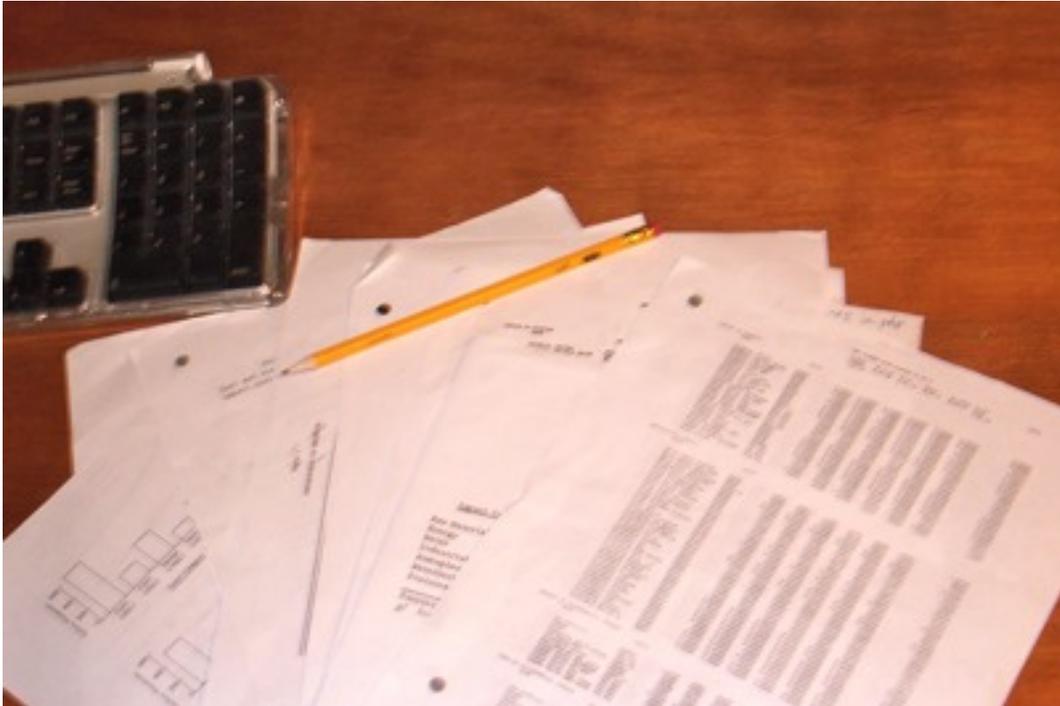


N E A R T A

*A fresh look at diapers*

## AN ANALYSIS OF THE DIAPER PORTION OF SW-152C



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# An Analysis of the Diaper Portion of SW-152c

## Introduction

The U.S. Environmental Protection Agency (EPA) contracted the Midwest Research Institute (MRI) to perform a study on the environmental impact of disposable versus reusable products in 1978. In order to complete this study, the MRI subcontracted Franklin Associates, Ltd. to collect data and help with the analysis<sup>1</sup>. The resulting report was entitled *Study of Environmental Impacts of Selected Disposable Versus Reusable Products with Health Considerations*. It is also known by the much more terse label SW-152c, and that is how we will refer to it here.

SW-152c was so widely criticized for its technical accuracy that the EPA chose not to review it but instead release it with a disclaimer stating that it “should be viewed as technically incomplete and inappropriate for the development of policy”<sup>2</sup>. This report is of especial interest for a few reasons: 1) having been initially funded by the EPA it appears on the surface to be less biased than later reports funded by one side or the other (this is misleading as Franklin Associates, Ltd. works for many of the companies that have a stake in disposable diapers); 2) it was extremely influential in future pro-disposable diaper studies with some apparently not even bothering to reevaluate its findings; 3) it was the first loud voice expounding the dubious notion that using single-shot throwaway items has less of an environmental impact than using reusable items because the latter have to be washed. Again it must be stressed that this paper was never officially reviewed by the EPA; in point of fact we will show a careful analysis of its contents shows that it even contains mathematical errors that influence its results. Even though more recent studies have shown that (at least in the case of diapers) throwaway items tend to be more environmentally harmful than reusable ones<sup>3</sup>, the general idea that washing things can be more harmful than recreating them persists.

In this paper we will take a detailed look at the portion of SW-152c that analyzes diapers and show that even in 1978 (when both clothes washers and toilets were far less efficient than their present day counterparts) the collected data demonstrated that reusable diapers were better for the environment.

## Basic Problems

SW-152c is not an easy read. In order to follow its analysis of diapers, one must work through several sections and tables scattered throughout the entire 659 page document. Units shift pretty rapidly from place to place with wastes sometimes being measured in pounds and sometimes in cubic feet, and the abbreviations used to represent these units lack consistency. Oftentimes the quantities being measured are miniscule compared to the units being used, so values like .001 (and the resulting rounding problems that occur with such numbers) are common throughout. The original printing quality also frequently makes it difficult to determine many of the actual values within the source tables, and one sometimes has to run calculations backwards to figure out some of the individual digits. Figure 1 demonstrates this fact by showing a short snippet from one such table chosen completely at random. As shown in this document it has been enlarged by approximately 50% so one can well imagine the difficulty entailed in working through the original source. These tables have far worse problems, however. In one extreme case a column of a table was missing a row in the middle. Unfortunately it masked the omission by using a slightly larger font. Figure 2

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<sup>1</sup> The history of SW-152c is described in its preface on page v.

<sup>2</sup> This disclaimer is covered in pages ii - iv of SW-152c.

<sup>3</sup> Of especial note here is *Diapers: Environmental Impacts and Lifecycle Analysis* by Carl Lehrburger, Jocelyn Mullen, & C. V. Jones; Energy Answers Corporation, Albany, NY, January 1991.

shows this example. By digging through the source tables, one can recover the missing value. In another case, the decimal point got shifted as a number was copied from the raw data tables to the summary making it look as though the solid waste generated by disposable diapers was ten times greater than really estimated<sup>4</sup>. Again, it was necessary to go back to the source tables to glean the truth.

.233	0.000	0.000	0.000	0.000	0.000	.230
0.000	0.000	0.000	0.000	.305	0.000	.305
0.000	0.000	.006	0.000	0.000	0.000	.006
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	.003	0.000	0.000	.205	0.000	.208
0.000	0.000	0.000	0.000	.168	0.000	.168
0.000	0.000	0.000	0.000	.149	0.000	.149
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	.002	0.000	0.000	.044	0.000	.046
.001	.002	.000	.000	.001	.000	.004
.000	.003	.000	0.000	.165	0.000	.169

Figure 1: The upper left corner of Table 46 from SW-152c.

Another example of a slipped decimal point occurs in SW-152c Table E-11. This one is more insidious because it occurs not just when being transcribed to the final summary, but rather during the calculation process, and it was flagged (but not accounted for) within the report itself. A cubic foot of natural gas is typically equivalent to between 1,000 and 1,030 BTU depending upon the composition. Likewise, a gallon of fuel oil is typically equivalent to between 138,000 to 160,000 BTU and 1 kw/hr is around 3,412 BTU<sup>5</sup>. In the table, 1.82 kw/hr (~6,210 BTU), 20.73 ft<sup>3</sup> of natural gas (~20,730-21,352 BTU) and 0.031 gallons of fuel oil (~4,278-4,960 BTU) are added to get 85,350 BTU. The normal maximum one would expect would be around 32,522 BTU, nowhere near 85,350 BTU. In the table the 1.82 is written as 18.2 with a footnote indicating that it is off by a factor of ten. Unfortunately, none of the calculations use the proper value so the end result is off by more than a factor of two and the summary report shows washing diapers to be more than two times more energy intensive than the data really suggested.

Cloth Diaper Home Laundered U100	Cloth Diaper Commercial Laundered U1	Cloth Diaper Commercial Laundered U50	Cloth Diaper Commercial Laundered U100	Disposable Diaper 103 Diapers
1.445	35.932	1.124	0.773	12.889
0.413	1.350	0.164	0.152	0.371
0.510	0.562	0.129	0.125	0.166
0.064	0.371	0.031	0.027	1.196
1.602	6.543	0.388	0.326	0.356
0.601	2.331	0.177	0.155	0.190
0.004	0.338	0.008	0.004	

Figure 2: The left side of Table 5 from SW-152c. The missing value is 0.04 and should be between the 0.166 and 1.196.

<sup>4</sup> Summary Table 33 from SW-152c indicates 0.64 ft<sup>3</sup> of solid waste for home laundering; this was miscopied from source Table 46 which indicates 0.064 ft<sup>3</sup>.

<sup>5</sup> None of these conversions are at all exact. One set of figures can be found at the U.S. Federal Government's energy page: <http://www.eia.doe.gov/neic/infosheets/apples.html> (Apples, Oranges, and BTU, August 2008).

It was really the preponderance of obvious problems we discovered with these tables that drove us to analyze them in detail. What we found was unexpected: every error was to the advantage of disposable diapers, and even in 1978 the raw data collected for *SW-152c* actually favored reusable diapers over disposable ones. Considering that this raw data both were based upon (by today's standards) fairly archaic clothes washing and toilet technology, and that much of the supporting lifecycle data added in later studies<sup>6</sup> was not yet present, this was a surprising result.

### Lost Waste

So far the errors we have documented have been straightforward clerical ones. In each case it has been fairly simple to work back through the detailed source tables and recalculate values to figure out what really ought to have been in the summary tables. There are, however, deeper problems with *SW-152c*. One of the biggest can be seen fairly clearly in *SW-152c* Table 37 and *SW-152c* Figure 36. The table calculates the total post consumer solid waste from 100 changes of disposable diapers as being 10.82 pounds of material from the product plus an additional 2.88 pounds of material from the packaging. The figure further refines how each of these numbers were calculated (although in each case there is a slight difference shown; the figure shows 10.5 and 2.81 respectively). What is completely missing is the actual human waste — the whole *raison d'être* for diapers and (as anyone who has ever handled a wet diaper can testify) certainly a significant contributing factor to the overall weight of the post consumer solid waste.

The human waste component is not missing from the tally taken for the reusable diapers. *SW-152c* Tables E-10 and E-12 respectively track the resources used in washing the soiled reusable diapers and flushing any solids from them prior to washing. *SW-152c* Table 46 dutifully sums the effects of urine and feces for reusable diapers so calculated, and when *SW-152c* Table 37 makes its summary comparison, it ultimately factors in these effects only for the reusable diapers, not the disposable ones.

At this stage undoubtedly some would choose to label *SW-152c* and any other study based in part on its results to be completely without merit. We took a slightly different approach. Considering that disposable diaper packaging advocates flushing feces from diapers<sup>7</sup> and that doing so is in spirit with World Health Organization recommendations<sup>8</sup> and various laws<sup>9</sup>, we decided to consider how the numbers would change if the simple act of flushing the feces from disposable diapers was performed prior to discarding them in the trash. This is quite simple to do fairly as *SW-152c* already has the data for flushing the feces from reusable diapers, and there is no reason to assume that the number of bowel movements babies have would vary based upon diaper type. While this still makes no attempt to quantify the urine and feces residue that still get tossed into the trash after the flushing, it at least accounts for some of the solid waste ignored by *SW-152c*, even if it still necessarily an underestimate.

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<sup>6</sup> Both the previously mentioned Energy Answers Corporation 1991 analysis and other versions by Franklin Associates (such as the later mentioned 1992 analysis) included more expansive data.

<sup>7</sup> Since packaging can change, one may wish to consult a more durable source: the meeting minutes from Oregon Senate Committee on Agriculture and Natural Resources April 24, 1991 can serve this need; in Hearing Room B shortly after 5:30 the recommended procedure for discarding disposable diapers (and the instructions found on the packaging) are discussed.

<sup>8</sup> See for example chapter 22: "Human excreta and sanitation: Control and protection" of *Protecting Groundwater for Health* by Oliver Schmoll, Guy Howard; John Chilton, & Ingrid Chorus, World Health Organization, 2006.

<sup>9</sup> Numerous laws attempt to regulate the handling of sewage and human excreta; 33 U.S.C. Chapter 26 - Water Pollution Prevention and Control, M.G.L. Chapter 21 § 26-53, M.G.L. Chapter 83 § 5-7, and MassDEP 310 CMR 19.000 may be of especial interest to the Massachusetts reader.

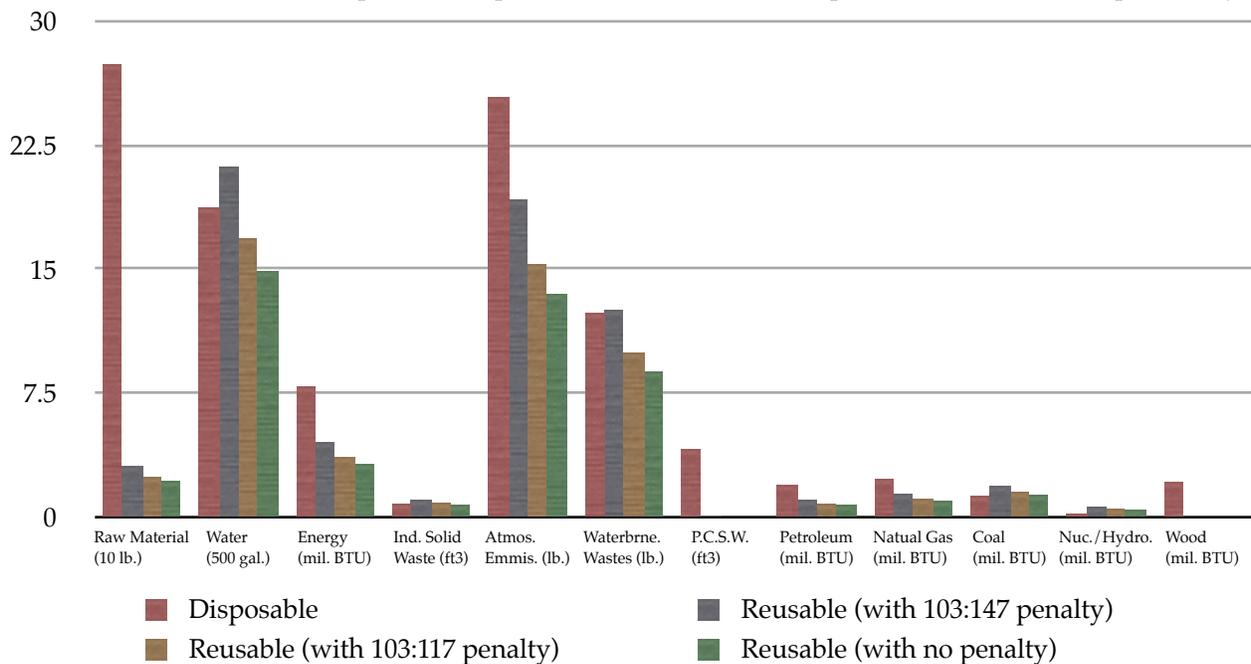
## Mysterious Multipliers

There is another important point in *SW-152c* that must be noted. When the report calculates the energy and waste costs for 100 diaper changes, it does not actually use 100 diapers. For disposable diapers it uses 103 diapers and for reusable diapers it uses 147 diapers. To defend the latter number, *SW-152c* simply states: “Industry data show 8.56 diapers used per day for 5.82 changes per day, resulting in 1.47 diapers per change” but gives no indication on how said “industry data” were obtained, but indicates the number is due to parents doubling up diapers 37% of the time (and even tripling up diapers 5% of the time). There is even less explanation for the former number (based on a 3% doubling). Granted, a baby will occasionally wet while a diaper (either disposable or reusable) is being changed, making it necessary to perform a double change; and in an informal survey we conducted we found some (although by no means all) parents using certain types of reusable diapers would double them up for the single overnight change (we did not find anyone who doubled up diapers during the day or tripled up diapers at all). Even if we were to assume *all* parents *always* doubled up the overnight reusable diapers and never doubled up disposable diapers, it would lead to a much smaller difference than 147 versus 103.

When the above-mentioned mistakes are corrected, the only way reusable diapers can be shown to be significantly more costly in *any* category is if this seemingly arbitrary multiplier is made large enough to overcome other differences. When the whole crux of a report is based upon such a penalty multiplier, there should be adequate research to support it. There is no such research within *SW-152c*.

The chart below shows the environmental effects implied by *SW-152c* when the errors mentioned above have been fixed. For comparison purposes it shows not just the 103:147 penalty prescribed by *SW-152c*, but also a more realistic 103:117 (double diapers at night) penalty and a case without any penalty applied. Without the 103:147 penalty being applied, the water usage for disposable diapers was still higher than the water usage for reusable ones based on the data collected in 1978. The supposed increased water usage of reusable diapers never existed.

Chart 1: Environment Impacts of Disposable Versus Reusable Diapers Based on *SW-152c* (per child year)



## Bad Assumptions

There are a host of other issues with SW-152c regarding assumptions that it makes. Perhaps the biggest is the assumption that every reusable diaper will be dried in a clothes dryer. It is our informal experience that many of the same people who use reusable diapers also eschew clothes dryers when it is possible to air dry garments. If even a small percentage of home laundering reusable diaper users were to prefer air drying over powered clothes drying, it can make a significant difference in the overall energy use numbers.

Likewise, while SW-152c considers the case for reusable napkins after 1,000 uses, it considers a maximum number of just 100 uses for disposable diapers. This is a low estimate as reusable diapers get handed down not just to younger siblings but also get traded (along with tips on how to best maximize the life expectancy of each reusable diaper) amongst communities of reusable diaper users.<sup>10</sup> Furthermore, when reusable diapers have finally passed their useful life as diapers, they tend to get reused as rags.<sup>11</sup> The greater the number of uses per individual diaper, the smaller environmental impact overall.

## Later Reports

This paper does not make any serious attempt to analyze any later reports. It must still be noted that in spite of the problems with SW-152c, it remains influential, and with funding from the industry rather than the government, Franklin Associates, Ltd. has gone on to generate more reports in the same spirit.

Just glancing at just an executive summary of their 1992 *Energy and Environmental Profile Analysis of Children's Single Use and Cloth Diapers: Revised Report*<sup>12</sup> we would perhaps expect some changes to be reflected in the nearly decade in a half between reports. While it is not really possible to reverse engineer the processes they used to obtain numbers for this later report with absolute certainty, on the surface this new report seems to reuse some of the same old numbers (albeit reformulated for different units or scales). For example, the new report states that in a year a child can use between 3,100 and 3,700 reusable diapers versus just 1,800 to 2,900 disposable diapers. The bounds of  $(3,100 - 1,800) / 3,100 (.42)$  and  $(3,700 - 2,900) / 3,700 (.22)$  comfortably contain the earlier mysterious  $(147 - 103) / 147 (.30)$  penalty factor used by SW-152c (in fact they have even been shifted somewhat to be even more in favor of disposable diapers in spite of technological improvements made to reusable diapers); they have just been reformulated for changes per year instead of 100 changes.

The 1990 report by Arthur D. Little, Inc., *Disposable Versus Reusable Diapers: Health, Environmental and Economic Comparisons* appears also to have many of the same flaws as SW-152c. It also was criticized for methodology, mathematical errors, and not tracking feces when considering disposable diapers<sup>13</sup>.

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<sup>10</sup> See for example <http://www.diaperswappers.com> and [http://community.livejournal.com/cloth\\_diapering](http://community.livejournal.com/cloth_diapering)

<sup>11</sup> Most diaper services sell their retired diapers as rags. Searching online via a Google query like <http://www.google.com/search?q=%22diaper+rags%22> will bring up numerous diaper rag suppliers.

<sup>12</sup> A summary of this report with all the numbers used above is available online at: <http://www.iere.org/ILEA/lcas/franklin1992.html> (Institute for Lifecycle Environmental Assessment, 2004).

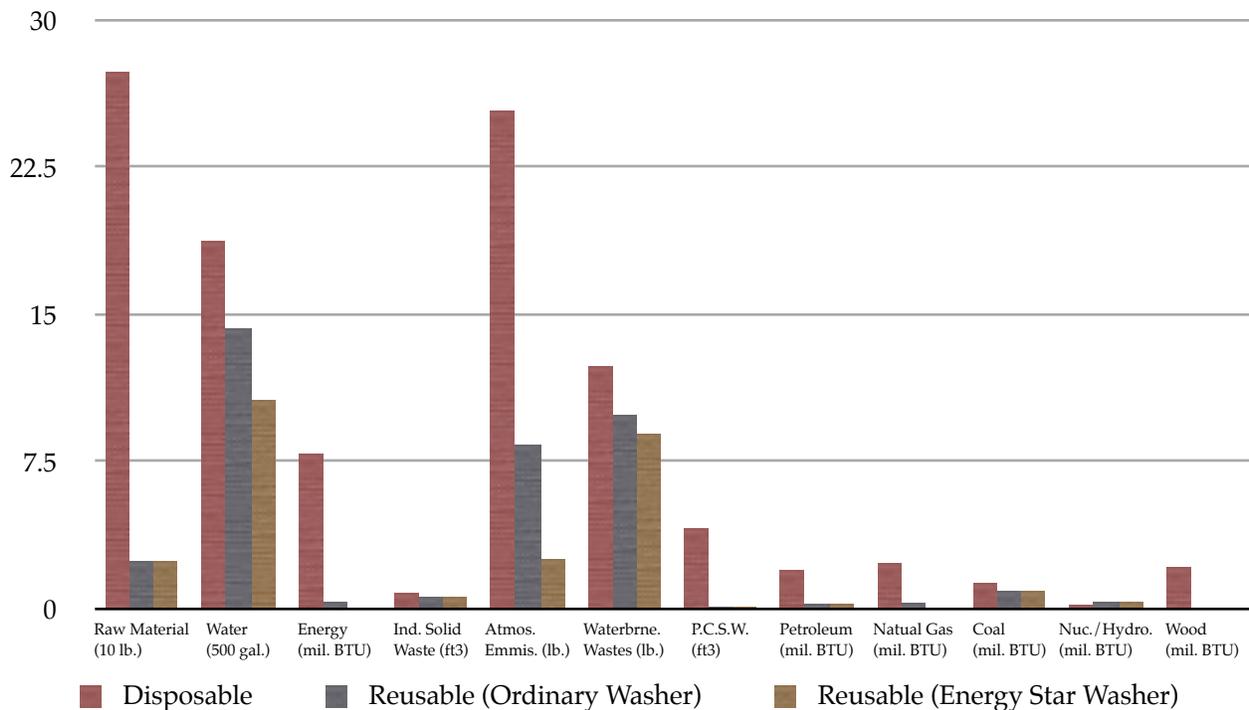
<sup>13</sup> See "What a Bummer! The Social Shaping of the Diaper in North America" by Leslie Regan Shade, *HOST: An Electronic Bulletin for the History and Philosophy of Science and Technology*, V. 2, January, 1994.

## Conclusion

The first significant comparison of the environmental effects of reusable and disposable diapers, *SW-152c*, was deeply flawed and contained significant errors. Unfortunately the EPA released it without doing a proper analysis and some of its erroneous conclusions (most especially the idea of reusable diapers consuming more water than disposable diapers) have wrongfully become “common knowledge” influencing future studies, making *SW-152c* an insidiously influential document.

While we have made no attempt to account for any of the incorrect assumptions made by *SW-152c* identified above (which will only skew the results more in favor of reusable diapers) and have furthermore made no attempt to work in any of the additional factors identified in later reports (which really do not end up skewing the results much in either direction), it did seem reasonable to update the results based upon known improvements in clothes washer efficiency. The chart below tracks the same categories as the one above, but assumes that the home laundered reusable diapers will be washed twice per week (more frequently than *SW-152c* and thus will actually show a greater impact) using modern equipment<sup>14</sup>. We make no assertions that this chart is scientifically valid; on the contrary, the two washings per week is decidedly somewhat arbitrary (albeit reasonable). We encourage further research to be done to determine the true effects of washing frequency, air drying, and diaper lifespan.

Chart 2: Environmental Impact of Disposable Versus Reusable Diapers Using Modern Washers



## Bibliography

Levesque, Robert; Welch, Richard O.; Fellman, Ron; Romine, Chuck; Hunt, Robert G.; Simister, Mary; & Keyes, Dan. “Study of Environmental Impacts of Selected Disposable Versus Reusable Products with Health Considerations (SW-152c).” U.S. Environmental Protection Agency, 1978.

<sup>14</sup> Energy requirements for modern clothes washers was taken from the Energy Star Web site: <http://www.energystar.gov> (the clothes washer energy calculator).