices regarding SWM. (Thorneloe et al., 1999, Barlaz et al., 1999b) Based on the feedback from reviewers, stakeholders, and ongoing case studies, this has been successfully accomplished.

The research responsible for the development of the MSW-DST was led by the Research Triangle Institute (RTI) through a competed cooperative agreement (CR 823052). RTI life-cycle practitioners and SWM experts formed a research team with other experts from North Carolina State University, the University of Wisconsin at Madison, Franklin Associates, and Roy F. Weston, Inc. The extensive work to develop the data and methodology for conducting a LCI analysis for MSW landfills was conducted through funding provided by the Environmental Research and Education Foundation (EREF) (Barlaz et al., 1999a). In addition to EPA and EREF funding, the U.S. Department of Energy provided cofunding which was devoted to data collection and analysis on electrical energy and MSW composting and combustion (i.e., waste to energy).

Currently, the MSW-DST is being used in a variety of case studies. A companion paper provides an overview of one of these case studies that was conducted for the U.S. Conference of Mayors to evaluate historical trends of greenhouse gas emissions from MSW management. The subject of this paper is an overview of the other case studies which have already been completed or are in the process of being conducted. Feedback from the case studies has helped to determine improvements that are needed in the MSW-DST before it is released to ensure that the needs of the end users will be met. This paper will identify some of the planned improvements and considerations when applying the MSW-DST.

2. MSW-DST

2.1 Description of the MSW-DST

The MSW-DST is an interactive tool that enables users to perform cost and environmental modeling of SWM systems. This may be existing systems, entirely new systems, or some combination of both based on user-specified data on MSW generation, requirements, etc. The processes that can be modeled include waste generation, collection, transfer, separation [material recovery facilities (MRFs) and drop-off facilities], composting, waste combustion (waste to energy), refuse-derived fuel production, and landfilling. Existing facilities and/or equipment can be specified in the model so that existing infrastructure and capital expenditures are reflected. Within each of the process models, there are different options. For example, there are 20 possible collection options, 8 types of transfer stations, 5 MRF designs, and 3 compost facility designs. The landfill model has tremendous flexibility including three time horizons that can be used to calculate life-cycle emissions, reflect differences in the management and control of landfill leachate and gas, as well as providing a means to model bioreactor landfills and ash landfills. For a case study, we tailor the model to the specific waste management activities and management practices in each sector of the community.

The MSW-DST can model two residential, two multifamily dwellings, and ten commercial sectors. The two residential and multifamily dwellings are typically used to represent urban and rural sectors although the user has the flexibility to use them to represent differences in waste composition and/or management practices. The 10 commercial sectors may be broken down by retail, manufacturing, hospitals, restaurants, etc. For each sector, material flow data are needed, so it is important to have waste-flow data available. Individual waste components (e.g., food waste, corrugated containers, steel or aluminum cans, high-density polyethylene, and green glass) can be targeted to help find solutions to minimize cost and environmental burdens.

As illustrated in Figure 1, the DST consists of several components including process models, waste flow equations, an optimization module, and a graphic user interface (GUI). Spreadsheets were developed using Microsoft Excel for each process model using either default or user-supplied data to calculate the life-cycle cost and environmental coefficients on a per unit mass basis for each of the 48 MSW components. For example, in the electric energy spreadsheet, the user specifies the geographic region of interest which links to the fuel mix of that region for generating electricity. (The user can also specify a certain fuel mix or use a national average.) Based on design information and the emission factors for generating electricity for each fuel type, the spreadsheet 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 lighting. The emissions associated with electricity generation would be assigned to the mass that flowed through that facility. The user can override default data throughout the tool if more site-specific data are available.

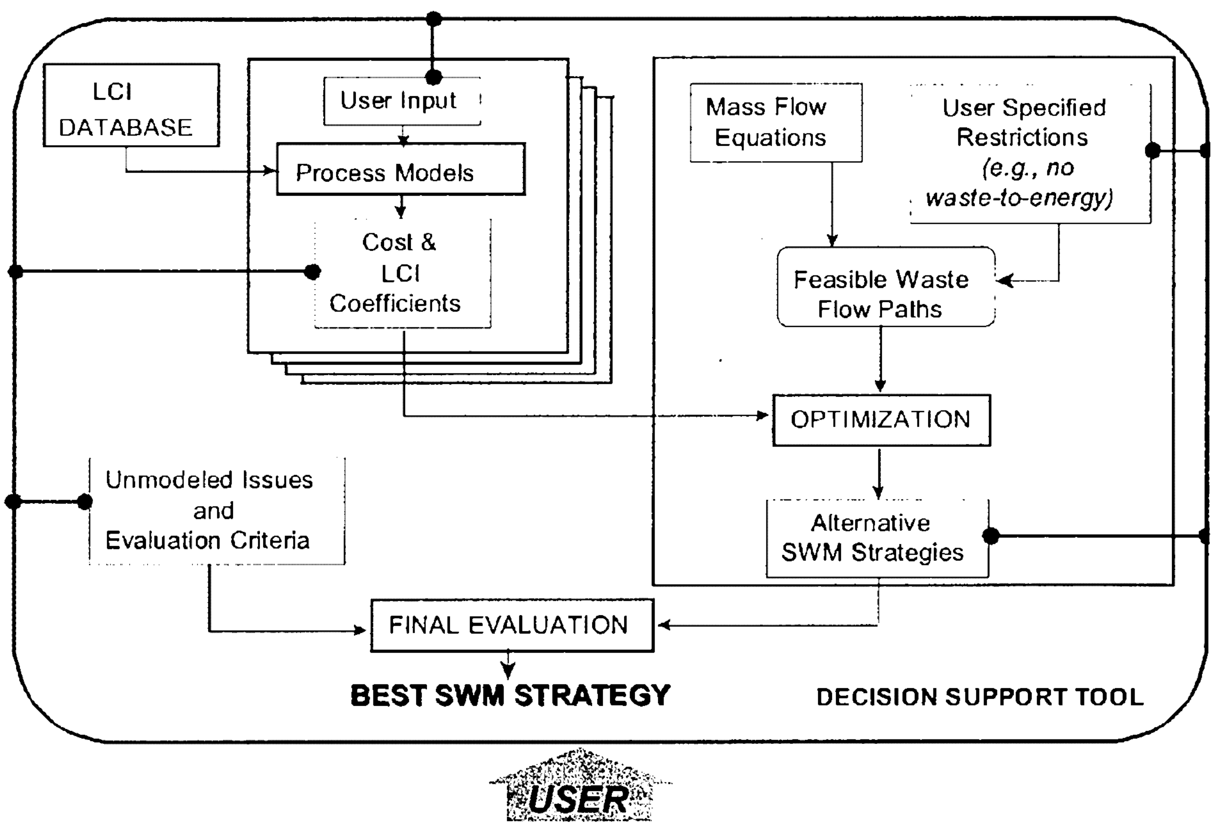

Figure 1. Framework for Decision Support Tool

The optimization module is implemented using the ILOG CPLEX linear programming solver. 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 absurd 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 user can identify the objective as minimizing total cost or life-cycle parameter [e.g., energy consumption, greenhouse gases (expressed in carbon equivalents), carbon monoxide, nitrogen and sulfur oxides, and particulate]. The optimization module determines the optimum solution consistent with the user-specified objective, mass flow, and constraints (e.g., existing equipment or facilities, minimum recycling, or landfill diversion rate).

2.2 Data Requirements for MSW-DST

Over 10,000 inputs for the MSW-DST enable the user to track the waste flow throughout the system. The waste flow is a mass balance of the total tonnage and percent composition of MSW in each management option (i.e., the total tonnage and percent composition of waste generated, collected by each collection option, recovered by each type of MRF, and discarded by each type of disposal activity). Figure 2 presents the system boundaries. Because much of this data would not be readily available to the user, extensive effort was expended in developing realistic and credible defaults for each of these parameters. It is very doubtful that a user would include all of the options that the MSW-DST has available. Often, existing infrastructure, including facilities and equipment, is reflected (i.e., if a new MRF has been built for processing certain waste streams, then any future plans will include continued use or even possible expansion of the MRF).

In working with case study participants, the relevant process models are identified, and the needed site-specific data are collected. For each sector that is specified (i.e., residential, multifamily, and commercial sectors), the waste flow is tracked for up to 48 components (e.g., corrugated containers, food waste, steel cans, and green glass). These can be aggregated

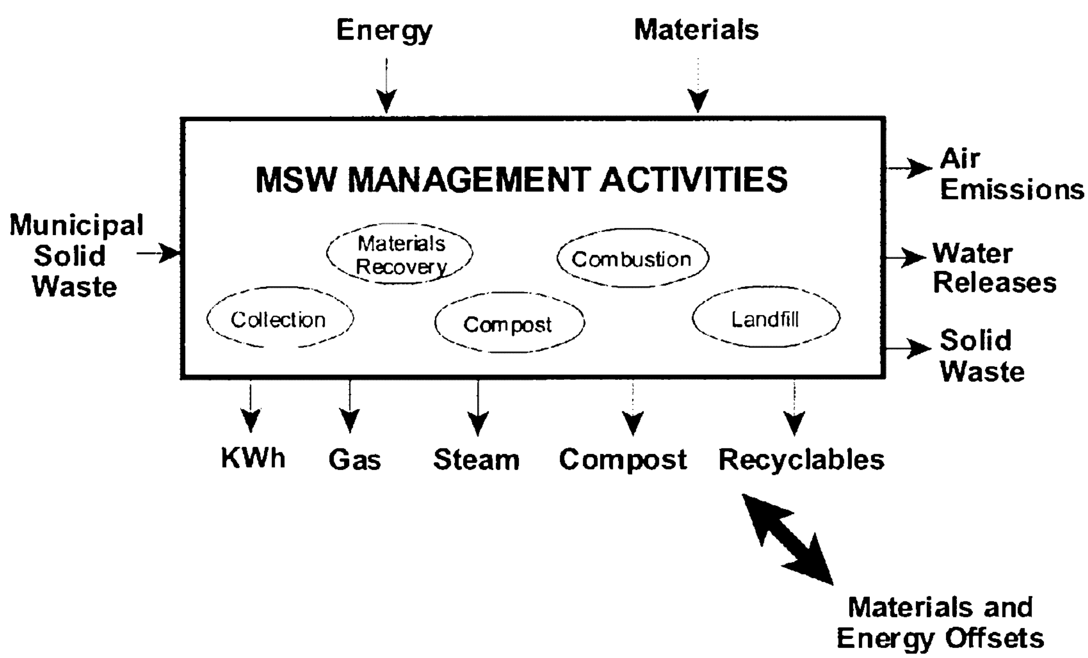

Figure2. System Boundaries for MSW-DST

or left as individual components depending upon the needs of the end user. The default composition is based on recent U.S statistics that are compiled by EPA's Office of Solid Waste (U.S. EPA, 1999).

Examples of some of the types of input data that are collected for each case study are:

- Fuel type in collection vehicles and type of transport
- Labor costs including overhead rates
- Market value of recyclables
- Distance between houses on the collection route
- Distance between end of route and the transfer station, MRF or treatment/disposal facilities
- Time to load vehicle at collection locations
- Time to unload at transfer station, MRF or treatment/disposal facilities

2.3 Types of Questions for the MSW-DST

The tool was specifically developed to help communities and SWM planners to make more informed choices regarding SWM (Weitz et al., 2000). The tool can be used to evaluate the effects of changes in existing MSW management on cost; identify least-cost options to manage recycling and waste diversion; quantify potential source reduction benefits; quantify carbon storage associated with MSW biomass; and evaluate options for reducing greenhouse gases, criteria pollutants, and environmental releases to water bodies or ecosystems. The tool will also be of value to other user groups including military bases, environmental and solid waste consultants, life-cycle practitioners, and environmental advocacy organizations in responding to the following example issues:

- changes in waste diversion or recycling goals,
- changes in market value for recovered materials,
- quantifying potential environmental benefits associated with recycling, and
- identifying strategies for optimizing energy recovery from MSW.

In addition, the tool is also being used in the Greenhouse Gas Center of EPA's Environmental Technology Verification Program to help compare new technologies with conventional technologies in use.

3. CASE STUDIES

Finding solutions that can lead to sustainability has resulted in the need for tools in the U.S. as well as in other countries. A recently published book, *Integrated Solid Waste Management: A Life-Cycle Inventory*, provides an overview of case studies using a life-cycle-based approach (McDougal et al., 2001). It is well recognized that this type of methodology is needed in order to provide an equitable comparison of the potential environmental tradeoffs. As a result of requests from states and local governments, the MSW-DST was developed to help provide information primarily on a local-community basis. However, as a result of requests for case studies at state and national levels, the MSW-DST was used to help evaluate the applicability of the tool on a wider geographical scale. The community, state, and national case studies are summarized in the next sections.

3.1 Community-Based Case Studies

Most of the case studies that are presented here were conducted by RTI and were funded through the participating communities. Initial case studies were conducted to help in troubleshooting the tool and testing individual process models. RTI is currently conducting a number of case studies where they are tailoring the MSW-DST for the specific community and providing training and technical assistance in the use of the MSW-DST. Options are being considered, such as the development of a web-based version of the tool, to provide wider accessibility at a lower cost.

- Lucas County, Ohio, was developing a 15-year plan for their SWM system. They were interested in identifying options that would be more economical and improve environmental performance. They were able to use the results to increase their recycling rate while actually realizing a reduction in cost. This also had benefits in reducing life-cycle environmental burdens. Additional runs are being made to look for further opportunities that will reduce costs and improve environmental performance.

- The Great River Regional Waste Authority in Iowa is exploring the efficiency of integrated collection system versus multiple collection options. Their goal is to evaluate effects of reconfiguring service areas and applying existing systems to them, and to develop a waste management plan for a 50% recycling scenario that is to be presented to the state authority.

- Anderson County, South Carolina, is evaluating the cost and environmental implications of implementing a residential curbside recycling program for the more densely populated areas of the County as well as setting up a yard waste composting program. The MSW-DST was used to assist in determining least-cost options for implementing a residential curbside recycling program while simultaneously considering environmental performance including potential benefits from increased recycling rates.

- The State of Georgia is interested in evaluating the effects of a ban on landfilling yard waste in Gwinnet County which is a suburb of Atlanta. Because of the existing air quality concerns, increased emission of nitrogen oxides (NO_x) and other pollutants that aggravate urban smog, are of concern. Current NO_x emissions attributable to yard waste collection are estimated to be 105 tons per year, and the implementation of a yard waste ban would result in an 11% increase in NO_x. This increase results from an increase in the number of trucks (from 171 to 201) needed for separate mixed waste and yard waste collection, as opposed to commingled collection.

- The State of Wisconsin is investigating the environmental benefits of statewide recycling programs. The MSW-DST was used to analyze how changes in levels of state-mandated recycling goals can potentially affect environmental aspects of recycling for a local community. Case studies were conducted for Madison and Milwaukee to assist the State in deciding what solid waste strategies should be used in the future to meet environmental improvement goals.

- Case studies are being conducted for the U.S Navy in the Pacific Northwest. There is major interest to reduce cost, increase recycling rates, and ensure that environmental goals are being met. In addition, with the closing of smaller local landfills and transporting waste by rail to a larger regional site, the Navy is interested in evaluating the change in cost, energy consumption, and environmental releases. The Navy is also evaluating options that would combine waste from nearby communities to identify more cost effective and environmentally preferable solutions to a more regional approach for integrated waste management. The case study is to be conducted to help with the implementation of a SWM plan. The Navy is also considering additional case studies in San Diego and the Pacific Rim.

3.2 State-Based Case Studies

The MSW-DST has been used to provide information to the States of Georgia, Minnesota, Washington, and Wisconsin. The State of Wisconsin was interested in being able to quantify the environmental benefits of statewide recycling programs. The MSW-DST was used to analyze how changes in levels of state-mandated recycling goals can potentially affect environmental aspects of recycling. The results of this study are being used to assist the State in deciding what solid waste strategies should be used in the future to meet environmental improvement goals. The States of Washington and Minnesota were also interested in being able to quantify the tradeoffs between options being considered. This has been primarily the result of issues raised about the cost of existing recycling programs. Before the MSW-DST was available, these kind of comparisons did not reflect the full costs of the system and consider only the landfill tipping fee which doesn't necessarily reflect the total cost of lining, operating, monitoring, leachate and gas treatment, etc. Also, many of the past comparisons did not consider potential benefits of recycling through conservation of resources. The MSW-DST provides states with a tool that provides an objective, credible, and life-cycle-based evaluation that is helpful in decision making.

In the spring of 2000, a workshop was conducted in Toronto, Canada, to help stakeholders identify opportunities for reduction of persistent bioaccumulative toxics (PBTs) including mercury and dioxin/furans. Solid waste management had been identified as one of the major contributors of PBTs to the Great Lakes. EPA's Great Lakes National Program Office (GLNPO) requested assistance in quantifying the PBTs associated with MSW management. The MSW-DST was used for providing results at the workshop and helping to provide perspective on the level of PBTs associated with MSW management versus other sources. MSW combustion, or waste-to-energy, had been one of the larger sources of dioxin/furans in the U.S. As a result of Clean Air Act regulations and use of improved air control technology, this source is now one of the lowest sources of dioxin/furans. Use of the MSW-DST helped provide workshop participants with up-to-date data and information to understand the relative contribution of PBTs from different sources. This helps to identify more cost-effective policies for reducing PBTs and reducing the current levels in the Great Lakes.

3.3 National-Based Case Studies

A model for a national-based systems engineering approach was the subject of a recent doctoral candidate (Söderman, 2000). This thesis demonstrated how resources and costs can be made more efficient through evaluation of SWM on a national scale. Although simplifying assumptions must be made, models can be run with the help of sensitivity analysis to provide credible results to decision makers. Currently, this type of information is not available and often policy-makers don't understand the potential costs and environmental impacts resulting from SWM.

The case study that was conducted using the MSW-DST on a national basis is the subject of a companion paper (Thorneloe et al., 2001). Participants in the study were primarily interested in evaluating historical trends of greenhouse gases associated with MSW management. Data from the 1970s were compared to recent data. The results indicated that, although the amount of MSW has almost doubled since the 1970s, the level of greenhouse gases has decreased by a factor of 4. The study was conducted for the U.S. Conference of Mayors through funding by the Integrated Waste Services Association. This information was helpful in understanding that programs that have been adopted have led to significant reductions of greenhouse gases. Many of the mayors were interested in the use of the MSW-DST for their communities to (1) help quantify the benefits resulting from improvements that have been made over time, and (2) identify further opportunities for improvement.

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16. ABSTRACT The paper provides an overview of some case studies using the recently completed municipal solid waste decision support tool (MSW-DST) in communities across the U.S. The purpose of the overview is to help illustrate the variety of potential applications of the tool. The methodology that the MSW-DST is based on incorporates both life-cycle inventory analysis and full-cost accounting. The results of this tool are helping communities to make decisions that will result in more efficient environmental management.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Life (Durability)	Pollution Control	13B
Wastes		Stationary Sources	14G
Management		Municipal Solid Waste	05A
Decision Making		Decision Support Tools	05J
Inventories			15E
Accounting			

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