# Life Cycle Environmental and Cost Analysis of Disposable and Reusable Ware in School Cafeterias, Including Dishwasher Operation

**Summary**

**Prepared For**
**School Nutrition Foundation**
**by**
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SCHOOL NUTRITION FOUNDATION
*Education, Research and Scholarship*

Title:
**Life Cycle Environmental and Cost Analysis of Disposable and Reusable Ware in School Cafeteria**

Sponsors:
The School Nutrition Foundation contracted with Franklin Associates, a consulting firm that provides life cycle analysis and solid waste management advice, to design, collect data, and analyze the information related to this project.

**INTRODUCTION**
School nutrition programs provide over 5 billion meals each year to students. These meals can be served using reusable ware, disposable ware, or a combination of the two. School nutrition programs consider many different factors when deciding what combination of reusable and disposable ware items make the most sense to use in their program. These factors include cost, available facilities/equipment, and customer behavior. While cost is usually the primary factor in this decision, increasingly schools districts are looking to implement environmentally friendly options. This analysis uses a life cycle approach to investigate the relative environmental and cost tradeoffs associated with the use of reusable and disposable ware in school cafeterias based on information from two US school districts.

A life cycle inventory examines the sequence of steps in the life cycle of a product system, beginning with raw material extraction and continuing on through material production, product fabrication, use, reuse or recycling where applicable, and final disposition. The information from this type of analysis can be used as the basis for further study of the potential improvement of resource use and environmental emissions associated with product systems. It can also pinpoint areas (e.g., material components or processes) where changes would be most beneficial in terms of reduced energy use or environmental emissions.

**GOALS & OBJECTIVES**
The goal of this study was to develop representative *environmental and cost profiles* for the production, use, and end-of-life management of disposable and reusable ware used in school cafeterias. The primary intended use of the study results is to:

- Inform school nutrition programs about the factors that influence an environmental and cost assessment
- Share the relative environmental burdens and costs associated with use of reusable and disposable ware within the situation/constraints of the schools analyzed.

**KEY FINDINGS**
Based on the serving ware systems studied, reusable compartment trays had a lower environmental impact and were less expensive when compared to disposable serving

ware options (i.e. a disposable tray carried on a reusable tray and disposable bowls/plate carried on a reusable tray). Reusable compartment trays used the least amount of energy, had the lowest amount of solid wastes, the lowest greenhouse gas emissions, and were also the least expensive.

Additionally the type of dishwasher used had a significant impact on the environmental factors studied. Newer model dishwashers (i.e. "replacement" dishwasher) which use less water and energy reduced water usage and energy by nearly half, resulting in substantial reductions in the overall energy, solid waste, and global warming potential for the serving ware systems analyzed in the study.

**METHODOLOGY**

*SOURCES OF DATA*

The environmental and costs analysis uses data from a number of sources. However, the primary source of operational data on serving ware was collected from a total of 7 schools in the Hoover, Alabama and Fort Zumwalt, Missouri school districts. These schools included 3 elementary schools, 2 middle schools, and 2 high schools.

**Profiles for Schools included in Study**

| School District | School | Grade Levels | Enrollment | Locale* | Percent Free/Reduced Price |
|---|---|---|---|---|---|
| Hoover City School District | Hoover High School | 9-12 | 2345 | Rural (fringe) | 11% |
| | Ira F. Simmons Elementary School | 6-8 | 819 | City (small) | 20% |
| | Greystone Elementary School | KG-5 | 653 | City (small) | 3% |
| | Riverchase Elementary School | KG-5 | 563 | City (small) | 15% |
| Fort Zumwalt R-ii | North High School | 9-12 | 1329 | Rural (fringe) | 9% |
| | South Middle School | 6-8 | 1179 | Suburb (large) | 10% |
| | Westoff Elementary | KG-5 | 558 | Suburb (large) | 13% |

* Locale categorizations are based on National Center for Education Statistics categorizations
Source: CCD public school district data for the 2006-2007 school year

The following list includes the data sources used in modeling the life cycle environmental burdens and costs for serving full meals in disposable and reusable ware:

- Survey forms completed by schools were the source of data on weights, material types, and costs of disposable and reusable ware used at the schools; quantities and costs of dishwasher chemicals; labor costs for cafeteria operations; waste disposal and recyclable pickup costs; and utility costs for water, gas, and electricity.
- Franklin Associates' private life cycle database was the source of life cycle inventory data for production of all types of disposable and reusable ware, corrugated packaging for disposable ware, representative commercial dishwashing detergent, and production of wastewater treatment chemicals.
- Energy and water use for school dishwasher operation was modeled based on manufacturer's analysis of dishwasher models used by surveyed schools and validated using the U.S. EPA ENERGY STAR commercial dishwasher calculator.[1]
- Energy and chemical use for treatment of dishwasher influent and effluent water were modeled by Franklin Associates using the results of a 2007 American Water Works Association (AWWA) survey.
- Production and combustion of fuels and U.S. average grid electricity used for process and transportation energy in all processes are from the U.S. LCI Database.[2]
- End-of-life modeling was based on the U.S. EPA reports and Environmental Science and Technology article cited earlier[3].

*SYSTEMS STUDIED*

*Serving Ware*

All schools reported using a mix of disposable and reusable foodservice items. In order to compare reusable and disposable ware on an equivalent basis, the analysis is limited to the items used to serve full meals. In these schools compartmented reusable trays serve the dual function of both containing and carrying the food. In the schools surveyed, meals served in disposable items were carried on flat reusable trays. Therefore the study looks at the following serving ware combinations:

- Reusable polycarbonate compartmented tray washed after each use
- Disposable compartmented polystyrene foam plate carried on a flat fiber-glass reinforced reusable tray that is washed after each use

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1 http://www.energystar.gov/index.cfm?c=comm_dishwashers.pr_comm_dishwashers .

2 Publicly available at www.nrel.gov/lci .

3 Barlaz, et al.

- Disposable polystyrene foam flat plate and bowl carried on a flat fiber-glass reinforced reusable tray that is washed after each use

**Types of Serving Ware Options Used for the Schools Included in the Study**

| | | Combinations used by each school are indicated with an "x" | | |
|---|---|---|---|---|
| **School District** | **School** | **Reusable Compartment Tray** | **Disposable Items & Flat Reusable Tray** | **Disposable Compartment Tray** |
| Hoover City School District | Hoover High School | | X | X |
| | Ira F. Simmons Elementary School | X | X | X |
| | Greystone Elementary School | X | X | X |
| | Riverchase Elementary School | X | X | X |
| Fort Zumwalt R-ii | North High School | | X | |
| | South Middle School | X | * | |
| | Westoff Elementary | X | ** | |

*Use of reusable compartment trays was reported for 84% of meals served at South Middle School. Use of disposable items was also reported, but there was no reported use of flat reusable trays or of disposable compartment trays. Therefore, meals consisting of a la carte items are assumed to be carried either without a tray or on a reusable compartment tray.

**Westoff reported essentially 100% use of reusable compartment trays. No use of flat trays was reported. There was some use of disposables for side dishes (e.g., bowls, if soup was part of the meal). For meals in which sides are served in disposables, the side items would be carried on the compartment tray with the rest of the meal.

All systems analyzed in this study include use of a tray that is washed after each use, so all the systems studied require use of a dishwasher. SNA recognizes that some schools may use only disposable items, so that a dishwasher is not required for serving ware items, however this study did not include analysis of any scenarios that eliminate the use of a dishwasher.

The scope of the analysis was defined to focus on the items used to contain and carry food (i.e., plates, bowls, trays). The scope of the analysis did not include manufacture,

use, or disposal of napkins or disposable and reusable drinking containers and cutlery used in the cafeterias.

*Dishwasher*

Each of the serving ware systems was analyzed using the current dishwasher (i.e. average electricity and water usage) as well as with a newer replacement dishwasher. Newer, replacement dishwashers use less water and energy resources to use compared to older models. This factor was included in the analysis in order to understand the effect that this has on the environmental profile of the serving ware systems. Table 1-2 outlines the water and energy usage of dishwashers used for each school.

**Table 1-2. ENERGY AND WATER USE FOR SCHOOL DISHWASHERS**

| | Current Dishwasher | | | Replacement Dishwasher | | | Replacement usage as percent of Current | |
|---|---|---|---|---|---|---|---|---|
| | | Per 100,000 Meals* | | | Per 100,000 Meals* | | | |
| | Dishwasher Type | Electricity Use (kWh) | Water Use (Gallons) | Dishwasher Type | Electricity Use (kWh) | Water Use (Gallons) | Electricity Use (kWh) | Water Use (Gallons) |
| **High Schools** | | | | | | | | |
| Hoover | Flight | 16,369 | 37,945 | Flight | 10,102 | 14,646 | 62% | 39% |
| North | Conveyor (two-tank) | 29,348 | 67,605 | Conveyor (two-tank) | 11,110 | 23,446 | 38% | 35% |
| **Middle Schools** | | | | | | | | |
| Simmons | Conveyor (single-tank) | 22,379 | 46,782 | Conveyor (single-tank) | 10,678 | 30,489 | 48% | 65% |
| South | Conveyor (two-tank) | 31,373 | 72,269 | Conveyor (single-tank) | 11,876 | 25,064 | 38% | 35% |
| **Elementary Schools** | | | | | | | | |
| Greyston | Flight | 47,897 | 97,635 | Flight | 34,321 | 47,961 | 72% | 49% |
| Riverchase | Conveyor (single-tank) | 59,728 | 156,383 | Conveyor (single-tank) | 30,916 | 65,681 | 52% | 42% |
| Westhoff | Fill and dump | 11,312 | 35,613 | Door | 4,222 | 11,979 | 37% | 34% |
| **Average of all schools** | | **31,201** | **73,462** | | **16,175** | **31,324** | **52%** | **43%** |

* Based on energy consumption and water use per hour of operation (provided by Hobart and validated by EPA Energy Star model) and hours of operation per meal served reported by schools. Operating energy includes energy use by school water heater for water entering dishwasher, and booster heater and operating energy for dishwasher.

*DATA ANALYSIS*

A life cycle inventory examines the sequence of steps in the life cycle of a product system, beginning with raw material extraction and continuing on through material production, product fabrication, use, reuse or recycling where applicable, and final disposition.

The life cycle inventory (LCI) presented in this study quantifies the total energy requirements, solid wastes, and greenhouse gas emissions resulting from the production, use, and end-of-life management of reusable and disposable ware used to serve full meals in school cafeterias. For more details on the specific environmental considerations, please see the full report.

A life cycle inventory quantifies the energy consumption and environmental emissions (i.e., atmospheric emissions, waterborne emissions, and solid wastes) for a given product based upon the study boundaries established. The cost analysis included costs for purchasing reusable and disposable ware, school labor costs related to lunchroom operations, costs for inputs to dishwasher, and disposal costs. The costs in the analysis do not include costs associated with manufacturing, installing, and maintaining dishwasher equipment.

Weight and composition data for the disposable and reusable ware items used for each meal scenario are shown in Table 1-1.

**Table 1-1. WEIGHTS AND COMPOSITION OF REUSABLE AND DISPOSABLE WARE**

| | Grams per 1 item | Lifetime Uses* | Losses During Use | Items/ case | Items per 100,000 meals | Pounds per 100,000 meals |
|---|---|---|---|---|---|---|
| **Reusable compartmented tray** | | | | | | |
| Polycarbonate tray | 560 | 2,700 | 3% | | 37 | 47.1 |
| **Disposable compartmented plate** | | | | | | |
| Polystyrene foam compartmented plate | 9 | 1 | | | 100,000 | 1,982 |
| Corrugated shipping box | 964 | | | 500 | 200 | 425 |
| Fiberglass-reinforced tray | 226 | 2,700 | 3% | | 37 | 19.0 |
| Composition: | | | | | | |
| Polyester 19% | | | | | | |
| Styrene 10% | | | | | | |
| Calcium carbonate filler 47% | | | | | | |
| Fiberglass 24% | | | | | | |
| **Total pounds per 100,000 meals** | | | | | | 2,426 |
| **Disposable plain plate & bowl** | | | | | | |
| Polystyrene foam compartmented plate | 4 | 1 | | | 100,000 | 881 |
| Corrugated shipping box | 804 | | | 500 | 200 | 354 |
| Polystyrene foam compartmented plate | 3 | 1 | | | 100,000 | 661 |
| Corrugated shipping box | 624 | | | 1,000 | 100 | 137 |
| Fiberglass-reinforced tray | 226 | 2,700 | 3% | | 37 | 19.0 |
| Composition: | | | | | | |
| Polyester 19% | | | | | | |
| Styrene 10% | | | | | | |
| Calcium carbonate filler 47% | | | | | | |
| Fiberglass 24% | | | | | | |
| **Total pounds per 100,000 meals** | | | | | | 2,052 |

* Based on one use per day, 180 school days/year, and 15 year life.

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*ASSUMPTIONS & LIMITATIONS*

In every research study, there are limitations. Please see the full report for more detailed information about this study's assumptions and limitations.

## RESULTS AND DISCUSSION

In a life cycle study, products are evaluated on the basis of providing a defined function (called the **functional unit**). In order to compare reusable and disposable ware on an equivalent functional basis, the basis used in this analysis is items used to serve full

meals. All environmental and cost results are expressed on the basis of 100,000 meals served.

*ENVIRONMENTAL RESULTS*

For each of the environmental impacts analyzed (energy, solid waste and greenhouse gas emissions), the following life cycle stages are included:

- Production of reusable compartmented trays (Compartment tray)
- Production of reusable trays used to carry meals served in disposable ware (Flat tray),
- Production of disposable plates and bowls (Disposable Items),
- Production of corrugated shipping boxes for disposable items (Shipping boxes),
- Production of dishwasher detergent (Detergent manufacture),
- Dishwasher operation (Dishwasher operation),
- Municipal and wastewater treatment (Water treatment), and
- End-of-life management of disposable and reusable ware and associated materials (End-of-life mgmt).

*Energy Results*

Total energy results for each serving ware system are presented in Figure 1-1. Three types of energy are included in the analysis:

- **Process energy** includes energy for all processes required to produce the products and materials used in each system, from acquisition of raw materials through manufacture of reusable and disposable ware and packaging, washing of reusable items, and operation of equipment used in landfilling postconsumer foodware items and packaging.
- **Transportation energy** is the energy used to move material from location to location during its journey from raw material to finished product, transport of products to schools, and collection and transport of postconsumer material.
- **Energy of material resource (EMR)** is not an expended energy but the energy value of fuel resources withdrawn from the planet's finite fossil reserves and used as material inputs for materials such as plastic resins. Use of fossil fuel resources as a material input removes fuel resources from the energy pool; however, some of this energy remains in the plastic material produced. In this study, energy of material resource is reported for the plastic resins used in the reusable trays and the polystyrene foam disposable ware.

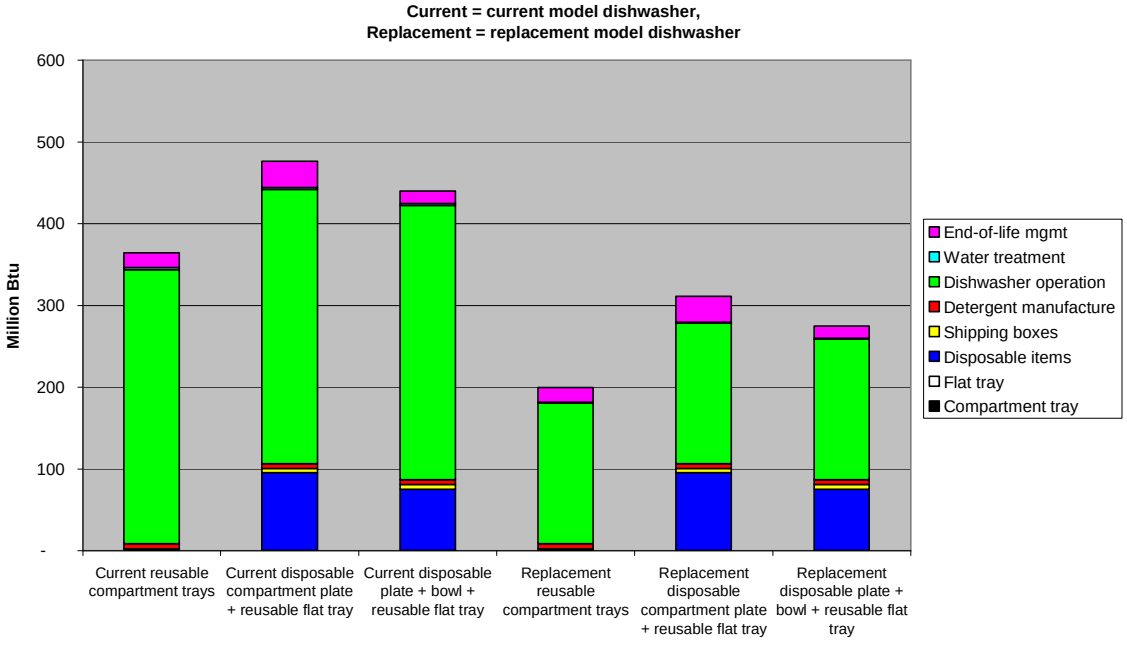
**Regardless of the serving ware system used, the majority of the energy is for operations of the dishwasher** (Figure 1-1). For disposable ware systems, manufacturing of the plates and bowls also makes a significant contribution to total energy

requirements. The negligible level of energy used for manufacturing of reusable trays is due to their many lifetime uses.

Use of more efficient dishwashing equipment reduces the energy requirements for dishwashing operations by approximately half, resulting in an overall energy reduction of 45 percent for the reusable system and 35 to 37 percent for the disposable systems. Systems using disposable items with reusable carrying trays require 20 to 30 percent more energy for the same number of meals compared to use of reusable compartmented trays when older dishwashers are used and 38 to 56 percent more energy when more efficient dishwashers are used.

**The energy results show that the life cycle of reusable compartmented trays requires less energy than the life cycle of disposable plates and bowls carried on reusable trays.** As would be expected, when washing of a tray (either a compartmented tray or a carrying tray) occurs for each meal served, energy requirements are higher for the disposable ware system since there are additional burdens for manufacturing the plates and bowls that are disposed after a single use. However, it is interesting to note that use of disposables with a more efficient dishwasher for cleaning trays shows lower total energy requirements than the reusable compartmented tray system using a less-efficient dishwasher.

**Figure 1-1. Energy Results for 100,000 Meals Served in Reusable and Disposable Foodservice Items (million Btu per 100,000 meals)**




*Solid Waste Results*

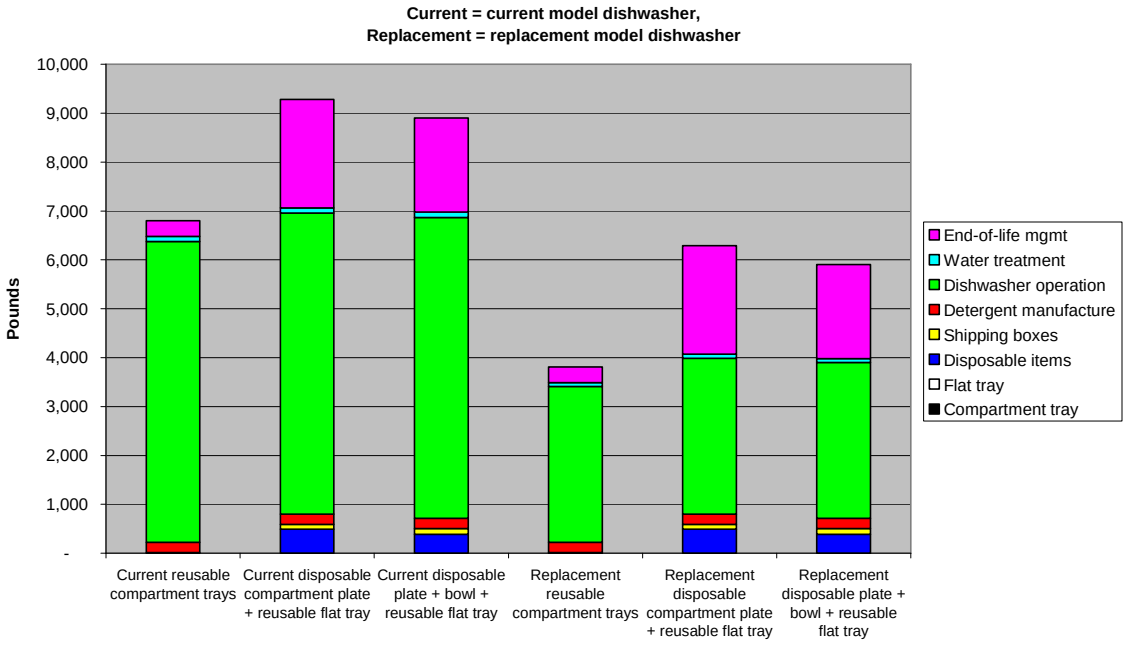
Solid waste was separated into the following three categories.

- **Process wastes** are the solid wastes generated by the various processes from raw material acquisition through production of products and packaging, production of dishwasher detergent (and associated containers), production of trash bags, and municipal water and wastewater treatment operations.
- **Fuel-related wastes** are the wastes from the production and combustion of fuels used for process energy and transportation energy, including operation of school water heaters, dishwashers, and fuel use by vehicles delivering disposable items and hauling school wastes.
- **Postconsumer wastes** are the reusable and disposable ware items and packaging that are landfilled at end of life (after adjustment for any recycling). This category also includes any ash resulting from waste-to-energy combustion of disposed items and packaging.

Figure 1-2 illustrates the weight of solid waste associated with each serving ware system. **The majority of the solid waste for all systems is fuel-related waste from operation of the dishwasher.** End of life management is the next largest solid waste category. This includes the weights of the following items: disposed plates, bowls, and trays; disposable product packaging; detergent packaging; and plastic film trash bags. The weight of solid waste for disposal of the food ware itself is 30 times higher for disposable plates and bowls compared to reusable compartmented trays. This results in higher costs for trash can liners and waste hauling costs.

**Using more efficient dishwashing equipment cuts the fuel-related solid waste for dishwashing operations by nearly half, resulting in an overall solid waste reduction of 44 percent for the reusable system and 32 to 34 percent for the disposable systems.** Systems using disposable items with reusable carrying trays produce 31 to 36 percent more total solid waste for the same number of meals compared to use of reusable compartmented trays when older dishwashers are used. When solid wastes for dishwasher operation are reduced by using a more efficient dishwasher, the weight of disposables constitutes a larger percentage of total solid waste, and solid waste for the disposable systems with reusable tray are 55 to 65 percent higher compared to the reusable compartmented tray.

**Figure 1-2. Solid Waste Results for 100,000 Meals Served in Reusable and Disposable Foodservice Items (pounds of solid waste per 100,000 meals)**




*Greenhouse Gas Emission Results*

The three primary atmospheric emissions reported in this analysis that contributes to global warming are:

- Fossil fuel-derived carbon dioxide,
- Methane, and
- Nitrous oxide

Each of these gases has a global warming potential (GWP) that represents the relative global warming contribution of a pound of that particular gas compared to a pound of carbon dioxide. The weight of each greenhouse gas generated from each serving ware system is multiplied by its GWP and total across each of the gases. The GWP factors used in the analysis are These results are shown in Figure 1-3. The GWP factors are based on internationally recognized standards/levels.

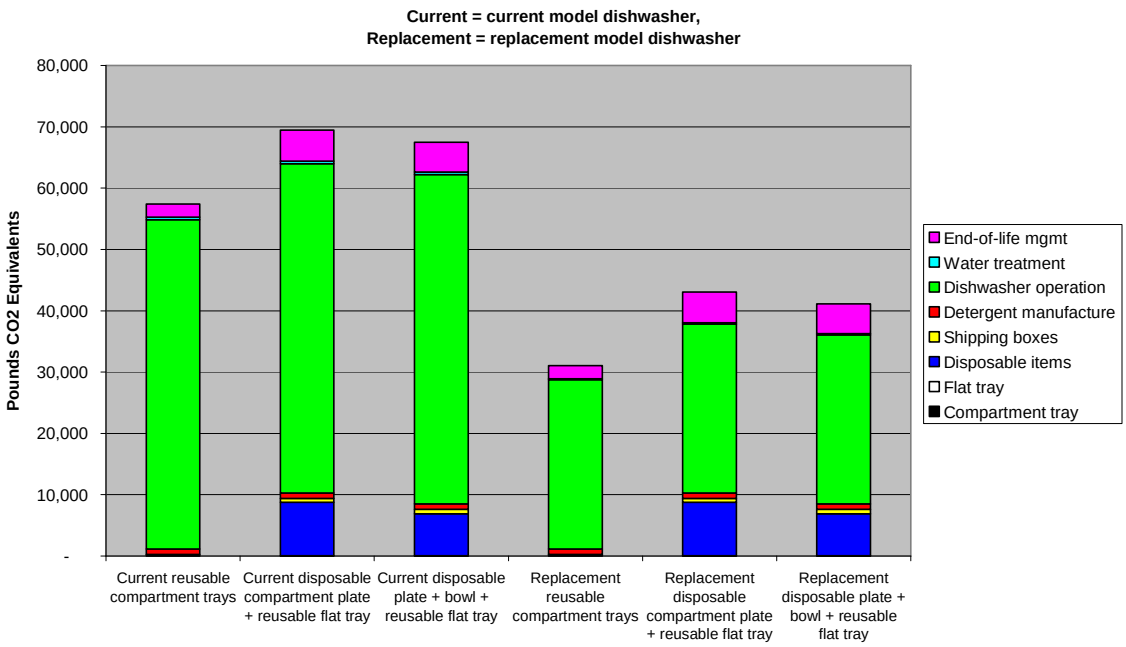
**The majority of the GWP for all serving ware systems is from dishwasher operation**. The manufacturing of plates and bowls is the second highest contributor to GWP for the disposable ware systems. End-of-life management is the second largest contributor to GWP for the reusable systems and the third largest contributor for disposable systems.

The “end-of-life mgmt” segment includes emissions associated with the production of trash bags used in the lunchroom as well as the emissions associated with the vehicles that haul the trash from the schools to disposal facilities. The end-of-life GWP also includes estimates of emissions from waste-to-energy combustion of postconsumer

plates and packaging, emissions from decomposition of landfilled corrugated shipping boxes, and emission credits for the grid electricity that is displaced by useful energy that is recovered from WTE combustion of foodservice items and related packaging and recovered landfill gas.

**Use of more efficient dishwashing equipment reduces the GWP for dishwashing operations by nearly half**. This results in an overall GWP reduction of 46 percent for the reusable system and nearly 40 percent for the disposable systems. Systems using disposable items and reusable carrying trays produce 17 to 21 percent more GWP for the same number of meals compared to use of reusable compartmented trays when older dishwashers are used, and 32 to 38 percent more GWP when more efficient dishwashers are used.

**Figure 1-3. Global Warming Potential Results for 100,000 Meals Served in Reusable and Disposable Foodservice Items (pounds CO2 equivalents per 100,000 meals)**




*COST RESULTS*

The analysis is based on meal cost and operating practices of each of the participating schools. Results are grouped into four main categories:

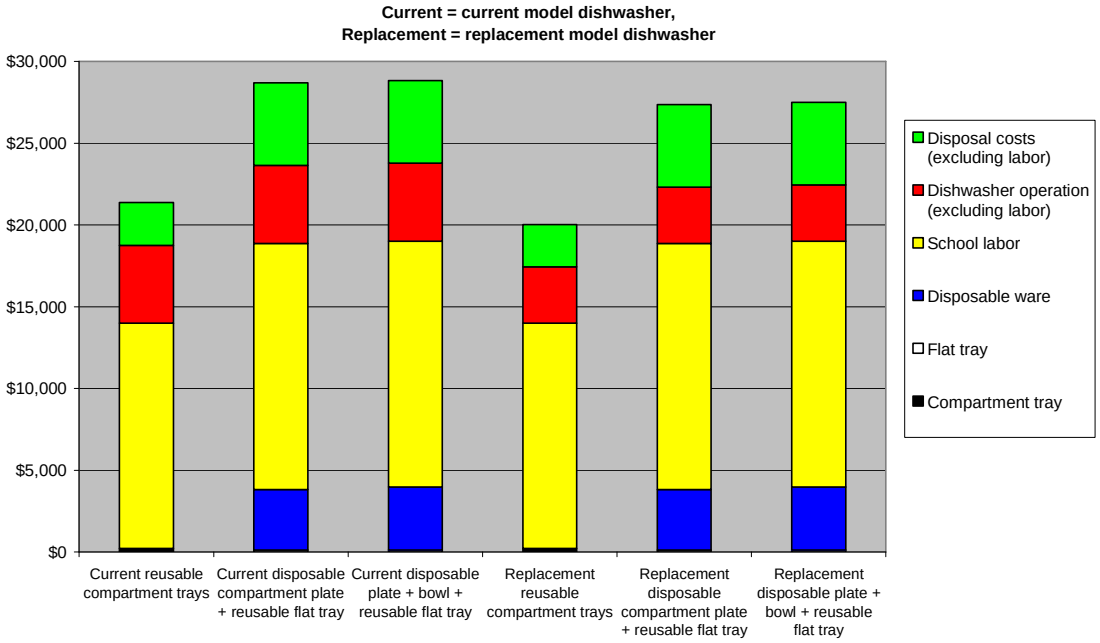
- Costs for purchasing reusable and disposable ware,
- School labor costs related to lunchroom operations,
- Costs for inputs to dishwasher, and
- Disposal costs

The cost analysis does not include capitol equipment costs.

Figure 1-3 presents a summary of the costs for the three serving ware systems. **Total costs for serving meals in reusable compartment trays are about 25% lower than serving meals in disposable ware (carried on reusable trays).**

Costs for purchasing disposable plates and bowls make the largest contribution to the cost differential. Costs for trash bags and volume-based waste hauling costs are about twice as high for the disposable are systems compared to the reusable compartment trays. The use of more efficient dishwashers would save approximately $1300 per 100,000 meals served, due to reductions in the amount of electricity and water used.

**Figure 1-4. Cost Results for 100,000 Meals Served in Reusable and Disposable Foodservice Items (dollars per 100,000 meals)**




## CONCLUSION AND APPLICATIONS

Based on the serving ware systems studied, reusable compartment trays used the least amount of energy, had the lowest amount of solid wastes, the lowest greenhouse gas emissions, and were also the least expensive. Additionally the type of dishwasher used had a significant impact on the environmental factors studied. Newer model dishwashers (i.e. “replacement” dishwasher) which use less water and energy can reduce water usage and energy by nearly half, resulting in substantial reductions in the overall energy, solid waste, and GWP results for the serving ware for these systems. Cost analysis was not studied for the cost of a replacement dishwasher due to varying ages and depreciations for current dishwashers in each school.

The following are the key findings for each of the specific factors studied:

- **Energy:** Dishwasher operation dominates energy requirements for the meal systems analyzed. Systems using disposable items and reusable carrying trays require 20 to 30 percent more energy for the same number of meals compared to use of reusable compartmented trays when older dishwashers are used, and 38 to 56 percent more energy when more efficient dishwashers are used. Some energy is recovered from postconsumer disposable plates and bowls that are managed by WTE combustion, as well as from combustion of landfill gas produced from decomposition of landfilled corrugated. However, the energy credits are small compared to the energy requirements for producing these items.

- **Solid Waste:** Fuel-related solid wastes from energy used by the dishwasher makes the largest contribution to total solid waste results for all systems. For systems using disposable ware and reusable carrying trays, the weight of postconsumer solid waste is much greater than the weight of reusable compartmented trays that are disposed after 15 years of use. Systems using disposable items and reusable carrying trays produce 31 to 36 percent more total solid waste for the same number of meals compared to use of reusable compartmented trays when older dishwashers are used, and 55 to 65 percent more solid waste when more efficient dishwashers are used. The weight of solid waste for disposal of the food ware itself is 30 times higher for disposable plates and bowls compared to reusable compartmented trays. This results in greater costs for purchasing trash can liners and higher waste hauling costs.

- **Global Warming Potential:** The majority of the GWP for all the systems analyzed is associated with dishwashing operations, primarily carbon dioxide from combustion of fossil fuels to generate the electricity used for school water heaters and the dishwasher booster heater and motor. Systems using disposable items and reusable carrying trays produce 17 to 21 percent more GWP for the same number of meals compared to use of reusable compartmented trays when older dishwashers are used, and 32 to 38 percent more GWP when more efficient dishwashers are used.

- **Influence of Dishwasher Efficiency on Results:** Dishwasher operations are responsible for the largest share of the energy, solid waste, and GWP for all the meal systems studied. However, newer dishwashers use considerably less water and energy than older models. The more water-efficient the dishwasher, the less energy is required for heating the water, reducing all energy-related burdens (energy use, fuel-related emissions and fuel-related solid wastes). The analysis shows that use of more efficient dishwashing equipment can reduce washing water use and energy (and associated costs) by nearly half, resulting in substantial

reductions in the overall energy, solid waste, and GWP results for the school meal systems.

- **Cost Analysis:** Total costs for serving meals in reusable compartment trays are about 25% lower than serving meals in disposable ware (carried on reusable trays). Costs for purchasing disposable plates and bowls make the largest contribution to the cost differential. The use of more efficient dishwashers would save approximately $1300 per 100,000 meals served, due to reductions in the amount of electricity and water used.

- **Elimination of Dishwasher**: This analysis indicates that operation of a school dishwasher use contributes a large share of the environmental burdens for school cafeteria operations. However, options for reducing or eliminating use of a dishwasher have tradeoffs that could substantially increase environmental burdens and costs in other areas. For example, replacement of all reusable items with disposable would increase per-meal environmental burdens for production of items, solid wastes from disposal of items, and costs for purchasing and waste management. Tradeoffs between all-disposable systems and systems including reusable items should be evaluated on a quantified basis before decisions are made.

**ADDITIONAL INFORMATION**

The information in this report represents a condensed version of the environmental life cycle analysis and cost analysis report. If you are interested in learning about the details of this study, please contact the School Nutrition Foundation and they can provide you with the detailed report and analysis.

The full report is available at [ADD LINK HERE].