

Waste Reduction in Child Day Care Services

Case Study Report: Gretchen's House III

prepared by the:

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PREFACE

PROJECT DESCRIPTION

Overall Project Objectives

This study of solid waste reduction practices at Gretchen's House III in Ann Arbor is part of a project comprising five case studies. The objective of the project is to analyze and document successful waste reduction programs implemented by commercial and industrial firms in the state of Michigan so the identified waste reduction practices can be transferred effectively to other firms. The information presented in these reports may also serve to suggest ideas for waste reduction which could be implemented in other industries beyond those selected for the five case studies.

The primary focus of each case study is a change or innovation in a product or process that resulted in source reduction of nonhazardous solid waste. Process, economic, and organizational/motivational analyses are performed in each study. The process analysis includes a description of the product and process changes and the amount of waste reduction achieved. The economic analysis evaluates the costs and revenues to the firm that result from the waste reduction activity. Baseline economic data, including fixed and variable costs and revenues before the intervention, are compared with the after-intervention data. An organizational/behavioral study then examines the decision-making process, incentives and organizational support, company policy, and employee attitudes related to the initiation of the waste reduction activity.

The overall benefits of waste reduction measures also depend on the reduction of societal and environmental impacts associated with the life cycle of the goods provided or services rendered. External social and environmental factors relating to each program are identified and discussed where possible.

Some of the waste reduction programs documented in this report can be implemented relatively easily, whereas others may require significant capital investment, employee training, or operational changes. Each case study attempts to identify key elements of the model waste reduction program that are necessary for its successful implementation.

Case Study Firms

The case study firms were selected according to the following criteria: a priority of source reduction over recycling and other waste management strategies; the transferability of the waste reduction practices to other firms; information availability and accessibility; the potential amount of solid waste reduction achieved if other firms adopt the model waste reduction practices; and a diversity of businesses in terms of their SIC Code, size, organizational structure, and geographic location.

The five firms studied are the following:

1. Hudson's department stores in Michigan; retail department stores
2. Gretchen's House III in Ann Arbor; child day care facility
3. McPherson Hospital in Howell; cafeteria and patient food service
4. Packard People's Food Cooperative in Ann Arbor; grocery store
5. Steelcase in Grand Rapids; office furniture manufacturer

Project Publications

- **Fact Sheets** - two page document summarizing waste reduction efforts of each case study firm.
- **Detailed Case Study Report** - a comprehensive guide to assist firms with the actual implementation of waste reduction efforts.
- **Final Project Report** - description of the methodology, major findings, and recommendations covering all five case studies.

A Fact Sheet and Detailed Case Study Report are published for each of the five case studies. Documents may be obtained from:

Office of Waste Reduction Services
Michigan Departments of Natural Resources and Commerce
PO Box 30004
Lansing, MI 48909
Phone: (517)-335-1178

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Solid Waste Research Group, School of Natural Resources, University of Michigan

The Solid Waste Research Group selected the case study firms, conducted the on-site data collection and analysis, documented the waste reduction activities, evaluated the potential impacts of these activities on the waste stream if they are adopted by other firms throughout Michigan, and prepared the case study reports. The following members of the Solid Waste Research Group participated in this project:

Jonathan Bulkley, Project Director, Professor of Civil Engineering and Natural Resources
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The Office of Waste Reduction Services, State of Michigan Departments of Commerce and Natural Resources, provided assistance in the selection of case study firms and in reviewing the final report. Ms. Myra Grant served as project manager and administered the grant for the Resource Recovery Section, Waste Management Division, State of Michigan Department of Natural Resources.

The information presented in this report is the sole responsibility of the Solid Waste Research Group, School of Natural Resources, University of Michigan.

Gretchen's House III

Gretchen Preston, the owner and director of Gretchen's House, a privately owned company which consists of four day care centers, greatly assisted our research group in conducting this study. Lorraine Hergenreder, the coordinator of Gretchen's House III, was very helpful in providing a description of the the duties and responsibilities of the care givers and cost information on diapering. Other staff members participated in time and motion studies of diapering activities and were interviewed about their attitudes on waste reduction.

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1. SUMMARY

This case study documents solid waste reduction achieved by the conversion from disposable to reusable cloth diapers at Gretchen's House III day care center in Ann Arbor, Michigan. Process, economic, and organizational/motivational analyses were conducted so that waste reduction resulting from cloth diaper use could be transferred to other day care centers, day care homes, nursery schools, households, pediatric hospital, and nursing homes for adult incontinents. The scope of this investigation was limited to solid waste reduction from the perspective of the day care center; life cycle environmental impacts and risks from raw materials extraction and manufacturing were not studied.

The conversion from disposable to cloth diapers resulted in a net reduction in solid waste of 53 lb per week, based on 12 infants/toddlers supervised eight hours each day, five days a week. Solid waste generated by the use of disposable diapers includes 46 lb of feces, 26 lb of disposable diapers, and 0.2 lb of refuse bags. Cloth diaper use generates only 0.2 lb of diaper waste and 0.3 lb of refuse bag waste each week. After the conversion, cloth diapers were used throughout the day, but infants/toddlers were sent home in disposable diapers which adds an additional 7 lb of disposable diaper waste to the cloth diaper case. Cloth diapers were used at the same rate as disposables; on average, a total of 210 diapers were used each week before and after conversion to a predominantly cloth diapering system.

Gretchen's House III purchased 36 nylon outer wraps for use with cloth diapers. Waterproof outer wraps are necessary for an effective cloth diapering system; they hold diapers firmly in place and prevent leakage. Cloth diapers were cleaned and delivered once a week by a diaper service in Kalamazoo, Michigan, and diaper wraps were washed at the day care center and dried inside on a clothes line once a day. Labor requirements increased from 15 min. per week for purchasing the disposable diapers to 69 min. for washing, drying, and folding the diaper wraps and purchasing some disposables. Diaper changing times were the same for both systems.

The total costs to the day care center were \$0.25 per disposable diaper and \$0.22 per cloth diaper. Converting to cloth diapers saved this day care center \$226 per year, or 9.3% of total diapering costs. The major cost for the disposable system is the diaper, while the major costs for the reusable system are balanced between the diaper service and labor for washing diaper wraps. Disposal costs are not included in these figures, because waste collection fees in the city of Ann Arbor are assessed via property taxes, independent of disposal amounts. Cloth diaper use would be even more attractive, in terms of cost, for day care centers that are charged on a volume or weight basis for refuse disposal.

Other waste reduction activities practiced by Gretchen's House III include the reuse of packaging material, food waste reduction, lawn waste reduction, leaf composting, and recycling.

Solid waste could be reduced by as much as 41,000 tons per year statewide if all care centers, institutions, and households used cloth diapers.

2. INTRODUCTION

THE PROBLEM OF NONHAZARDOUS SOLID WASTE IN THE CHILD DAY CARE SERVICE SECTOR

Disposable, or single-use, diapers are a major constituent of the solid waste stream from day care centers. In 1987 there were 653 child day care service businesses operating in Michigan.¹ After newspapers and food and beverage containers, disposable diapers contribute more to the solid waste stream than any other consumer product. Data from Dr. William Rathje of the University of Arizona indicate that diapers comprise 3.6% of the household solid waste stream. An estimated 18 billion disposable diapers are discarded each year.²

Other components of waste generated by day care facilities are food waste and packaging waste associated with preparation and consumption of meals and snacks. Day care centers using disposable dishware contribute additional material to the waste stream.

The waste reduction activities documented in this case study are transferable to a wide range of institutions other than day care centers. Child care services are provided at day care homes (up to 12 children can be supervised in a day care home), pediatric hospitals, church/community centers (many are day care centers), and at some work places. Diapers are also used by adult incontinent at home, in nursing homes, and in hospitals. Adult incontinence occurs in 10 to 20 % of the population over 65 years and in 40-50 % of the elderly population of nursing homes.³

WASTE REDUCTION IN CHILD DAY CARE

A major reduction in solid waste can be achieved by converting from disposable to reusable cloth diapers. The type of diaper used, single-use disposable or multiple-use cotton, is usually determined by the day care center. Most day care centers currently use disposable diapers. Some day care centers may not accommodate the parent's choice of diaper. In other cases, parents are required to provide disposable diapers for their own child.

Two options are available for washing soiled cloth diapers: they can be laundered in-house or by a diaper service. At Gretchen's House III, diapers were laundered by a diaper service.

In addition to waste reduction associated with diapering, other opportunities exist for waste reduction at a day care center. Food waste can be reduced by teaching children to take only what they can eat. Packaging waste can be eliminated or reduced through the following measures: buying bulk instead of prepackaged food, using refillable beverage and milk bottles, reusing primary and secondary packaging, and recycling packaging material that is not reusable. Food scraps can be diverted from landfills by composting them with yard waste. Day care staff and

¹ County Business Patterns, U.S. Department of Commerce, Bureau of Census, 1987.

² Lehrburger, C. "Diapers In the Waste Stream: A Review of Waste Management and Public Policy Issues," December, 1988, p. 59.

³ Ouslander, J. "Urinary Incontinence in Elderly Nursing Home Patients." Journal of the American Medical Association (1982) 248(10) pp.1194-1198.

management can develop the environmental consciousness of the older children and their parents through such waste reduction programs.

Waste reduction activities must balance economic, technical, social, ecological, and regulatory constraints. The model waste reduction activities documented in this case study report might not be directly transferrable to every day care center. Some modifications of the model system may be required.

CRITERION FOR SELECTION OF GRETCHEN'S HOUSE III

Gretchen's House III was selected as a model day care center because it recently achieved significant solid waste reduction by successfully converting from disposable to reusable cloth diapers. Gretchen's House III also practices additional waste reduction methods that can be transferred to other day care centers.

DESCRIPTION OF THE BUSINESS

Gretchen's House III
1745 W. Stadium
Ann Arbor, MI 48104
(313) 663-4767

Contacts: Gretchen Preston (owner), Lorraine Hergenreder (director)

Gretchen's House III is one of four day care centers owned and directed by Gretchen Preston, who initiated the conversion to cloth diapers. Only one day care center, Gretchen's House III, was selected for in-depth analysis. Gretchen's House III provides care to about 12-16 infants/toddlers (infants are less than 12 months old; toddlers are 1-3 years old), 23 preschool children, and 17 kindergarten children. Approximately 60 children are cared for on average, which is at the low end of a medium size center (ranging from 60 -100). Both full-day and half-day care are available. The staff at Gretchen's House III consists of four full-time and one part-time care givers in the infant/toddler area, three full-time preschool care givers, one kindergarten teacher, a cook, and a director.

CONTENT AND ORGANIZATION OF THIS REPORT

This case study examines the conversion from disposable to reusable diapers at Gretchen's House III. Other waste reduction measures, including reuse of packaging and reduction of food waste, are described more qualitatively. The report contains the following main sections:

- A detailed case study consisting of process and economic analyses of the conversion from disposable to reusable diapers
- A description of other successful waste reduction activities: reuse of packaging and food waste reduction
- A discussion of organization and behavioral factors related to waste reduction
- A discussion of the transferability of the identified waste reduction activities and their potential impact on the waste stream if adopted by other firms throughout Michigan.
- Conclusions and recommendations

Although this case study report presents numerous successful waste reduction practices, it is not intended to be a comprehensive guide to waste reduction for the child care services sector. In addition to this report, there exist several other resources at the State (Office of Waste Reduction Services - Michigan Departments of Natural Resources and Commerce) and Federal (U.S.

Environmental Protection Agency) levels that are available to assist firms in identifying opportunities and strategies for waste reduction.⁴

3. DETAILED CASE STUDY: DISPOSABLE VS. REUSABLE DIAPERS

The market for disposable diapers has expanded rapidly since the 1960s due primarily to their convenience. Gretchen's House day care centers, along with some hospitals and households, have contradicted this trend by converting to cloth diapers to reduce solid waste. This section of the report describes the conversion, including: changes in waste generation; operational steps; labor, equipment, and supply requirements; and the costs associated with these changes.

PROCESS ANALYSIS

Methodology

The process analysis describes and compares the sequence of steps associated with diapering an infant/toddler in both single-use and reusable diapers. The analysis includes only those activities directly related to diapering beginning with the procurement of the diapers and ending with their disposal. Impacts and costs associated with manufacturing the diapers are not investigated. Lehrburger (1988) and A.D. Little (1990)⁵ have investigated life cycle environmental impacts of both diapering systems. Neither study, however, provides a comprehensive evaluation of impacts and health risks.

An on-site investigation of the day care center was conducted to evaluate material inputs and outputs, and equipment and labor requirements for each operational step. Time and motion studies were performed to evaluate the labor requirements. For these studies, single measurements were made with an estimated uncertainty range of 15%. The on-site research was supplemented by published data from other sources on disposable and cotton diaper processes and economics.

The net amount of material inputs and waste associated with diapering was measured, and data were gathered on the labor and energy requirements for buying, preparing, changing, washing, and discarding the diapers. In addition, care givers were interviewed about health, comfort, and performance of disposable and reusable diapers.

Analysis is based on twelve infants/toddlers using diapers during a five day week. The staff routinely check infants/toddlers four times during the day (7:30am - 5:30pm). This practice was followed both before and after the conversion. After the conversion to cloth diapers, disposable diapers were still used for most children's final change of the day. If parents used cloth diapers at

⁴ Manual for Waste Minimization Opportunity Assessments; U.S. EPA Hazardous Waste Emergency Research Lab, April 1988 (EPA/600/2-88-025); and Waste Minimization Manual; Developed by University of Michigan School of Natural Resources for U.S. EPA ; Draft, July 1990.

⁵ Arthur D. Little, Inc., "Disposable Versus Reusable Diapers: Health, Environmental and Economic Comparisons," Report to Proctor and Gamble, March 16, 1990.

home, infants/toddlers were sent home in cloth diapers and returned in cloth diapers the next day; however, only a few of the children are diapered in cloth at home.

Results and Discussion of Process Analysis

A flowchart of the process steps for the disposable diaper system is shown in Figure 1. A similar flowchart for reusable diapers is presented in Figure 2. The major differences between the two systems are the additional steps associated with washing the cloth diaper and wraps. The cloth diapers are washed by a diaper service and the diaper wraps are washed by the staff at the day care center.

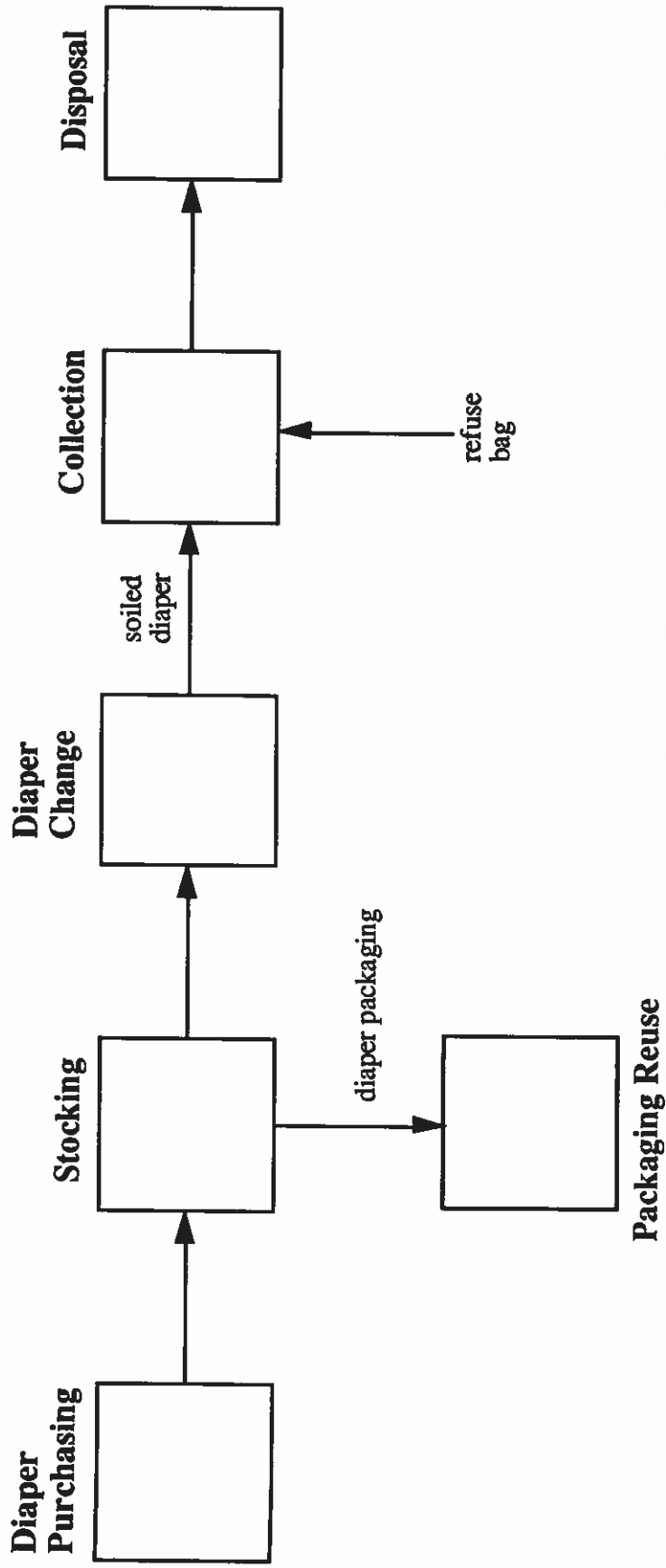


Figure 1. Material Flow Diagram for Disposable Diapers

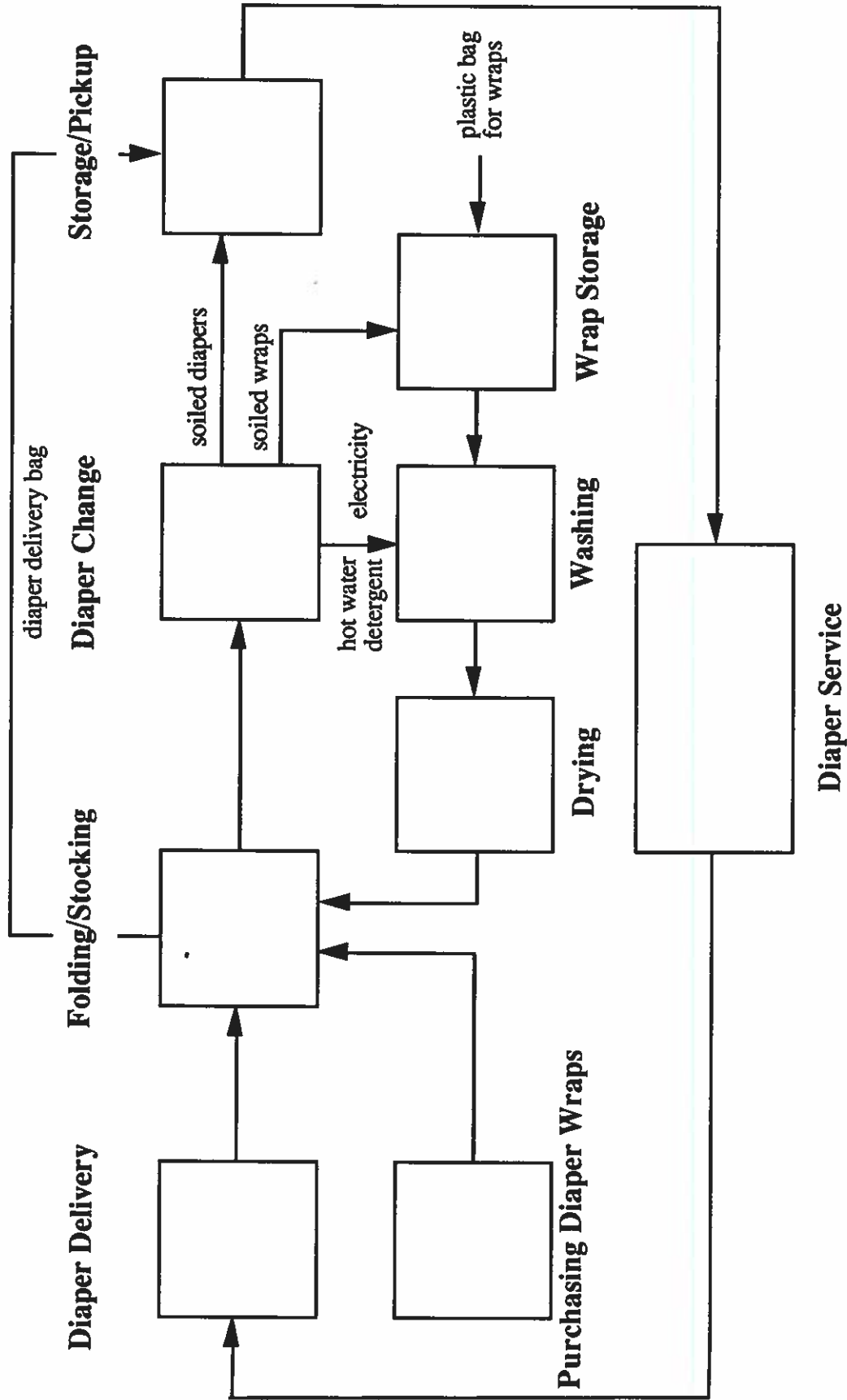


Figure 2. Material Flow Diagram for Cloth Diapers

A summary of the results from the process analysis are presented below in Table 1.

Table 1. Weekly Process Analysis Results

Unit being measured	Before Case		After Case	
	<i>Disposable Diapers</i>	<i>Cloth Diapers</i>	<i>Disposable Diapers</i>	<i>Total</i>
Children Diapered/Day	12	12	12	12
Diapers Used/Child/Week	17.5	12.5	5.0	17.5
<i>Total Diapers Used</i>	<i>210</i>	<i>150</i>	<i>60</i>	<i>210</i>
Solid Waste				
Feces Disposal Weight	46.26 lb.		11.56 lb.	11.56 lb.
Diaper Disposal Weight	25.77 lb.	0.21 lb.	7.36 lb.	7.57 lb.
Diaper Packaging Wt.	0.302 lb.	0.065 lb.	0.086 lb.	0.151 lb.
Refuse Bag Wt.	0.234 lb.	0.323 lb.	0.067 lb.	0.389 lb.
Total Material Reuse	0.302 lb.	0.065 lb.	0.086 lb.	0.151 lb.
<i>Total Material Discards</i>	<i>72 lb.</i>	<i>0.3 lb.</i>	<i>19 lb.</i>	<i>19.3 lb.</i>
Utilities				
Clothes Washing Water		144 gal		144 gal
Gas to Heat Wash Water		0.1404 Ccf		0.1404 Ccf
Electricity for Washer		0.75 kwh		0.75 kwh
Labor				
Purchase & Stocking	15.0 min		4.3 min	4.3 min
Washing		11.7 min		11.7 min
Drying and Folding		53.0 min		53.0 min
<i>Total</i>	<i>15.0 min</i>	<i>64.7 min</i>	<i>4.3 min</i>	<i>69.0 min</i>

Procurement

Before the conversion to cloth diapers, disposable diapers were purchased once a month at a local department store. An average of 210 disposable diapers were used each week for 12 infants/toddlers. After the conversion, the Diapers Unlimited diaper service, located in Kalamazoo, Michigan, delivered diapers once a week. On average, 150 cloth diapers are used each week for diapering 12 infants/toddlers; 10 additional diapers are used for purposes other than diapering such as burp clothes and diaper changing pads. Gretchen's House III still uses 60 disposable diapers each week for the final diaper change of the day. Three dozen wraps were purchased with a expected life of one year or more for use with cloth diapers. Approximately two dozen wraps are used and washed each day.

The care givers reported that both cloth and disposable diapers are used at the same rate: one diaper per change. Interviews with parents using cloth diapers indicate that some double diapering is done at night because diapers are changed less frequently. A report commissioned by disposable diaper manufacturer Proctor and Gamble (Arthur D. Little, 1990) suggests that mothers use 1.9 times more cloth diapers than equivalent disposable diapers and that care givers may tend to change cotton diapers more frequently because they readily show that a baby has wetted. The Proctor and Gamble report also notes, "All interviews conducted with mothers using reusable diapers indicated

that two diapers were used per change in order to prevent leakage." (Arthur D. Little, p. A-1). However, the care givers at Gretchen's House III did not double diaper.

More area was required for the storage of disposable diapers than for the cloth diapers, but this difference was not quantified.

Waste Generation

The conversion from disposable to reusable diapers resulted in a reduction of 53 pounds of solid waste per week. If cotton diapers were used exclusively, the diaper-related solid waste generation rate would decrease an additional 19 pounds per week. Solid waste produced by the disposable system includes disposable diapers, fecal matter and urine, and the garbage bags used for discarding soiled diapers. The day care center uses medium and large Dry Babies Ultra disposable diapers, which are distributed by Meijer's. The average weight of these diapers (.123 lb) is comparable to the typical weights reported by Arthur D. Little (1990).

The excrement generation rate was estimated from data by Arthur D. Little (1990). The excrement waste is not included as part of the solid waste from the cloth diaper system because this material is incorporated into the sewage flow to a wastewater treatment plant. Plastic (LDPE) packaging for a case of 64 diapers, which weighs 0.092 lb, is reused by the day care center to hold wet clothes to be sent home with parents. Therefore, this packaging was not considered a component of the waste stream.

Solid waste generated by cloth diapers is comprised of plastic bags (0.0645 lb) provided by the diaper service to collect both soiled diapers and wraps. Gretchen's House III receives extra bags for collecting soiled wraps, even though wraps are not laundered by the diaper service. A single bag is used each day to collect the wraps and one bag is used each week to return soiled diapers to the diaper service. The diaper service is currently investigating opportunities to recycle these bags.

The average diaper washed by the diaper service can be reused 125 times.⁶ The Arthur D. Little study reported an average usage rate of 90 cycles. Old diapers are sold to paint shops, car wash stations, auto body shops, janitorial companies, and furniture manufacturers for use as rags. Cloth diapers enter the waste stream only after they are further degraded by these secondary uses. Discarded cloth diapers generate 0.21 pounds of waste per 150 diapers, compared to the 25.77 pounds of diaper material waste, not including the feces, generated by 210 disposable diapers.

Hampers and diaper pails used for cloth diapers and refuse containers used for disposable diapers were assumed to generate an equivalent amount of waste at the end of their useful life and were therefore not included in the analysis.

Labor and Other Requirements

Labor requirements for each case are reported in Table 1. The cloth system requires more total labor input than the disposable system. Washing and drying wraps, then folding cloth diapers into clean wraps, accounts for the increased labor. Additional labor in the cloth diaper case is somewhat offset by the decreased time spent shopping for disposable diapers. Cloth diapers are delivered to the day care center, whereas the disposable diapers were purchased once a month from a local store. Delivery service for disposable diapers is now available, but the owner considered it too costly.

⁶ from tests conducted by Diapers Unlimited in Kalamazoo, Michigan

The care givers indicated no significant difference in changing times between disposable and cloth diapers.

Diaper wraps are laundered in a washing machine. Laundering requires hot and cold water and electricity for operating the washing machine. Wraps are dried on a clothes line in the diaper changing room which saves energy and extends the useful life of the wraps.

COST ANALYSIS

Methodology

Operating and fixed costs incurred by the day care center for each step identified in the process analysis are analyzed before and after the conversion from disposable to cloth diapers. The cost analysis is limited to those items required for comparison of the two cases. For example, expenses that are essentially constant for both cases, such as telephone, heating, insurance and building maintenance costs, are not evaluated. The main cost categories analyzed in this report include labor, equipment (washing machine), utilities, supplies (disposable diapers), and services (diaper service). The cost of diaper pails for the soiled cloth diapers and refuse containers for the disposable diapers were assumed to offset each other and were not included in the comparison.

The external life cycle costs associated with diapering were not studied in detail, because they were outside the scope of this study, but several external costs will be identified and discussed. Ideally, the total environmental and social costs of each diapering system should be evaluated and compared so that hidden costs, which are frequently borne by society and not reflected in the price of goods, may be properly considered.

Results and Discussion of Cost Analysis

The conversion from disposable to cloth diapers resulted in a cost savings to the day care center of \$226 per year. The total cost per week for the disposable system was \$52.40. The cost after conversion to cloth was \$47.96 per week, which includes a cost of \$32.99 for cloth diapering and \$14.97 for the last change of the day into disposable diapers.

Itemized cost data are presented in Table 2. Additional cost data, such as utility rates and hourly wages, are provided in Appendix B. The first column indicates the costs associated with the disposable diaper system before conversion to cloth. The second and third columns itemize costs for cloth and disposable diapers (last change of the day) respectively, after the conversion was implemented. Column four is the sum of columns two and three. It shows total costs for each item in the after conversion case. Cloth and disposable diapers currently represent comparable costs to the day care center; the unit cost per diaper is \$0.25 for the disposable diapers, and \$0.22 for the cloth diapers. However, the components of these costs are quite different. Furthermore, these costs include only the internal costs; they do not represent the total costs of diapering to society .

Table 2. Weekly Diapering Costs

Unit being measured	Before Case		After Case	
	<i>Disposable Diapers</i>	<i>Cloth Diapers</i>	<i>Disposable Diapers</i>	<i>Total</i>
Diaper Costs				
Diapers	\$48.15	\$18.75	\$13.76	\$32.51
Diaper Wraps		\$2.12		\$2.12
<i>Total</i>	<i>\$48.15</i>	<i>\$20.87</i>	<i>\$13.76</i>	<i>\$34.63</i>
Supplies				
Washing Supplies		\$0.68		\$0.68
Refuse Bags	\$0.40		\$0.11	\$0.11
<i>Total</i>	<i>\$0.40</i>	<i>\$0.68</i>	<i>\$0.11</i>	<i>\$0.79</i>
Equipment				
Washer Depreciation		\$0.49		\$0.49
Washer Maintenance		\$0.29		\$0.29
<i>Total †</i>		<i>\$0.26</i>		<i>\$0.26</i>
Utilities				
Water/Sewage		\$0.54		\$0.54
Gas		\$0.11		\$0.11
Electricity		\$0.08		\$0.08
<i>Total</i>		<i>\$0.73</i>		<i>\$0.73</i>
Transportation				
<i>Total Transportation</i>	<i>\$0.26</i>		<i>\$0.07</i>	<i>\$0.07</i>
Labor				
<i>Total Labor</i>	<i>\$3.59</i>	<i>\$10.45</i>	<i>\$1.03</i>	<i>\$11.48</i>
Total Costs				
<i>Per Diaper</i>	<i>\$0.25</i>	<i>\$0.22</i>	<i>\$0.25</i>	
Total Costs Per Week	\$52.40	\$32.99	\$14.97	\$47.96
Total Costs Per Year	\$2672.55	\$1682.42	\$763.59	\$2446.00
Total Costs including Refuse Disposal				
Disposal Cost/Week††	\$2.39	\$0.01	\$0.63	\$0.64
Disposal Cost/Year	\$121.98	\$0.54	\$32.06	\$32.61
Weekly Total w Disposal	\$54.79	\$33.00	\$15.60	\$48.60
Yearly Total w Disposal	\$2794.53	\$1682.96	\$795.65	\$2478.61

† weekly washer cost is one third the total depreciation and maintenance since the washer is used only one third of the time for washing wraps.

†† these are the collection and disposal costs to the City of Ann Arbor; these costs are not included in the total cost incurred by the day care center.

The major cost for the single-use system is disposable diapers. This cost accounts for 92% of the total cost per child. Other costs include refuse bags for diaper disposal, transportation costs for purchasing the diapers each month, and labor costs for purchasing and stocking the diapers. Transportation costs were calculated using a rate of \$0.26/mile.

Solid waste disposal is a significant environmental cost not included in the total costs incurred by the day care center. Gretchen's House III owns a four cubic yard dumpster that is serviced weekly by the City of Ann Arbor. The conversion to cloth diapers reduced waste discards by half, but the collection and disposal cost to the day care center remained unchanged. The City of Ann Arbor includes collection and disposal fees as part of the property tax assessment; these fees are not calculated on a weight or volume basis.

Actual costs to the city for collection and disposal of the diaper waste are shown at the bottom of Table 2. Total costs per week would increase \$2.39 before the conversion and \$0.64 after the conversion if disposal costs to the city were included in the overall analysis. Essentially all (\$.63 of \$.64) increased costs in the cloth diaper case are attributable to waste produced by the disposable diapers infants/toddlers wear to the day care center. A disposal fee system based on weight or volume would make the cloth system even more favorable economically.

The costs of diapering a child in cloth, presented in column two of Table 2, consist of diaper service fees and costs for purchasing and cleaning outer wraps. The diaper service charges \$0.125 per diaper, or \$18.75 per week which includes a \$4.00 service charge for delivery. The purchase price for each wrap was \$3.00, which translates into a weekly cost of \$2.12 (based on an average life of one year for three dozen wraps).

Most other costs associated with the cloth diaper system are related to washing the wraps. Wrap laundering requires use of a clothes washer, utilities, detergent, and labor. The weekly cost for depreciation and maintenance of the washing machine, based on it being used two-thirds of the time for other purposes, is \$.26. Detergent for washing wraps costs \$.68 per week, and utilities cost \$0.73 per week. The cost of the clothes line was negligible. Labor for laundering wraps, which includes washing, drying on a clothes line, and folding cloth diapers into the wraps, costs \$10.45 per week.

Unit costs for disposable diapers in the after case, presented in column three, are identical to costs for disposable diaper use before conversion, presented in column one.

Figure 3 provides a graphic representation of how costs were allocated before and after conversion to cloth diapers at Gretchen's House III.

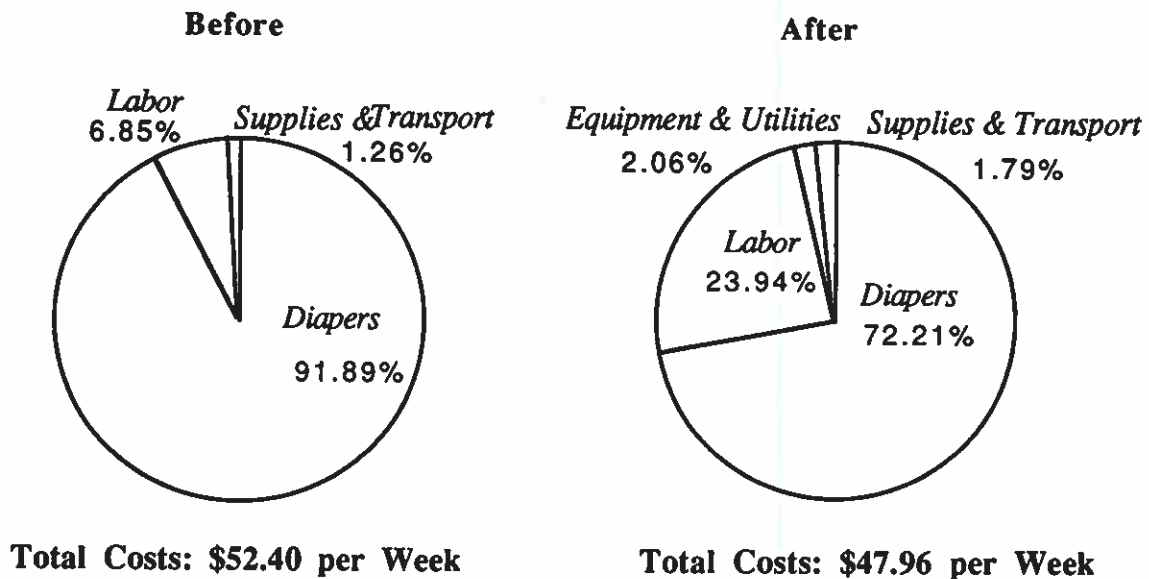


Figure 3. Comparison of Weekly Diapering Costs

Diapers constituted the major costs in both cases. Labor comprised only 6.85% of total costs in the disposable case but nearly 24% of total costs in the cloth diaper case. Supplies, equipment, transportation, and utilities do not contribute significant costs to either case. As figure 3 indicates, the conversion to cloth diapers saved Gretchen's House III \$4.44 per week, or 9.3% of total diapering costs.

4. ADDITIONAL WASTE REDUCTION ACTIVITIES

DESCRIPTION OF ACTIVITIES

Reusable Tableware

The day care center uses washable tableware for all meals and snacks.

Food waste

Lunch-time rules are a good example of how Gretchen's House III promotes waste reduction behavior among the children. Starting at early age, children are expected to serve themselves. They are encouraged to take only as much food as they intend to eat, thereby eliminating food waste. Gretchen explains that many parents have the "don't let baby starve" syndrome which manifests itself in serving their children much more food than they are able to eat. After a two week training period, new children at Gretchen's House III usually take just what they can eat, so very little food is discarded from excessive servings.

When eating outside, those bits of food that do not make it from children's plates to their mouths are fed to birds and squirrels. Excess food prepared for lunch is usually turned into snacks the next morning or eaten by the day care staff

Reuse of Packaging Materials

Staff at Gretchen's House III send children's wet clothes home in plastic packaging salvaged from each case of disposable diapers, allowing the center to avoid purchasing new bags for this purpose. Although such packaging reuse may appear to have a minor impact on the waste stream, it demonstrates a strong conservation ethic.

Waste Reduction in Lawn Maintenance

Grass clippings are allowed to remain on the lawn. The City of Ann Arbor collects grass clippings for composting, but it is more efficient from a resource and solid waste management perspective to return the clippings to the lawn. Grass clippings also improve soil quality and eventually lead to improved lawn appearance. Clippings only present a maintenance problem when an active fungal lawn disease is present. In this case, return of spore laden clippings helps spread the disease and exacerbates the problem.

Most leaves are raked onto an area of the play yard mulched with wood chips, where they decompose. The City of Ann Arbor gathers any remaining leaves raked into the gutter for composting. No chemical pesticides or fertilizers are applied to the lawn thus avoiding packaging waste. Chemical pesticides and fertilizers also pose an unnecessary health risks and environmental impacts in their manufacture and use.

Recycling

Aluminum, cardboard, glass, kraft paper bags, and office paper are collected for recycling.

5. ORGANIZATIONAL AND MOTIVATIONAL ANALYSIS

INNOVATION ORIGIN AND IMPLEMENTATION

Several years ago, while Gretchen's House day care centers were using disposable diapers, Gretchen Preston considered the possibility of using cotton diapers. At the time, waterproof outer wraps essential for a successful cloth diapering system were not provided or handled by the local diaper company. Purchasing wraps required some investment, and laundering wraps in-house appeared inconvenient, so Gretchen decided against cloth diaper use.

As the cost of disposable diapers rose and the purchase of large quantities became an ordeal, cloth diapers seemed an increasingly attractive option. In 1989, prompted to "do her part for the environment" by continuing debate over the rapid depletion of Ann Arbor's landfill, Gretchen once again began actively seeking a cloth diaper service. A local diaper service that provided and cleaned an outer wrap (called Nikki) was located and Gretchen informed the staff that cloth diapers would now be used at her day care centers.

Although some staff members viewed this change with skepticism, within a week their reservations were allayed. One staff member recalls, "It was definitely Gretchen's idea and came from her philosophy of being a part of the community...as a community-based center we should do our part."

Another staffer notes, "We approached the change with the attitude, 'How can we do this without making our day harder?' At first I thought it would be messy and hard to do. It took some time to learn how to put them (cloth diapers and wraps) on, but now it's quick, easy, and better for the babies."

Significant shortcomings soon developed in the diaper company's service. Deliveries were not made promptly, leaving the center with piles of dirty diapers. The outer wraps lacked sufficient velcro causing diapers to slip off infants/toddlers. After struggling for several months, the company went out of business, and Gretchen returned to paper diaper use. In the meantime, she searched for a reliable company that supplied and laundered outer wraps.

A Kalamazoo-based diaper company interested in expanding its service area was the only suitable firm Gretchen could locate, but it did not supply outer wraps. After being assured by another day care center that her staff could launder outer wraps every day in-house without great inconvenience, Gretchen's House day care centers reverted to cloth diapers.

Cloth diaper use required some minor reorganization of the changing room at Gretchen's House III. The staff approached these changes with a relaxed attitude. "We have a 'try anything' mentality; if someone can see a more efficient or more organized way of doing something that is still good for the children, we'll do it!" Another staff person commented, "After all, we work with children; you have to be flexible."

ENCOURAGING INNOVATION

Gretchen's House encourages innovation, change, and improvement in its operation in several ways. First, the staff are considered professionals. They are given membership in the National Association for the Education of Young Children and invited to attend the annual state conference at no expense. Ten hours of observation at other centers or of professional development are required per year, and the staff are encouraged to bring suggestions back to their center. Also, the administration of Gretchen's House cultivates an atmosphere of flexibility and openness that encourages staff to look for better ways of doing their work. Even though Gretchen reserves the right to make final decisions, the staff can make suggestions for changes and complain about problems.

Upper-level direction-setting (e.g., We will begin to use organic, non-toxic cleansers.) and full staff involvement in implementation (e.g., Which cleansers, where should they be stored, how can this be accomplished?) seem to be productively combined at Gretchen's House III. Suggestions can be made verbally to the administration or directly at biweekly staff meeting. New ideas are regularly implemented on a trial basis. During orientation for new staff, directions are sometimes introduced with, "this is the way we do things now...it could change at any time!"

SPINOFFS

In addition to feeling that they are helping solve the problem of excess solid waste production, many of the staff sincerely believe cloth diapers are more comfortable for infants/toddlers.

Receiving encouragement from the staff, several parents have switched from paper to cloth diapers since Gretchen's transition. Cloth diaper use at home results in further waste reduction not quantified in this study.

Finally, Gretchen's House day care centers received the Ecology Center of Ann Arbor's *Most Waste Conscious Business* award in 1989. This award was based largely on cloth diaper use but also reflects the centers' efforts to reuse and recycle waste products wherever possible.

6. IMPACT AND TRANSFERABILITY

IMPACT ON WASTE REDUCTION

Michigan's solid waste stream could be significantly reduced if there was a statewide conversion by all day care centers from disposable to cloth diapers. The greatest potential reduction would be achieved if all infants/toddlers and adult incontinent in the state were diapered with reusable cloth. An estimated 0.68 billion disposable diapers are used annually in Michigan (based on annual total sales of 18 billion diapers nationally and assuming that usage is directly proportional to population (1990 population projection under age five: Michigan/U.S. = 3.8%)⁷). Disposable diaper use thus generates 41,000 tons of solid waste each year in Michigan, if only the weight of the diaper material is considered.

⁷ Statistical Abstract of the United States, National Data Book. U.S. Dept. of Commerce, Bureau of Census, ed. 110. 1990.

The potential for waste reduction in the day care service sector in Michigan can be estimated through an extrapolation of the waste reduction data for Gretchen's House III. For this analysis, it is assumed that Gretchen's House III is representative of the average day care center in Michigan (i.e., number of children served per day, age distribution), and that other centers adopt the same diapering program implemented at Gretchen's House III. This method of approximation is very crude, but yields an order of magnitude estimate of the potential statewide impact. An annual statewide reduction of 880 tons of solid waste can be expected based on the above assumptions.

TRANSFERABILITY

A diapering program designed to reduce solid waste can be modeled on Gretchen's House III but may require some modifications. As this study indicates, the conversion from disposable to cloth diapers should result in a cost savings. The basic requirements for conversion according to the Gretchen's House III program are:

- a clothes washer, which may require the capital investment for a new or used machine
- a set of diaper wraps
- clothes line and pins
- diaper pail
- availability of a diaper service
- some additional labor requirements associated with washing the diaper wraps

Five diaper service companies are presently operating in Michigan, providing service to most major urban areas throughout the state. Therefore, most day care centers should have access to a diaper service, which should facilitate the conversion to cloth diapers.

Day care centers that are charged on a volume or weight basis for refuse collection and disposal have a substantial economic incentive to reduce waste and can be expected to be more amenable to cloth diaper use than centers with no pressing economic incentives for waste reduction.

Conversion from disposable to cloth diapers may be accomplished in several ways. Large institutions such as hospitals may find in-house laundering of cloth diapers and wraps to be more economical than a diaper service. This option also eliminates environmental impacts associated with delivery and collection. In selecting outer wraps, it is essential to consider the compatibility of the material with the drying system. Some wrap material melts when dried in commercial machines. Teflon lined drying chambers can be used to avoid this problem, or material capable of withstanding higher temperatures can be selected. In smaller institutions where a clothes washer is not available, arrangements could be made with a diaper service to include diaper wrap washing.

Although this study examines the diapering program at a day care center, many aspects of the analysis are also applicable to households. However, the merits of home laundering compared to a diaper service are not addressed specifically in this study.

Community awareness of environmental issues can be an important factor in gaining the commitment and support of the director or owner of a day care center, and the staff and parents.

The cloth vs disposable diaper controversy has received much attention by the media recently, but a comprehensive product life cycle environmental impact and risk assessment of diapering has not yet been conducted. Life cycle studies to date have concentrated on inventories of energy and material flows without assessing risks. A full life cycle analysis could make the cloth diaper case even more attractive.

A.D. Little (1990) performed one often cited life cycle analysis. A critical review of this study reveals several inaccurate and misleading components of the data analysis. A summary of life cycle impacts reported by A.D. Little indicates that cloth diapers consume fewer resources in manufacturing and generate much less solid waste in use. However, total mass of air emissions and water discharges over the life cycle were reportedly higher for a cloth diaper system.

These statistics do not properly reflect risk levels which are dependent on the toxicity of constituent emissions and their overall environmental impact. A.D. Little also found that total life cycle energy requirements were less for disposable diapers. This conclusion was based on omitting the energy content of the primary raw materials used in manufacturing disposable diapers, which accounts for approximately fifty percent of total energy inputs.

Other analyses in the A.D. Little study were based on questionable assumptions. As an example, survey data were cited that suggest double diapering is standard practice in cloth diaper use. This exaggerated cloth diaper usage rate has a significant effect on comparative results. Numerous limitations render A.D. Little's conclusions unreliable.

This case study report documents the process and economic changes associated with the conversion to a new diapering system by one day care center. It does not necessarily serve as a comprehensive manual for all day care centers.

7. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

This study examined the conversion from disposable to cloth diapers successfully implemented at Gretchen's House III day care center. Conclusions derived from the process, economic, and organizational/motivational analyses are:

- The conversion from disposable to cloth diapers resulted in a significant reduction in solid waste. A total of 53 lb of solid waste has been eliminated per week for the 12 infants/toddlers supervised (eight hours per day, five days per week) or 0.24 lb per diaper change.
- An annual savings of \$226 was realized by the day care center. The total costs to the day care center were \$0.25 per disposable diaper and \$0.22 per cloth diaper.
- Cloth diaper use required small additional labor inputs associated with washing and handling diaper wraps, and a clothes washer to clean the wraps. However, no additional staff was required at Gretchen's.
- The same diaper usage rate was observed before and after the conversion.
- No change in the incidence of diaper rash was observed after the conversion to cloth diapers.
- Solid waste could be reduced by as much as 41,000 tons per year statewide if all businesses, institutions, and households used cloth diapers.

RECOMMENDATIONS

The conversion to cloth diapers should be transferable to pediatric hospitals, households, and nursing homes caring for adult incontinents. The following recommendations may facilitate this process:

- Review the conversion from disposable to reusable cloth diapers at Gretchen's House III day care center.
- Evaluate the operational steps in this conversion: e.g., investigate the availability of a diaper service or decide to wash the diapers in-house.
- Conduct a cost analyses using this study as a guide. It should be emphasized that a disposal fee system based on refuse weight or volume would increase the economic advantage of cloth over disposable diapers.
- Appeal to staff to generate ideas and to participate in the development and implementation of waste reduction programs. Evaluate the feasibility of these ideas and develop a plan and time frame for implementation.
- Make a decision to do it. Formulate a policy to reduce waste.
- Train staff in the necessary procedures.
- Inform parents about the conversion to cloth and the reduction in solid waste that will be achieved. Encourage parents to use cloth diapers at home.

After the conversion to cloth at Gretchen's House III, disposable diapers are still used for the last diaper change of the day. This practice is necessary because few parents of infants/toddlers attending the day care center use cloth diapers at home. As more parents convert to cloth diapers, additional disposable diapers can be replaced with cloth diapers, resulting in further waste reduction.

APPENDIX A.

	Before Case		After Case	
Unit being measured	Disposable Diapers	Cloth Diapers	Disposable Diapers	Total
PROCESS ANALYSIS				
Ave. Daily Number of Diapered Children	12	12	12	12
Ave. Diapers Used/Child/5 Day Week	17.5	12.5	5.0	17.5
Total Diapers Used per Week	210	150	60	210
Total Diapers Used per Year (51 weeks)	10,710	7,650	3,060	10,710
Solid Waste Management				
Ave. Feces Disposal Weight per Week	46.26 lb.		11.56 lb.	11.56 lb.
Ave. Diaper Disposal Weight per Week	25.77 lb.	0.33 lb.	7.36 lb.	7.69 lb.
Ave. Diaper Packaging per Week	0.302 lb.	0.065 lb.	0.086 lb.	0.15 lb.
Ave. Refuse Bags per Week	0.234 lb.	0.323 lb.	0.067 lb.	
Material Reused for Another Purpose/Week	0.302 lb.	0.065 lb.	0.086 lb.	
Total Disposed Material per Week	72 lb.	0.3 lb.	19 lb.	19 lb.
Utilities				
Clothes Washer Water Use per Week		144 gal		144 gal
Hot Water Gas Use per Week		0.1404 Ccf		0.1404 Ccf
Clothes Washer Electricity Use per Week		0.75 kwh		0.75 kwh
Labor				
Purchase & Stocking Labor per Week	15.0 min		4.3 min	4.3 min
Washing Labor per Week		11.7 min		11.7 min
Drying and Folding Labor per Week		53.0 min		53.0 min
Total Labor per Week	15.0 min	64.7 min	4.3 min	69.0 min
ECONOMIC ANALYSIS				
Diaper Costs				
Diapers Cost per Week	\$48.15	\$18.75	\$13.76	\$32.51
Diaper Wraps Cost per Week		\$2.12		\$2.12
Total Diaper Costs per Year	\$2455.80	\$1064.25	\$701.66	\$1765.91
Supplies				
Washing Supplies Costs per Week		\$0.68		\$0.68
Refuse Bags Cost per Week	\$0.40		\$0.11	\$0.11
Equipment				
Clothes Washer Annual Depreciation		\$25.11		\$25.11
Clothes Washer Annual Maintenance		\$15.00		\$15.00
Total Washer Cost per Year†		\$13.37		\$13.37
Utilities				
Water/Sewage Costs per Week		\$0.54		\$0.54
Water/Sewage Costs per Year		\$27.49		\$27.49
Gas Costs per Week		\$0.11		\$0.11
Electricity Costs per Week		\$0.08		\$0.08
Total Energy Costs per Year		\$9.57		\$9.57
Transportation				
Transportation/Service Costs per Week	\$0.26		\$0.07	\$0.07
Transportation/Service Costs per Year	\$13.26	\$0.00	\$3.79	\$3.79
Labor				
Total Labor Costs per Week	\$3.59	\$10.45	\$1.03	\$11.48
Total Labor Costs per Year	\$183.09	\$533.18	\$52.31	\$585.49
Total Costs incurred by daycare center				
Total Costs Per Diaper	\$0.25	\$0.22	\$0.25	
Total Costs Per Week	\$52.40	\$32.99	\$14.97	\$47.96
Total Costs Per Year	\$2672.55	\$1682.42	\$763.59	\$2446.00
Total Costs including Refuse Disposal				
Refuse Disposal Cost per Week††	\$2.39	\$0.01	\$0.63	\$0.64
Refuse Disposal Cost per Year	\$121.98	\$0.54	\$32.06	\$32.61
Total Costs Per Week with Refuse Disposal	\$54.79	\$33.00	\$15.60	\$48.60
Total Costs Per Year with Refuse Disposal	\$2794.53	\$1682.96	\$795.65	\$2478.61

† the total annual cost of the washer is taken as one third the total depreciation and maintenance costs since the washer is used only one third of the time for washing diaper wraps.

†† these are the collection and disposal costs to the City of Ann Arbor; this cost is not included in the total cost incurred by the daycare center.

	A	B
4		Before Case
5		Disposable
6	Unit being measured	Diapers
7		
8	PROCESS ANALYSIS	
9	Ave. Daily Number of Diapered Children	12
10	Ave. Diapers Used per Child per 5 Day Week	=3.5*5
11	Total Diapers Used per Week	=B10*B9
12	Total Diapers Used per Year (51 weeks)	=B11*B1
13	Solid Waste Management	
14	Ave. Feces Disposal Weight per Week	=16.19*5*12/(3*7)
15	Ave. Diaper Disposal Weight per Week	=B11*0.1227
16	Ave. Diaper Packaging per Week	=B11*0.092/64
17	Ave. Refuse Bags per Week	=0.0234*2*5
18	Total Material Reused for Another Purpose/Week	=B16
19	Total Disposed Material per Week	=(SUM(B14+B15+B17))
20	Utilities	
21	Clothes Washer Water Use per Week	
22	Hot Water Gas Use per Week	
23	Clothes Washer Electricity Use per Week	
24	Labor	
25	Purchase & Stocking Labor per Week	=60/4
26	Washing Labor per Week	
27	Drying and Folding Labor per Week	
28	Total Labor per Week	=SUM(B25:B27)
29		
30	ECONOMIC ANALYSIS	
31	Diaper Costs	
32	Diapers Cost per Week	=0.2293*B11
33	Diaper Wraps Cost per Week	
34	Total Diaper Costs per Year	=B32*B1
35	Supplies	
36	Washing Supplies Costs per Week	
37	Refuse Bags Cost per Week	=2*5*0.04
38	Total Miscell. Materials Cost per Year	=B37*B1
39	Equipment	
40	Clothes Washer Annual Depreciation	
41	Clothes Washer Annual Maintenance	
42	Total Washer Cost per Year†	
43	Utilities	
44	Water/Sewage Costs per Week	
45	Water/Sewage Costs per Year	
46	Gas Costs per Week	
47	Electricity Costs per Week	
48	Total Energy Costs per Year	
49	Transportation	
50	Transportation/Service Costs per Week	0.26
51	Transportation/Service Costs per Year	=B50*B1
52	Labor	
53	Total Labor Costs per Week	=B3/4
54	Total Labor Costs per Year	=B53*B1
55	Total Costs incurred by daycare center	
56	Total Costs Per Diaper	=B57/B11
57	Total Costs Per Week	=B58/B1
58	Total Costs Per Year	=SUM(B34+B38+B42+B48+B51+B54)
59	Total Costs Including Refuse Disposal	
60	Refuse Disposal Cost per Week††	=B19*0.0331
61	Refuse Disposal Cost per Year	=B60*B1
62	Total Costs Per Week with Refuse Disposal	=B57+B60
63	Total Costs Per Year with Refuse Disposal	=B58+B61
64		
65	† the total annual cost of the washer is taken as one third	the total depreciation and maintenance
66	costs since the washer is used only one third of the time	for washing diaper wraps
67	†† these are the collection and disposal costs to the City	of Ann Arbor;
68	this cost is not included in the total cost incurred by	the day care center

	C	D
4	After Case	After Case
5	Cloth	Disposable
6	Diapers	Diapers
7		
8		
9	12	12
10	=2.5*5	=1*5
11	=C10*C9	=D10*D9
12	=C11*B1	=D11*B1
13		
14		=16.19*5*12/(4*3*7)
15	=C11/125*(2.75/16)	=D11*0.1227
16	=0.0645	=D11*0.092/64
17	=0.0645*5	=0.0234*2*5*5/17.5
18	=C16	=D16
19	=(SUM(C17))	=(SUM(D14+D15+D17))
20		
21	=(32*0.9*5)	
22	=16*893.6/101800	
23	=0.15*5	
24		
25		=B25*D11/B11
26	=140/60*5	
27	=636/60*5	
28	=SUM(C25:C27)	=SUM(D25:D27)
29		
30		
31		
32	=0.125*C11	=0.2293*D11
33	=3*36/B1	
34	=(C32+C33)*B1	=D32*B1
35		
36	=0.1355*5	
37		=B37*5/17.5
38	=C36*B1	=D37*B1
39		
40	=565/22.5	
41	15	
42	=(C40+C41)/3	
43		
44	=C21*2.8/100/7.48	
45	=C44*B1	
46	=C22*0.7979	
47	=C23*0.1009	
48	=(C46+C47)*B1	
49		
50		=0.26*5/17.5
51	0	=D50*B1
52		
53	=C28*B2/60	=B53*5/17.5
54	=C53*B1	=D53*B1
55		
56	=C57/C11	=D57/D11
57	=C58/B1	=D58/B1
58	=SUM(C34+C38+C42+C45+C48+C51+C54)	=SUM(D34+D38+D42+D48+D51+D54)
59		
60	=C19*0.0331	=D19*0.0331
61	=C60*B1	=D60*B1
62	=C57+C60	=D57+D60
63	=C58+C61	=D58+D61
64		
65		
66		
67		
68		

APPENDIX B.

Wages and Utility Costs

<u>Management Labor</u>	<u>\$14.36</u>
<u>Care Giver Labor</u>	<u>\$9.70</u>
<u>Trash Disposal per lb.</u>	<u>\$0.0330</u>
<u>Electricity, kwh</u>	<u>\$0.1009</u>
<u>Gas per 100 cu. ft.</u>	<u>\$0.7979</u>
<u>Water & Sewer/ 100 cu.ft.</u>	<u>\$2.80</u>