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AN ENERGY ANALYSIS OF CONSUMER PRODUCTS PACKAGING

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CONSUMER AND CORPORATE AFFAIRS CANADA

CONSUMER RESEARCH & EVALUATION BRANCH

BOSTON
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AN ENERGY ANALYSIS OF CONSUMER PRODUCTS PACKAGING

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PREFACE

The question might well be asked, "Why is the Canadian Government interested in the energy conservation potential in consumer packaging?" For many people, the answer is not readily apparent.

Few people recognize that in Canada today packaging is a four billion dollar a year business.[1] Canadian industry spent that much on packaging to contain, protect, and ship over one hundred billion dollars worth of manufactured goods.[2] These goods represent about one quarter of the Canadian Gross National Product (GNP). Packaging is about 2% of GNP.

Almost every consumer good we purchase is packaged. It has been said that the only consumer product purchased that does not come packaged is the family car. But even so, almost every single part during manufacture was supplied to the auto maker in a package or container of some sort. Even when the consumer purchases services, a package or wrapper is part of the transaction. Examples are dry cleaning, shoe repair, or cash from a chequing account.

It is no wonder then that the consumer who sees packaging all around him every day feels an excessive use of packaging from his vantage point. Many of these packages and containers seem to serve a less than truly useful purpose. Environmentalists are quick to point out that one third of all the municipal solid waste is represented by packaging.[1] As one travels along the highways or on the streets through the city, litter is frequently evident. A very large percentage of litter (85%) is packaging.* No wonder public attention has focused on packaging as an environmental problem and a great opportunity for resource conservation.

Now it is being recognized that packaging consumes more than natural resources in the materials contained in

* Boston, Gilbert, Henry Associates Ltd. estimate.

packaging. There is a substantial amount of energy that can be recovered from refuse derived fuels (RDF). Eliminating the non-combustible packaging elements like glass bottles and steel cans, about 1% of Canada's total energy requirements are represented by energy recoverable from packaging materials in the municipal solid waste stream. But there is more to be considered than this. A substantial amount of energy went into the manufacture of the packaging and container materials. Throughout the package manufacturing and package filling operations more energy was consumed. Transportation and the physical distribution system goes from the manufacturer, through the warehouse, to the retailer, on to the customer and finally to the land fill site. This represents a very substantial increase in total energy consumed for packaging purposes. We have estimated that some 3% of Canada's total energy consumption is used in the four billion dollar Canadian packaging industry.

We also know that about 15% of Canada's total energy demand is required by our food system. That is what is required to take food from farm production through the processing and distribution systems to the consumer's table and the disposition of the resulting wastes. These products represent about two thirds of all Canada's packaging requirements. Obviously food products should be an area of further investigation. There is evidence of food waste throughout our Canadian food system. Improved packaging and improved product design could alleviate some of this wastage.

Intuitively recognizing these factors, the consumer has a very natural tendency to deplore packaging as a waste of Canada's natural resources. Both the consumer and Government are becoming increasingly concerned about the energy losses directly attributable to wasteful or unnecessary packaging. To a large measure these attitudes of the public are due to a lack of understanding of the importance

of packaging. Recently some grade school children were asked their views about packaging. As tomorrow's consumer their thoughts on the subject of packaging were considered very important. Somewhat typical were the following:

> "We ought to make all packages out of metal then we could recycle everything and not waste the environment."
>
> "It holds stuff that you don't always want, but the package makes you buy it anyway and when you're finished with the stuff inside it, it just makes garbage."

Very few of today's children, or adults for that matter, can give a truly valid explanation of the importance of packaging to: the manufacturer, the wholesale distributor, the retailer, or to the safety of the consumer. Many people still believe that the old method of bulk supply of the general store is less expensive. But studies have shown that the hand scooping, measuring and packaging of food is much less hygienic and far more costly than our present food merchandising methods. Also, convenience products are often not available in bulk. They are provided in highly engineered and low cost specially designed packages. They can only be sold that way.

The consumer product manufacturers and the marketing experts of department stores and supermarket chains can glibly defend their heavy use of packaging when pressed to do so. But it is a case of too little a public relations effort done too late. The public no longer believes implicitly what they are being told by the merchandiser. Few in government know where in the distribution of consumer goods there may be excessive packaging with large energy conservation potential. Thus government so far was unable to clarify the situation.

The purpose of this particular study is to act as a planning guide, one that can suggest where the greatest opportunities for reducing excessive or unnecessary packaging may exist. Some attention was also given to inadequate or underpackaging involving product loss or damage during distribution. But the primary emphasis is on resource and energy conservation opportunities.

EXECUTIVE SUMMARY

It was recognized from the outset of this study that the Terms of Reference were too broad and the time available too short to accurately quantify the potential for energy conservation in the Canadian Consumer Products Packaging sector of the economy. Thus in responding to the Terms of Reference we endeavoured to satisfy the primary purpose of the study requirements. That is, the Terms of Reference item specifying that the study was to "serve as a foundation, state of the art, planning document for the newly formed Federal Interdepartmental Packaging Conservation Committee." The Committee Liaison Officer agreed with this emphasis as did the other Committee Members.

MARKET ANALYSIS

Having reached an understanding of the proper emphasis to place on our research efforts, we next undertook to define the packaging industries of Canada. Using the Standard Industrial Classification of Statistics Canada we identified the Canadian industries manufacturing packaging materials and those consumer products manufacturers who are purchasers of packaging materials.

From this initial work we were able to complete an analysis of the market demand of packaging and/or of packaged consumer goods. At this point we discovered that seven consumer product manufacturing industries were responsible for 86% of the packaging of Canadian manufactured consumer products. Of those seven, the food and beverages alone accounted for 57% of the value of packaging as a percentage of the total packaging consumed by Canadian manufacturing industries. And for those latter industries, 7.4% of the product shipments was the value of consumer product packages or containers. We also determined that six categories of

packaging (i.e. corrugated boxes, metal cans, folding and set-up boxes, glass bottles, transparent film and bags, paper) accounted for 71½% of the value of all packages used by Canadian consumer product manufacturers. As would be expected, food and beverage manufacturers in Canada consumed well over half of all these types of packages or containers used in Canadian manufacturing industries.

It was for these reasons that early on in the study we singled out the Canadian food and beverage industries as an important area of examination.

PACKAGING GUIDELINES

While the work on the market analysis was progressing, we reviewed findings with respect to solid waste management. From many references we concluded that whether in the United States or Canada, municipal solid waste composition tends to be as follows:

TABLE 1

MUNICIPAL SOLID WASTE COMPOSITION - as generated

Material	U.S., 1977 Percentage (MSW)	Can., 1977 Percentage (MSW)
sources	(3)	(4)
Paper	30%	36½%
Yard Wastes (incl. Fines & Rubble)	20%	8½%
Food Wastes (Putrescibles)	17%	28%
Glass	10%	7%
Metals	10%	6½%
(Ferrous)	(8½%)	(6%)
(Aluminum)	(1%)	(½%)
(Other non-Ferrous)	(½%(	----
Rubber, leather, textiles	5%	4
Plastics	4%	5
Wood	3%	4
Miscellaneous inorganics	1%	½%
Total	100%	100%

Source (3) National Center For Resource Recovery, Inc.

Source (4) Bird and Hale Ltd.

Of the paper waste, about half is wrapping material attributable to some three thousand to five thousand product types. As for glass, about half of it comes from the beverage industries (soft drinks, breweries, wineries, and distilleries). Not quite half of the glass derives from food products such as: jam, jelly, peanut butter, ketchup, pickles, mayonnaise, etc. Probably no more than twelve to fifteen consumer product classes are represented by this quantity of glass containers. As for metals, about three quarters of that portion of municipal solid wastes comes from food cans. The aluminum is almost entirely foil wrapping or closures from the food and beverage industries. Of the plastics, it is almost entirely made up of containers and packaging materials, both consumer food and non-food products being the majority and represented almost equally.

Again it was found that the food and beverage industries were major contributors to municipal solid waste. Hence packaging guidelines to minimize packaging wastes became another important area of emphasis for the study.

ENGINEERING ANALYSIS

From the work done by the Ontario Research Foundation on packaging materials, we had some preliminary information to go on. Generally, from an energy consumption point of view, glass is a bad actor as a packaging material. Even recycling bottles as broken glass (cullet) saves only 5% on energy consumption. If glass bottles as for milk are returned and refilled, they tend to make only 20 trips on average. Although glass from an hygienic point of view is preferred, plastic milk containers are much superior as regards energy consumption. This is because plastic milk containers on the average will make 200 trips.

Plastic containers are good if reused. They can also have energy recovered after disposal as refuse derived

fuel (RDF). Even without reuse or waste energy being extracted from plastic containers they tend still to be better than many other packaging materials from an energy content point of view.

For beer, another product of the food and beverage industry, it was found that folding and set up boxes had a higher energy content for the same quantity of containers than did those made of plastic materials. In part this was a comparison of apples and oranges because the polyurethane container in one case was designed as a retripper (100 trips) as opposed to a single trip corrugated carton. But even with a retripper carton, survival rates were so low (3 trips) that the energy content in the package was still higher than for the plastic one. Similarly, plastic bags and pouches were found to be better than plastic coated paperboard containers for milk. In addition the secondary uses of the plastic pouches and the mother bag provided additional energy savings.

Another preliminary finding was that plastic film (pouch) containers were far superior to comparable molded plastic or glass containers. This is primarily because of the very light weight of plastic film (30 grams) as compared to the rigid plastic (200 grams) or glass (2,000 grams) containers. Not only is initial manufacturing energy less, but subsequent transportation energy savings throughout the physical distribution system became important factors in the analysis.

Once again it looked as though shifting from one type of package to another within the food and beverage industry could lead to significant energy savings potential. However, some of the consumer chemical and chemical products manufacturing industries could also have interesting energy savings potential too.

CANADIAN ENERGY CONSUMPTION

For some time now energy conservation in Canada has concentrated on a rather simplistic source and destination analysis. With the ever increasing price of petroleum, efforts were increased to cause consumers to switch from imported oil to domestic energy sources. Energy conservation efforts similarly focused on what were considered to be undesirable uses of liquid hydrocarbon fuels. Simultaneously, energy conservation efforts focused on the general public. This was because the residential sector was found to consume about one third of Canadian energy demand with some 80% of this demand for space heating and transportation alone. (See Table 4)

TABLE 2 - DIRECT ENERGY CONSUMPTION IN CANADA [5]

by source - 1976

Direct Energy Source	Energy Consumption
Coal and Coke	4%
Electricity	16
Natural Gas	26
Liquid Petroleum Fuels	54
Total = 6.1×10^{15} BTU =	100%

Source: Statistics Canada

TABLE 3 - DIRECT ENERGY CONSUMPTION IN CANADA

by consuming sector - 1976

Consuming Sector	Energy Consumption
Energy Supply Industries	10%
Commercial	13
Domestic *	17
Transportation *	26
Industrial	29
Farm (Production)	3
Other	2
Total = 6.1×10^{15} BTU =	100%

Source: Statistics Canada

* NOTE:		
	Domestic	17%
	Transportation	13
	Total Residential Sector	30% (CCA. est.)

TABLE 4 - RESIDENTIAL SECTOR, ENERGY CONSERVATION POTENTIAL (6)

Sector Energy Consumption Categories	Residential Sector Energy Consumption
Space Heating	48%
Transportation	32
Water Heating	12
Appliances	5
Lighting	3
Total Sector Energy Consumption	100%

Consumer and Corporate Affairs Canada developed a matrix framework to show Canada's potential residential energy saving. (See Table 5). This basic 2 x 5 matrix has an arithmetic sum of 49 elements. Just 18 of these product and consumer focii can be directed at 80% of the residential energy sector. Thus the payoff can be very large from a small number of householder energy conservation policy initiatives.

TABLE 5 - CANADA'S POTENTIAL RESIDENTIAL ENERGY SAVINGS MATRIX (6)
(Showing number of elements of matrix)

Sector Category	Product Focus (Install/Upgrade)	Consumer Focus (Behaviour)
Space Heating	4	3
Transportation	5	6
Water Heating	4	5
Appliances	9	3
Lighting	4	6

This level of knowledge of the residential energy saving potential is the result of considerable energy research, study and analysis. By comparison, much less is known about packaging energy conservation. Consumer product packaging seems a far more complex and diffused energy consuming sector. It is also one where any packaging or product changes are likely to be inherently linked to consumer life style changes, quality of life and standard of living. And though packaging energy may be small as a percentage (3%) of total energy consumption the products associated with the packaging are a large portion (25%) of GNP. A good example of this is food system energy consumption and its related packaging.

The traditional form of energy accounting analysis has obscured an important fact. About 15% of all Canadian energy is consumed in the Canadian food systems - from the field through to the household consumer, including the 1,000 pounds per person of municipal solid wastes of which about one third is made up of consumer products packaging materials.

One reference[6] implies that this figure could be as high as 25% of Canadian energy consumption. But this figure is considered incorrect by experts.

TABLE 6 - DIRECT AND INDIRECT ENERGY USE [6]
CANADIAN FOOD SYSTEM - 1976

Consuming Sector	Energy Consumption
Farm Production	18%
Processing and Packaging	20
Transportation and Distribution	32
Home Preparation	30
	100%

Source: Agriculture Canada

Obviously food system energy should become a major focus for energy conservation studies. In these systems packaging averages 7½% of the cost of food processing and another 1% at the physical distribution level. Another significant energy consumption factor is food industry transportation. These energy costs are considered 8% of food industry sales. Potentially they can be greatly affected by packaging and physical distribution costs. Losses of food in the system due to poor packaging and handling methods are additional.

For all these reasons, our study has concentrated on packaging in the food and beverage industries of Canada.

FOOD AND BEVERAGE PACKAGING

Once made, the first-stage decision to concentrate on the Canadian food and beverage industry led to a more detailed examination. Regardless of which approach was used, we noted the complexity of the physical distribution system and the large variety of consumer products and packages. The paucity of information to determine energy conservation potential at a detailed level of examination was evident repeatedly.

As a planning guide, we constructed a matrix for Canada's potential food and beverage packaging energy savings. This basic matrix of Table 7 was 4x8, with an arithmetic sum of 200 elements. Even then, it represented only a first approach to the problem. Comparison of the summary matrix of Table 7 with the detailed residential energy savings matrix of Table 5 further stresses the need for more study of packaging systems and their energy consumption aspects.

TABLE 7

CANADA'S POTENTIAL FOOD AND BEVERAGE PACKAGING ENERGY SAVINGS MATRIX

(Preliminary Estimate of Number of Elements Shown)

Sector Category	Product Focus	Food & Bev. Focus	Category Focus	Package Focus
Farm	6	7	5	4
Processing	10	11	8	19
Packaging	7	7	6	8
Transportation	8	5	4	6
Wholesaler	4	3	4	4
Retailing	7	8	8	7
Consumer	5	5	7	2
Disposal	4	4	4	3

CANADIAN PACKAGING ENERGY

The engineering analysis concentrated on the energy content of packaging materials. A well-developed methodology existed for this work. Much research had already been done in Canada. By examination of statistics for municipal solid waste, we determined the amount of packaging at the end of the system, by package type. Packaging system energy requirements were applied to the total amounts of packaging waste. It was calculated that, in 1977, the total system energy associated with 4.374×10^6 tons of packaging waste was 0.176×10^{15} BTU's (quads).

Taking total 1976 Canadian energy demand as 6.1 quads, packaging consumed 2.75% of the total energy used in Canada.

The market analysis of purchases of packaging by Canadian manufacturers was extended. We obtained costs of packaging type by weight. Energy content by weight was available also by package type. This method allowed determination of packaging consumed at the manufacturing level in Canada. For 1977, this was 0.123×10^{15} BTU's. Estimates of packaging at the wholesale and retail level were obtained. They were in the range of 25% to 30% of manufacturers packaging costs. The highest estimate of 0.16 quads for 1977 Canadian packaging energy was within 10% of the previously computed amount. (176 quads) We felt this was reasonable confirmation of the higher figure which we considered more accurate, and possibly a conservative estimate.

POTENTIAL PACKAGING ENERGY SAVING

To determine potential packaging energy savings, we explored a number of approaches. We determined that the Canadian Input-Output model could be a useful research tool. But time, nor budget did not allow such work to be undertaken.

We extended the waste management considerations regarding packaging. Since packaging amounts to as much as 40% of all municipal solid waste, we sought guidelines to minimize this particular waste element. The one adopted in Britain (INCPEN) appeared a good starting point.

We applied these waste management guidelines to the food and beverage industry. We found that every possible present waste management improvement program could be applied to the selected beverages: carbonated soft drinks, beer, milk, fruit juice, wines and spirits. These products account for over 40% of the packaging consumed by Canadian food and beverage manufacturers. Additionally, relatively little is known about other consumer product packages. We, therefore, concentrated our study on these beverage products and their packaging alternatives.

Our analysis revealed that package or material substitutions are the best means of achieving energy saving packaging improvements. Plastic materials can save as much as 20% of packaging systems energy over competitive packages. Going to larger containers can save 25% to 30% of packaging system energy.

Moving to refillable plastic containers for beverages can lead to up to 65% energy savings. This finding may not hold true for all package types, or for other consumer products.

Optimizing waste management options (i.e. recycling all glass, metal and plastic, and burning all wood paper and cardboard could theoretically result in a 61% savings in all energy associated with packaging. If all the waste is burned for energy recovery only 42% energy saving would result. These upper limits are not achievable. Furthermore, at this time, we can only infer by example what may be possible.

We examined the question of "necessary packaging". Our best estimate is that there is, in fact, little truly unnecessary packaging in our present physical distribution system. Some extreme examples of unnecessary packaging can be found. A "worst case" may amount to as much as 40% over-packaging by weight. In general, over-packaging may represent about a 3% to 5% packaging energy saving potential. But, we also found numerous examples of insufficient packaging in the physical distribution system. One estimate of the cost of insufficient packaging was 2% of packaging costs. Another estimate was ½% of the wholesale price.

We, therefore, made a first estimate of the energy savings attributable to truly non-functional or unnecessary packaging. We concluded it was, at most, 3% of packaging energy.

Our work on physical distribution made particular reference to foods and beverages. Here, we found that packaging of consumer products could markedly affect total energy use in Canada. For example, we found that certain foods were associated with very high energy contents. Total food system energy content of Canadian food and beverages average about 8 times their packaging energy content. But, certain technological

developments hold the promise of drastically reducing total food energy requirements. We have been unable to estimate this potential energy saving. It could be very large. It will undoubtedly be associated with other energy conservation initiatives too. But, food processing and packaging innovations may be the required catalyst.

PLANNING HORIZON

Our review of consumer product and packaging trends indicated much is being done to affect energy conservation. Societal factors too are encouraging these trends. But, the rate of change has been slow. It promises to continue slowly, but at an accelerating rate.

We identified a number of impediments to change. An important one is the reluctance of large firms in the Canadian consumer products industry to introduce energy savings packaging more quickly. Time spans of 10 to 15 years are common for the widespread introduction of a packaging innovation. Thus, the shorter-term trends are reasonably identifiable. Longer-term ones are more difficult to predict.

We postulate that Government dissemination of information and assisting key change agents make system innovations could accelerate energy conservation innovations. More study of this hypothesis is essential.

We suggest that an increased packaging energy conservation planning effort is required. Research should be aimed at the Canadian food system, with special reference to the food processing and beverage industries. Concurrently, further planning studies of the Canadian packaging and consumer product distribution systems are essential.

In the short term of two years, we foresee no major packaging energy conservation results. Over the longer term of 10 years, much improvement is feasible. One advantage is the large corporate size and significant concentration in certain Canadian industries. For example, the Royal Commission on Corporate Concentration showed substantial

dominance of the food and beverage industries and of retailing by a few large firms. (See Tables 8 and 9). This support could lead the way on packaging energy conservation initiatives.

TABLE 8

100 LARGEST NON-FINANCIAL CANADIAN COMPANIES (7)

Ranked by Sales, 1975/76

Type of Company	Number of Firms in Top 100
Food Products	6
Food Retailers	7
Department Stores	10
Packaging Materials (pulp & paper, chemicals, aluminum)	10
Distilleries	2
Breweries	2
Tobacco	1

TABLE 9

CANADIAN CONSUMER PRODUCT AND PACKAGING MANUFACTURERS WITH HIGH FOUR FIRM CONCENTRATIONS (7)

Tobacco Products
Glass Manufacturing
Breweries
Distilleries
Meat Processors
Dairy Products

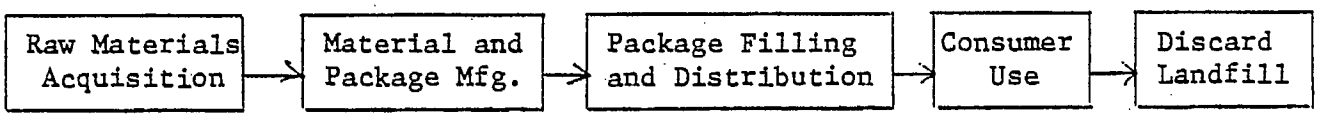
Planning studies are required to identify government policies to win industry and consumer support for packaging energy conservation. We believe an initial effort costing as much as $3 million is required. Resulting consumer product packaging energy savings could be enormous. They could amount to over $100 million annually after 1985.

PACKAGING MATERIALS ENERGY

INTRODUCTION

A methodology for the computation of energy contents of materials is well-established and, while different studies report slightly different values, these differences are usually explainable by difference in assumptions, or in what is included in the energy accounting.

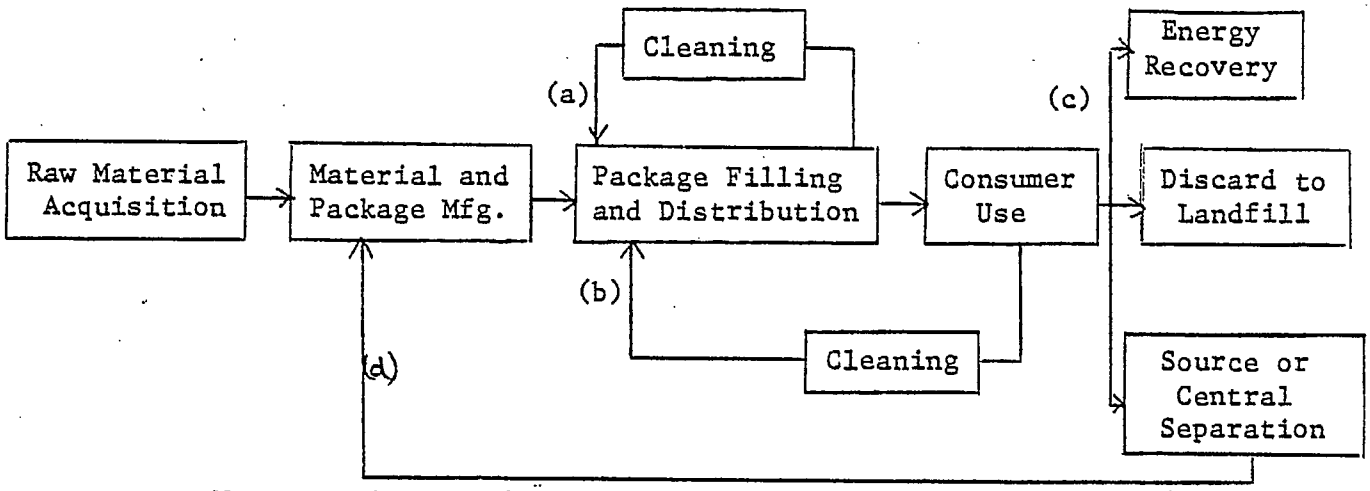
Arriving at gross energy content figures for packaging materials used in Canada would be relatively simple if the flow sheets for these materials were as follows:



This is a very simple "ashes to ashes, dust to dust" once-through system which requires energy inputs at each stage. These energy inputs can be quantified per ton of containers, and, knowing the total tons of containers of a given type used in Canada, can form the basis for a calculation of total energy used by this packaging form.

There are unfortunately complications added to this basic flow sheet. Recycling loops and either/or options are complicated to address even for a single packaging type delivering a single product. Including these in a gross assessment of the Canadian packaging industry may be impossible. Nevertheless, packaging alternatives can have substantial effects on process energy inputs (e.g. retortable pouch, packaging on an aseptic processing line, etc.)

A very simple example of the kind of options open is shown below, using the same basic flow sheet as before.



Note:- Arrows imply a transportation step.

(a) is the reuse of secondary or tertiary packaging, crates, etc., within the distribution sector. This is perhaps the easiest of all the recycle options to deal with and quantify. Control remains within the packing/wholesale/retail sectors and relatively reliable data on trippage and loss rates are available.

(b) is the reuse of primary containers, bottles, plastic milk jugs, etc. This is a much more complex loop, as the entire population are potential participants in this loop. Trippage rates for soft drink bottles are not well-defined, except for a few specialized instances, such as for domestic beer or for specialty outlets for soft drinks such as "Pop Shoppes". Return rates of other reusable containers vary considerably with a number of societal factors. Rates are quite different in urban, suburban, and rural locations.

(c) is a disposal option for discarded containers, where any contained energy value would be realized through incineration, gasification, or pyrolysis. This option would, of course, only be applicable to those packages which are combustible (e.g. plastic, paper, or wood). Energy recovery options may result in some materials recovery of non-combustibles (e.g. glass or metal components).

(d) is the materials recycling option (not to be confused with (a) and (b) which is container reuse). This may be achieved either through consumers separating materials at home for separate collection (source separation) or through central processing plants designed to separate the components

of the refuse stream. Just as the energy recovery option may result in some materials recovery, so the materials recovery option may result in energy recovery from an unseparable combustible residue.

So, to develop an accurate picture of energy use of packaging materials in Canada, we must be able to quantify trippage rates for reusable containers and the proportion of discarded containers following each of the disposal option routes.

The reuse of secondary materials generally results in lower energy costs for materials production, per unit of product handled. The computed energy costs for packaging material production must be proportionately reduced.

Another question to be addressed in carrying out an energy analysis is what is to be counted as energy? Is a tree an energy source or is it merely a raw material for cardboard, wood, and paper packaging material? Is the oil and natural gas locked up in polyethylene products counted as energy or a raw material? The answers to these kinds of questions can only be answered when the purpose of the analysis is known. In most instances, energy analyses are being conducted because we are running out of fossil fuel energy sources, natural gas, oil, and, to a lesser extent, coal. We would, therefore, count any actions which deplete the reserves of these commodities as using energy. In the questions phrased above, therefore, trees should not be counted as an energy source, while the oil and gas locked up in polyethylene should be counted.

As we progress into the 1990's, trees may become more and more a raw material for energy production, and so, at that time, their use to produce packaging should result in an "energy charge" equivalent to the energy content of the resource utilized.

When analysing electrical power consumption we always consider power being produced by thermal generation from fossil fuels. The argument for this is based upon the general purpose behind any energy analysis activity.

The purpose normally is to produce information which forms the basis for implementing changes in procedures, materials use, or whatever saves energy. Thus, the analyst is dealing with marginal reductions in energy utilization. Any marginal reduction in electrical power demand will result in cut backs in thermal electric generating stations. Since nuclear and hydro-electric stations normally form the base load of any generating system, they are less likely to be affected by marginal energy savings. It is, therefore, appropriate to consider electrical power in terms of fossil fuel equivalent. This is generally considered the equivalent of 10,000 to 12,000 BTU/kwh.

MATERIALS ENERGY CONTENT

Table 1, Appendix 1, summarizes the energy content of materials commonly used in packaging. The figures are based on earlier ORF studies, which agree fairly well with other published values. There is some mixing of values in that some (e.g. glass and LDPE film) include forming of the container, while others do not. Glass containers are formed directly from the molten glass, and so a value for one ton of solid glass would be rather meaningless.

The figures in brackets all take into account that wood could be regarded as an energy source. It takes approximately two tons of wood to produce one ton of cardboard or paper, and it is estimated that lumber production is also only about 50% efficient. Much of the one ton of wood not actually ending up in the cardboard is used as an internal source of energy. The 20-25 million BTU/ton for paper product production relates strictly to purchased energy. The actual total energy required (including purchased and internal energy sources from wood residue) to produce a ton of paper product is closer to 40 million BTU/ton. A further 18 million BTU/ton is contained in the paper or wood product if trees are regarded as an energy source.

ENERGY OTHER THAN MATERIAL IN PACKAGING

The preceding section outlined the energy content of materials commonly used in packaging in Canada. Thus summarized all of the energy going into materials up to the point where they are shipped from the primary producer (e.g. tin plate, HDPE plastic resin, aluminum foil, etc.). This included all energy factors, including raw materials acquisition, raw materials transportation, processing energy to form the material, energy contained in miscellaneous chemicals used in the processing, and energy associated with capital. These figures are fairly reliable and can be applied to any individual package type which uses them. To go the next step to determine the total energy associated with packaging is much more complex, and really to do this accurately, the individual package and its contents should be examined. Since this is a very general study of total energy involved in all packaging used in Canada, it would not be feasible to go through each and every product and its package. As a result of previous ORF studies, we can estimate the proportion of the total energy associated with packaging material (e.g. tin plated steel, corrugated board, etc.) from raw material manufacture until the package is finally discarded in the dump. The "other" energy not actually computed in the material energy costs will include:

- transportation costs to the place where the package is made
- filling and sealing of the package
- transportation to the retailer
- return transportation and washing in the case of returnables
- transportation to final disposal
- disposal.

Estimates of the proportion of energy associated with the material for various package types are shown in Table 2, Appendix 1. The balance is the "other" energy. For example for non-refillable glass bottles it is estimated that 100%-81% or 19% of the total energy associated with non-refillable glass bottles is consumed in the non-materials uses outlined above. For refillable bottles making 20 trips, this proportion is increased to 74%. This is due to the large amounts of energy associated with the washing of the bottles each time they are filled. By the time the refillable ends up in the dump after twenty trips, fourteen times as much energy has been expended on that package as compared to the energy required to initially make the bottle.

This proportioning is useful to approximately compute the total energy associated with packaging. If the amount of material discarded in a landfill-site is known. This must, of necessity, be an approximation which is rather better for one use packages than for those which are reused.

Table 3, Appendix 1, combines the figures from Table 1 and 2 to determine the total energy which has been discarded in a landfill-site associated with the various package types. This figure then includes all energy associated with transportation, filling, sealing, etc. and, in the case of reusable packages, energy required to return, wash, and reuse the package.

PACKAGING MATERIAL IN THE WASTE STREAM

One approach to determining the total energy associated with packaging is to use the energy figures developed in Table 3, Appendix 1, combined with a breakdown of packaging material in the solid waste stream.

Tables 4 and 5, Appendix 1, give breakdowns for materials entering the solid waste stream in the U.S. in 1975. Table 5 specifically indicates the material breakdown for

packaging material. These figures are used in Table 6 to compute total energy associated with these materials. For categories such as glass and plastics, guess-estimates have been used to arrive at a composite energy figure incorporating all the different package types making up that category.

The total energy associated with packaging being discarded in the United States in 1975 is estimated to be 1.6 quads (10^{15} BTU). Taking a population ratio of 0.107 for Canada, compared to the United States, would suggest a Canadian Energy Content of 0.17 quads associated with 4.46×10^6 tons of packaging wastes.

A recent Canadian study[4] indicated that, for 1977, 11.1×10^6 tons of waste were generated in Canada. Table 7, Appendix 1, is reproduced from that study showing the breakdown of material commodities. These are not specifically separated into packaging and non-packaging components, however, sufficient information is given to essentially derive this division.

Table 8 extracts from Table 7 the quantities of packaging waste for Canada and develops the quantity of energy associated with that waste. The total energy associated with packaging, in 1977, is then estimated as 0.176 quads associated with 4.374×10^6 tons of packaging waste. The two methods of calculating total energy associated with packaging in Canada give remarkably similar results.

Total Canadian Energy demand for 1976 was estimated to be 6.1 quads.[6] Thus, packaging consumes about 2.88% of the total energy used in Canada. While this may seem a rather small percentage, it is equivalent to the complete output from an 80,000 barrel/day oil refinery, and the value of the energy at $4/million BTU is $704 million annually.

Packaging is a highly visible product which has a very obviously short, useful life. The importance of conservation in this highly visible area may be more important for public encouragement to conserve than is indicated by the influence on total Canadian energy demand.

Comparison of Tables 6 and 8, Appendix 1, shows that the Canadian and U.S. data show rather different proportions of the various waste components. These are separated out and shown in Table 9. The most noteworthy differences are in the glass and plastics categories. Aluminum is expected to be lower in Canada because of the non-use of aluminum beer or beverage containers in Canada. While these differences do exist, the order of energy usage is more or less the same for both sets of statistics, (see Table 9):

TABLE 9

COMPARISON OF MATERIALS CATEGORIES IN U.S. AND CANADIAN PACKAGING WASTE

Packaging Material	U.S.A., 1975 % of Total Packaging Wastes	Canada, 1977 % of Total Packaging Wastes
Paper Products	45.8%	55.5%
Glass	29.0	14.9
Ferrous Metal	12.5	8.9
Aluminum	1.7	1.3
Plastics & Textiles	6.7	11.8
Wood	4.3	7.6
	100.0%	100.0%

The level of energy usage is quite significant in all categories, except wood, so that all other categories should be examined for energy savings potential. (See Table 8, Appendix 1) One obvious possibility is in the reclamation of materials from the waste stream and/or recovery of energy through the use of waste as a fuel. This will be examined in the following section. Other savings potentials are more complex and must be examined in a much more detailed manner.

In this section we have been concerned only with packaging materials entering the waste stream in terms of gross statistics. The energy figures are solely associated with

packaging. Later in this report, the importance of considering a total systems approach to delivery of goods is discussed. For example, from a purely packaging point-of-view, a plastic bag for frozen peas might be a less energy intensive package than a can for the peas. This does not take into consideration differences in energy for preparation and storage of the peas. This is particularly important when considering new packaging concepts which are being introduced, such as the retortable pouch.

POTENTIAL ENERGY SAVINGS THROUGH RESOURCE OF ENERGY RECOVERY

If, rather than land-filling the packaging waste, all of this waste could be separated and recycled to make new material, some energy savings could be effected. Savings are shown in Table 10, Appendix 1. They total 66.4×10^{12} BTU. This is about 38% of the total energy associated with the packaging waste. It must be stressed that this is potential energy, and this may, in fact, not be realizable. It probably will be impossible to recover all of these materials from the waste stream.

Table 11, Appendix 1, shows the potential savings realization if all the waste were to be converted to or used directly as a fuel. This totals 74.2×10^{12} BTU/year, or 42% of the overall energy associated with packaging waste.

In Table 12, Appendix 1, we have considered each package type and determined which would give the greatest energy savings, recycling or using the material as a fuel. For glass, ferrous metal, aluminum and plastics recycling is more energy effective. For paper and wood, use as a fuel is preferred. By adding the six preferred energy savings alternatives, an optimal potential saving of 107.2×10^{12} BTU/year may be realized.

In practice, this total is unlikely to be realized. For example, separation of plastic from paper is practically impossible. The total is solely a measure of the ultimate theoretical savings which might be attained. It will be uneconomic in many areas, particularly in small communities or in rural locations to establish either recycling or energy recovery systems for waste that otherwise goes to landfill sites. Careful study will be required to determine what proportion of this potential saving could be economically realized through good waste management practices.

PACKAGING ENERGY CONTENT

In order to compare packaging alternatives, a specific delivery system has to be chosen for examination. The mandate of this study was to look at all packaging in Canada. Within the time and budget constraints available for this project, it was obviously not possible to examine every product delivered. We chose two systems to examine. They represent about 40% of packaging consumed by food and beverage manufacturers. Also, these systems have been analysed previously and so reliable data is available. They all illustrate possible future trends in packaging, and the importance of the systems approach to include the examination of the influence of packaging on other processing steps.

The two packaging systems which we will consider are:

1. Milk.
2. Beverages: beer, soft drinks, wine and spirits.

PACKAGING SYSTEMS ENERGY ANALYSIS

The methodology for energy analysis is well-established, and a number of studies were completed during the period 1970-1976. Methodology was reviewed in the study undertaken in 1976 by Ontario Research Foundation, "Energy Analysis of Resource Recovery Options", (report prepared for the Ministries of Energy and Environment, April, 1976). The reader who is interested in details on the methodology used for energy analysis is referred to that report for further information.

The following list summarizes the steps recommended to carry out an energy analysis. The procedure includes both direct process analysis for direct energy inputs and input-output analysis for energy requirements associated with plant capital costs.

1. Determine the Objective of the Study

This is important as it will influence decisions such as whether trees are included as an energy resource depletion, or only fossil fuels are considered energy sources. (See text pages 19 and 20) In most cases, it is purchased fossil fuel energy which is of interest. The objective of the study is to try to find ways of reducing consumption of these non-renewable resources.

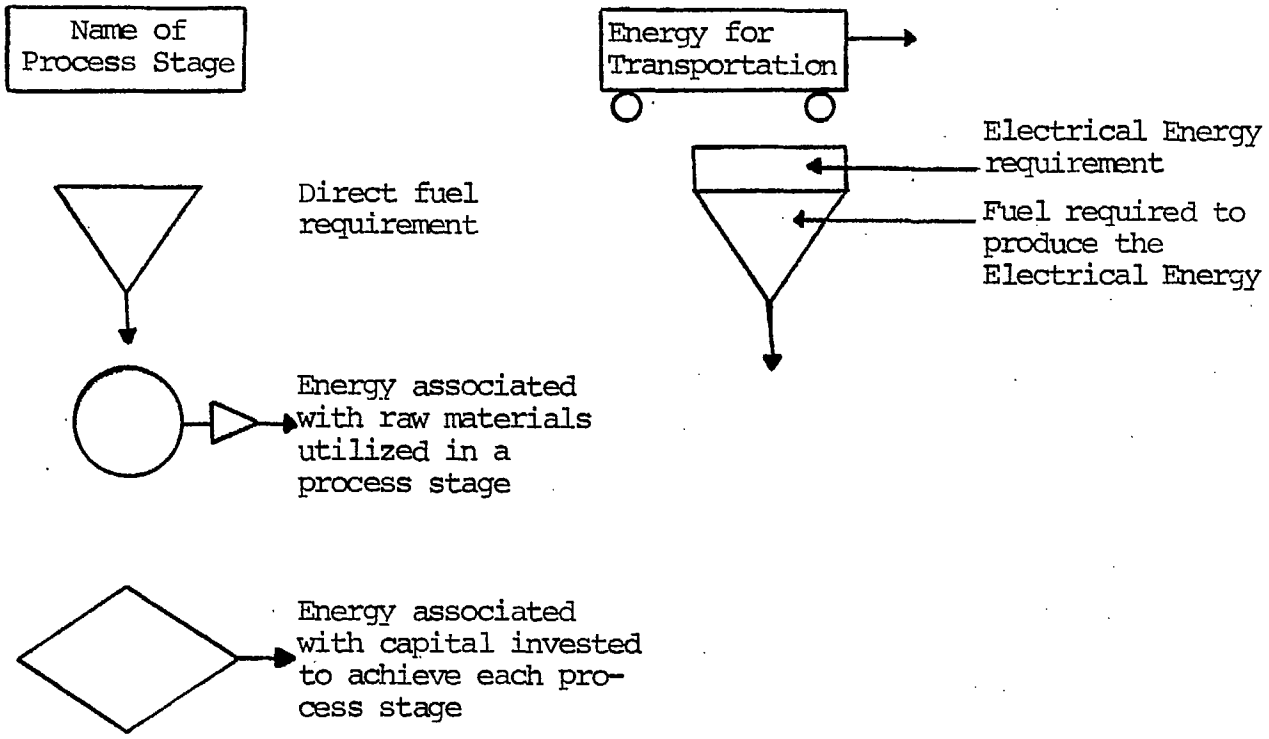
2. Draw a Flowsheet of the production, consumption, and final disposal of the item of interest

The flowsheet will include a mass balance to deliver a chosen weight of material or, in the case of packaging, may be based on the delivery of a certain quantity of the milk, beer, etc.

3. Add energy requirement symbols to the flowsheet

As above, all energy requirements are normalized to one unit of production.

Energy requirement symbols normally used are as follows:



4. Choose a System Boundary

A system boundary must be chosen to determine what is counted and what isn't. Is energy expended outside Canada to be considered in a Canadian Energy Analysis? Are losses in energy through oil production and refining to be considered? This decision is linked to the definition of the objective of the study.

In municipal solid waste, for example, there is a complex system boundary. Geographic differences are significant (e.g. urban, suburban, rural). Exports of packaged goods are not included and imports and included. Packaging disposed of other than municipally is a factor.

5. Obtain the Data Required to Complete the Analysis

The Energy Analyses that follow are based on the following assumptions.

Objectives: To determine the quantities of non-renewable fossil fuel energy resources which are being used by different packaging types.

System Boundary: The system boundary chosen is not geographic and has some anomalies, but is felt to be practically useful.

- Energy use counted no matter where in the world it is expended.
- No account taken of energy inefficiencies in producing coal, natural gas, and petroleum products (i.e. we start from a delivered BTU of coal, oil or natural gas where it is expended).
- Anomolous to the above inefficiency is producing electrical energy from coal or oil or gas. A conversion rate of 10,500 BTU/kwh electrical is utilized.

Energy for Transportation: This is taken as:

Trucks	2,800 BTU/ton mile
Rail or Barge	700 BTU/ton mile

These are approximate figures, but as will be seen, transportation is normally a rather minor component of the total energy expenditures. We can thus use this general figure without fear of unduly invalidating the final result.

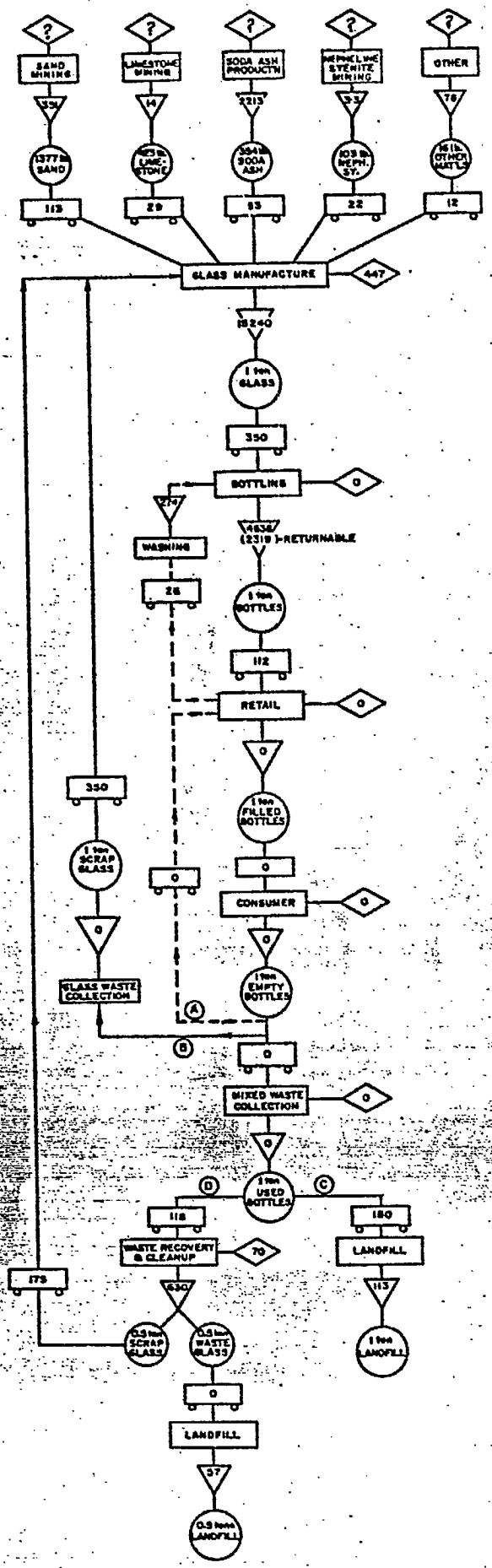
Energy for Capital Investment: From input/output analysis for general manufacturing and primary material production, an average figure of 26,600 BTU/1976$ will be taken as the energy associated with capital investment. Again, this is a very approximate figure, but this does at least estimate the energy which had to be expended to erect the packaging plant. The energy is amortized over the predicted life of the plant and the number of units produced per year to assign an energy cost to each product unit.

Figures A and B are included hereafter. They are typical flowsheets taken from the ORF Report "Energy Analysis of Resource Recovery Options".[20] They are examples of energy analysis flowsheets for the production of newspaper and for non-returnable glass bottles.

MILK PACKAGING

Milk packaging is available in several different sizes, therefore, to compare the energy utilized by the packages, a fixed amount of delivered milk is chosen, and comparisons made on this basis. The size of isoquant used in previous studies was 3,000 quarts delivered (i.e. Mid-West Research Institute and Maddox).

FIGURE. A ENERGY ANALYSIS - MOTO
(BASED ON 1 ton GLASS)



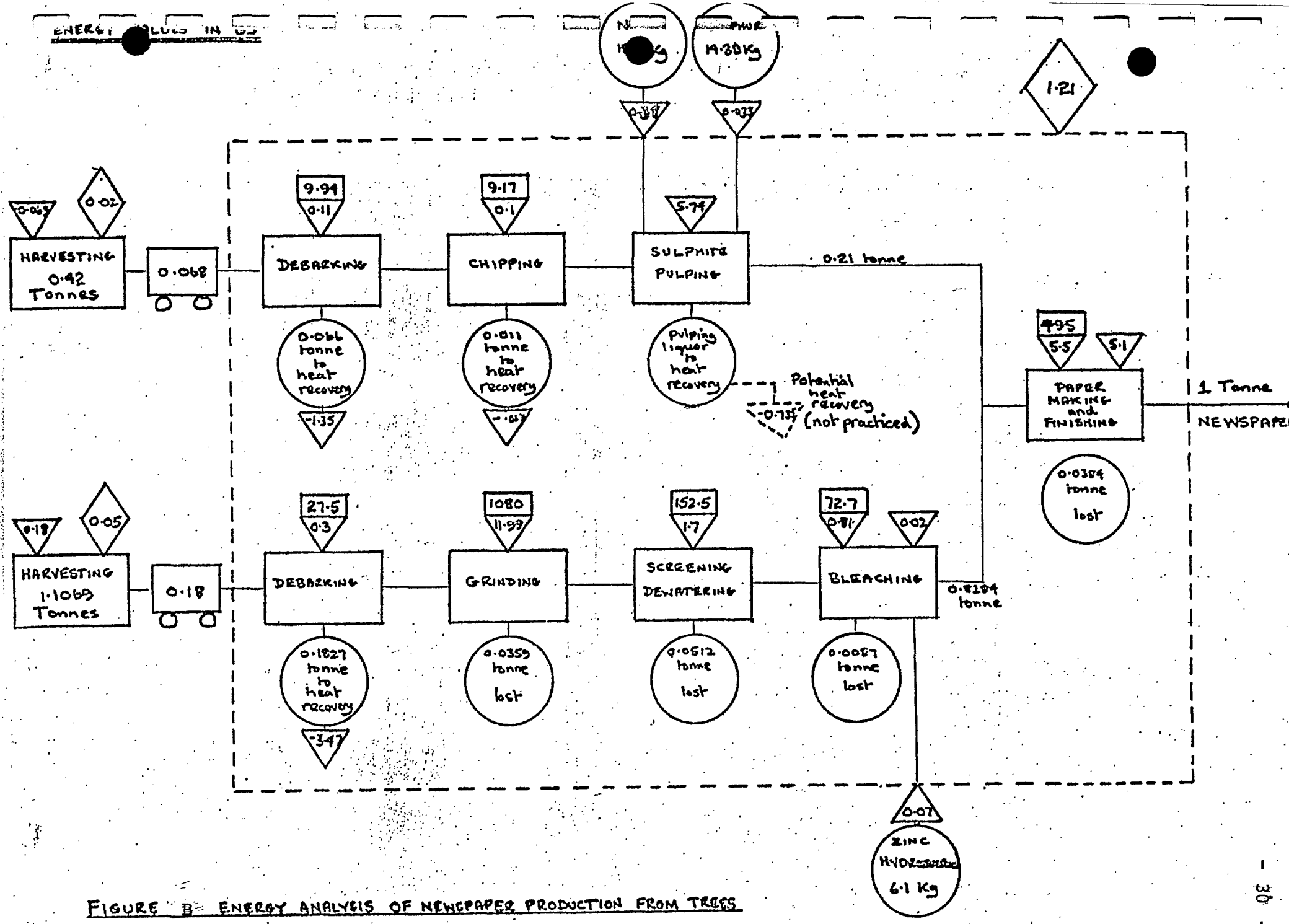


FIGURE B ENERGY ANALYSIS OF NEWSPAPER PRODUCTION FROM TREES

There are three data sources on milk packaging which will be used here:

1. Bousted, I., Open University, "Resource Implications with Particular Reference to Energy Requirements for Glass and Plastic Milk Bottles", Journal of the Society of Dairy Technology, 27 (3), July 1974, pp. 159-165.

2. Brown, C.K. and Laughlin, R.G.W., Ontario Research Foundation, "Energy Analysis of Milk Packaging", Report ORF ECS-72-02 to the Waste Management Advisory Board, February 5, 1976.

3. Waste Management Advisory Board Secretariat, "Report to the W.M.A.B. on Milk Packaging in Ontario", Energy Supplement, June 1977.

Total energy requirements to deliver 3,000 quarts of milk using the most popular forms of milk packaging used in Canada are reproduced as Table 1, Appendix 2. The data were abstracted from the three reports cited above. Also included are some figures on polyethylene throwaway bottles not presently used in Canada. For the most part, W.M.A.B. figures are based on the ORF energy figures developed in their 1976 report. The figures ascribed to W.M.A.B. (R) were developed by W.M.A.B. in response to criticisms of the ORF data by the producers of throwaway containers. The W.M.A.B. figures were developed to be favourable to the throwaways. A telephone survey was undertaken to determine how many people made secondary uses out of the throwaway packages. The proportion of materials re-used by the householder was then used to reduce the energy content of the throwaways proportionately. The trippage on the plastic jug was also reduced by W.M.A.B. Even with this bias in favour of the throwaway package, the refillable three-quart jug is still by far the least energy intensive package for the delivery of milk. (See Table 1, Appendix 2).

(2) = Mid-West Research Institute (3) = Maddox, K.P.

e.g.:	Returnable			Energy Required
	plastic	3 quart	100 trips	1.46×10^6 BTU
	glass	1 quart	100 trips	1.89×10^6 BTU
	Non-returnable			
	pouch	3 quart		2.5×10^6 BTU
	carton	2 quart		3.9×10^6 BTU

Table 2, Appendix 2, is extracted from the ORF report to show the breakdown of where the major energy expenditures occur. Also shown in this table are the energies recoverable if all the packaging waste is utilized for energy generation.

Table 3, Appendix 2, is extracted from the W.M.A.B. Report to show a comparison of both energy and waste quantities, weight and volume, for the various package types.

One interesting container dealt with by the Waste Management Advisory Board is the one-litre TetraBrik package. This is not presently used in Ontario for milk. The packaging material consists of cardboard, aluminum, and polyethylene:

17.2 grams cardboard
1.7 grams aluminum
5.5 grams polyethylene.

This type of container does not require refrigeration, and so, while the container itself is rather energy intensive, when a credit is taken for the lack of refrigeration required, this energy is substantially reduced from 5.8×10^6 to 2.7×10^6 BTU per isoquant. This illustrates the importance of a total systems approach to energy consumption in the packaging industry.

BEVERAGE PACKAGING

A large number of investigations were undertaken from 1972 to 1975 to compare energy consumption of different packaging materials for beer and carbonated soft drinks. The results of these studies are summarized in Table 4, Appendix 2. An isoquant of 3,000 quarts of delivered beverage is used, so that these energy values can be readily compared to those discussed in the section on milk packaging. The studies used a variety of methodologies and assumptions to derive the values presented here, and some of the studies reported are based on each other for data. Comparing the modified average values (ignoring highest and lowest value in each column) for the non-returnable containers with the 10-trip returnable glass gives ratios of:

Non-returnable Glass:	10-trip glass	2.75:1
Bi-metallic Can:	10-trip glass	2.43:1
Aluminum Can:	10-trip glass	3.7 :1
Plastic:	10-trip glass	2.72:1

In an unpublished study undertaken by ORF in 1976, Canadian data for beverage containers were studied with particular reference to the refillable bottle and the bi-metallic can. The results indicated that Canadian energy use on these two packaging types would fall within the range of values slightly higher than the quoted average and the bi-metallic can slightly lower.

Also, in that study, future packaging trends for beverages were considered. Developments considered included the following:

- Lighter weight, re-designed glass bottles.
- Drawn and ironed, all-steel cans.
- Necked-in bi-metallic can, allowing smaller diameter closures.
- Use of tin-free steel for cans.
- Ultra-violet curing of coatings on cans.
- Cemeted or welded side seams on cans.

Possible energy savings of 5-10% in refillable glass containers and of up to 45% in non-returnable metal containers were identified.

The energy cost for the carbonated beverage packaging sector is much greater than for milk. This is due, in large part, to the size of beverage containers considered here. Ten 12-ounce containers are required to deliver three quarts, compared to the one three-quart refillable jug, or the three-pouch disposable three-quart package. The carbonation requires a stronger container, with a more energy intensive cap. Some energy savings should be observed when considering larger containers for carbonated beverages. Haller* suggests that going from a 10-ounce to 32-ounce glass bottle would reduce energy from 42.0×10^6 to 32.0×10^6 BTU per 3,000 quarts. For a rigid plastic container, the reduction would be from 45.6×10^6 to 32×10^6 BTU per isoquant.

Table 5, Appendix 2, shows the energy required for the delivery of 3,000 quarts of wine or spirits in various containers. This information is all derived from a Stevenson Kellog Study undertaken for the Ontario Waste Management Advisory Board ("Wine and Spirts Packaging in Ontario", Stevenson & Kellogg Ltd. Report to W.M.A.B., October, 1976). These figures are, again, much higher than those developed for milk packaging. Table 6, Appendix 2, is reproduced from the Stevenson Kellog Report to show how the energy consumption is split for the various packages. (NOTE: This table considers an isoquant of 625 quarts, thus all values must be multiplied by 4.8 to compare them to an isoquant level of 3,000 quarts.)

* Ref. 4, Table A, Appendix 2.

PACKAGING MARKET ANALYSIS

In Appendix 3, we have provided a market analysis of packaging at the level of the manufacturing industries of Canada. Table 7, Appendix 3, shows that in 1977, Canadian manufacturing industries spent about $2.5 billion on containers and packaging supplies. There were no regularly published statistics on packaging consumption in Canada at the retail and wholesale level. The Waste Management Advisory Board of Ontario estimated that between 25-30% of Canadian manufacturing package consumption was the amount used at the retail and wholesale levels. Using 25%, we arrive at a figure almost identical to that produced by Maclean-Hunter Research Bureau in their study for the Canadian Packaging Association. By allowing for imports and exports, Maclean-Hunter estimated total apparent domestic supply of Canadian packaging in 1977 as $3.4 billion. Using trend analysis, the Association now estimates that the Canadian packaging industry is a $4.0 billion market in 1980.[1]

PACKAGING IN THE CANADIAN MANUFACTURING INDUSTRIES

In 1977, Canadian manufacturing industries spent about 2.3% of the value of goods shipped on packaging. Seven of the manufacturing industry groups accounted for 86% of the value of total package consumption at the manufacturing level. It is noteworthy that food and beverages accounted for 57% and chemical and related products, 13% of the value of packaging used at the manufacturing level. Both of these industry groups had packaging as a cost of shipments at 7.4% and 4.9% respectively, both well above the national average of 2.3%. It was also noteable that the tobacco products industry, although accounting for only 3.4% of package consumption, had the highest cost of packaging as a percentage of shipments (8.9%).

An analysis of package consumption by the manufacturing industries over time is shown in Table 1, Appendix 3. When allowing for price changes and adjusting for constant dollars, some interesting observations resulted. Firstly, it was found that the manufacturing industries of Canada are spending less on packaging today than they did in 1972. Additionally, packaging now represents a smaller proportion of the total cost of all materials used by the manufacturing industries of Canada than they did in 1972, This modest decrease is slightly less when the physical quantities of packaging materials are considered, instead of just the costs. Nevertheless, this finding is consistent with the observation made in the United States that industries are moving to lower cost, lighter weight packaging, representing a decreasing proportion of final product cost.

CONSUMPTION BY PACKAGE TYPE

From Table 5, Appendix 3, it is seen that six major categories of packaging account for 71.5% of the total consumption of packaging by the Canadian manufacturing industries. The breakdown of this total is shown in the table below.

TABLE 10

CONSUMPTION OF PACKAGING TYPE

By the Canadian Manufacturing Industries, 1977

Package Type	Value of Consumption (Million $)	Percent Consumption (%)
Corrugated Boxes	476.4	19.4
Metal Cans	445.2	18.1
Folding/Set-up Boxes	326.8	13.3
Glass Bottles	225.6	9.2
Transparent Film (Bags & Sheets)	151.9	6.2
Paper (Bags & Other)	128.7	5.3
SUB-TOTAL		71.5%
Other	100.8	28.5
TOTAL	$2,455.4	100.0%

Source: Boston, Gilbert, Henry Associates Ltd.

From Table 7, Appendix 3, it is seen that the food and beverage industry is a major consumer of Canadian packaging, 57%. A breakdown of this industry's consumption of packaging by type is shown in the table below (see column 1). It is also noteworthy that the food and beverage industries account for a very large percentage of the total Canadian manufacturing consumption of glass bottles, metal cans, and transparent plastic film, amounting to 87%, 82%, and 78% respectively (see column 2 in the table below).

TABLE 11

FOOD AND BEVERAGE MANUFACTURING
PACKAGING CONSUMPTION, By Type, 1977

Package Type	Food & Beverage Consumption (%)	Food & Bev. Proportion of Total Mnfg. Use (%)
Metal Cans	26	82
Corrugated Boxes	15	45
Glass Bottles	14	87
Folding/Set-up Boxes	13	55
Transparent Film	8	78
Paper	5	54
Other	19	37
TOTAL	100%	

Source: Boston, Gilbert, Henry Associates Ltd.

Again, from this set of statistics, it became once more apparent that the study of packaging and energy conservation should concentrate a good measure of its effort on the food and beverage manufacturing industries in Canada. Further analysis is directed toward identifying which food and beverage manufacturers would be of special interest. Table 8, Appendix 3, suggested we should concentrate on six manufacturing sectors of the food and beverage industry. These six leading packaging consumers accounted for 65% of all the food and beverage manufacturer packaging consumption. We also felt that two other

industries were significant, namely biscuit manufacturers and frozen fruit and vegetable processors. The reason for considering them is that the packaging consumption in those industries was such a high percentage above the average, 11.1%, that they might represent some significant packaging and energy conservation opportunities. Other examples might also have been chosen, but our first-stage selection was the decision to concentrate on the first six food and beverage manufacturers listed in the table below.

TABLE 12

LEADING PACKAGE CONSUMING MANUFACTURERS IN CANADIAN FOOD AND BEVERAGE INDUSTRIES

Industry	Consumption as Percent Total Food & Beverage Pkg. Industry (%)	Packaging Cost as Percent Total of Materials (%)
Fruit & Vegetable Canners, Preservers	15.3	39.8
Dairy Products	13.4	8.1
Miscellaneous Food Processors	12.3	14.7
Soft Drink Manufacturers	11.9	43.5
Breweries	9.0	50.2
Distilleries & Wineries	7.7	45.0
Biscuit Manufacturers	2.8	27.7
Frozen Fruit & Vegetable Processors	1.3	16.1
Total	73.7%	

Source: Boston, Gilbert, Henry Associates Ltd.

Appendix 3 contains discussion of further factors that should be considered in selecting key industries for further investigation regarding packaging use and energy conservation opportunities. With the approval of the Interdepartmental Committee, it was decided not to proceed further with the analysis of any of these industry opportunities at this time. We did, however, go on to examine packaging consumption items with significant energy content. There were two reasons for doing this. The first was to confirm that the industries that

we had selected did, in fact, have high energy conservation potential due to packaging substitutions. This assumption was, in fact, largely confirmed as shown by Table 20, Appendix 3. The second reason for doing the energy analysis of packaging consumption at the manufacturing level was to determine the total Canadian energy consumption in respect to packaging. The packaging expenditures by Canadian manufacturers were obtained from Statistics Canada. Estimates of the cost of packaging materials per unit of weight were obtained from the Ontario Waste Management Advisory Board. Price indices were used to adjust to the more recent year of 1977. Energy content, by weight, of different packaging types were obtained. It was then possible by multiplication to obtain the total energy equivalent of packaging consumed by the Canadian manufacturing industries (see Table 10, Appendix 3).

The calculations show that the energy content of all packaging consumed at the manufacturing level in Canada in 1977 was 0.12 BTU's x 10^{15} (quads). When increased by 30% to 0.16 quads to allow for packaging at the wholesale and retail level, this total is in very close agreement with that derived by the Ontario Research Foundation through two different methods analysing energy content in packaging found in the municipal solid waste stream in Canada.

It was also important to find that the calculations of energy content confirmed that the six major package types previously identified accounted for 77% of the total energy used in packaging in Canada. (Table 10, Appendix 3) Also, the food and beverage industries previously selected all had high packaging energy contents (see Table 20, Appendix 3).

INPUT-OUTPUT ANALYSIS

We reviewed the consumption of packaging at the manufacturing level. We found concentrations of packaging consumers. We also observed certain industries dominating the market for a specific package type. In other instances, the decentralization geographically of an industry with many individual packaging consumers was a major factor. This convinced us that the market for packaging is complex. Similarly, flowcharting the processes for manufacturing packaging materials and the energy related to their production, filling, distribution, use, and ultimate disposal was complex. This was without adequate information on the significant use of packaging at the wholesale and retail levels.

The quantity of packaging and the products contained therein are a significant proportion of Canada's gross national product. The interactions related to packaging and energy conservation are interwoven throughout the economy. Little is known about the inter-industry impacts of altering these relationships, nor do we know the multiplier effect that changes in packaging may bring. One estimate indicated that one packaging substitution could have an energy conservation multiplier of the order of 10 to 1. This possibility must be further examined.

We have confirmed that the Canadian Input-Output model could be used for this purpose. It is a large computerized model which is relatively easy and inexpensive to use. It can be used to test "what if" questions of a government policy development nature. The model can test packaging substitution assumptions in a macro-economic sense. There is an energy package element of the model to test energy conservation policies as well.

The size of the model is indicated in the following table. D.B.S. (Statistics Canada) described the analytical use of the model to study automobile manufacturing. This brief description is included as Appendix 4.

CANADIAN INPUT-OUTPUT MODEL
DIMENSIONS OF THREE LEVELS OF AGGREGATION

Designation of Aggregation	Number of Industries	Number of Final Demand Categories	Number of Commodities and Primary Inputs
S	16	14	49
M	43	14	100
L	191	136	602

Tables at aggregations S and M are available. Some cells of the aggregation M are confidential. These cells have been suppressed though industry totals and commodity totals have been preserved. However, complete information (including confidential cells) may be used for the calculation of impact tables.

An example of what might be accomplished is Professor Morris Wayman's book, "Wealth and Welfare". The Science Council has long advocated the use of the model for such purposes. Industry and other researchers have made hundreds of uses of the model in recent years. It would be useful to further research packaging policy proposals for energy conservation using the Canadian Input-Output model.

WASTE MANAGEMENT CONSIDERATIONS

In the design of this study, it was felt desirable to consider guidelines for preferred packaging from a waste management point-of-view. The following is a discussion of some of the waste management options which lead to preferred material choices and packaging alternatives. The concept is that packaging substitutions should avoid adverse environmental impacts, and afford energy conservation opportunities. These should apply during all stages of the packaging life cycle - from material choice to post-consumer waste disposal.

ELEMENTS OF PACKAGING

In preparing any packaging guidelines, there seem to be four basic areas of interest to consider. Firstly, the requirements of the manufacturing and packing industries are for efficient and cost-effective packages. Consumer protection requirements are another of the basic elements of packaging. For example, label information must not mislead the consumer. The package design should adequately protect the product from damage and ensure the consumer the quality of product anticipated. There are other legal requirements that packages must meet. In some cases, these are size requirements. In other cases, they are product information to be contained on labels. Finally, there is the waste management or environmental requirement. Today this means that packaging materials and package type should recognize that excessive energy consumption is not only uneconomical, but no longer in the public interest. Similarly, efforts to minimize post-consumer waste and the cost of the solid waste disposal of packaging materials need to be recognized.

EMPHASIS

For this study, we have chosen to stress waste management requirements in the preparation of packaging guidelines. In this respect, it is desirable to minimize potential contribution to solid waste, both with respect to the physical volume and weight of packaging waste. Even more important is the need for guidelines to emphasize packaging systems which minimize total energy requirements. By this, we refer not only to the energy content in the manufacturing of packaging materials, but in the forming, filling, and related packaging and distribution operations. Included also is the recognition of the cost of energy to reclaim or reuse packages such as refillable bottles. Guidelines should also recognize resource conservation. Minimizing the use of non-renewable materials is a desirable goal and the switch to renewable resources wherever possible in the manufacture of packages and containers seems to be a desirable goal. Guidelines should also recognize the tendency of North Americans to litter. Packaging should, therefore, be designed wherever possible to minimize litter. One possibility is to devise packages with secondary uses, or ones which may be incorporated easily into reclamation or recycling systems. Additionally, packaging should minimize adverse atmospheric emissions or water-born wastes whether they derive from the raw material extraction, materials processing, container fabrication, product use, final product disposal to land-fill sites, or the recycling/reclamation of solid wastes.

PACKAGING SCOPE

In the preparation of packaging guidelines, we include all those products which are available to consumers in packages (i.e. primary packaging). Also to be considered are the packages to unitize multiple products for consumer convenience (secondary packaging). We must also consider the packages needed for the physical distribution process to get products from manufacturers through wholesale to retailers (tertiary packaging).

WASTE MANAGEMENT IMPROVEMENT PROGRAMS

The simplest approach to waste management improvement is the source reduction of waste. This can be accomplished, first of all, by the increased use and reuse of refillable containers. It can also be accomplished by reducing the amount of packaging, either in quantity or in weight, per unit of output. Source reduction may also be accomplished by reducing the quantity of a consumer good output which has a high littering propensity (e.g. canned soft drinks, cigarettes).

In general, source reduction deals with packaging and package substitution.

Other approaches to waste management improvement are reclamation and recycling. To accomplish either, source separation at the household level is the first important step. Thereafter a collection depot system with wide-spread geographic coverage is essential. Thereafter return to the product manufacturer or to reclamation becomes a possibility. An alternative to the depot system is the return of containers to the point of sale at the retail level for the return of a deposit or other credit.

Mechanical resource recovery may be a substitute for or additional to source separation. Substantial technological developments have occurred in recent years to separate municipal solid wastes into several discrete waste streams. Mechanical separation is now possible for such things as: steel cans, aluminum containers, glass bottles or broken glass (cullet), wood, paper, and plastic from organic materials. These technological developments allow for the stock piling and subsequent reclamation of municipal solid waste components.

Another approach to reclamation and recycling is the incineration of refuse derived fuel (RDF). This tends to be the light weight fraction of municipal solid wastes which have substantial heat value when dry. To be economical, however, heat recovery or steam generation for heating or electric power generation is, at present, an absolute must. RDF may also be used as fuel in cement kilns. Neither are yet proven economically viable for general application in Canada.

Another outcome of waste reclamation and recycling is the stock piling of select waste items. Typical of this will be tin cans, batteries, or newsprint, where it is necessary to have large quantities either to satisfy the market or to process economically to meet manufacturers raw material requirements (i.e. 1,000 lb. bale of newsprint). Also, stock piling can be justified by some waste material brokers who gamble on the rising market price of a scarce material such as tin. Also, under the reclamation/recycling heading, it is necessary to stress that what is reclaimed must be recycled to achieve the objectives of the program.

Another approach to municipal waste reclamation and recycling is the use of organic wastes for municipal or for home composting purposes. This is an interesting opportunity for a large component of the waste stream. Much interest was generated in recent years over this possibility. But, on a large scale, high transportation costs make the operation uneconomical.

In general, reclamation and recycling deals with recovery from the post-consumer solid waste stream. It is, therefore, concerned primarily with packaging materials which make up as much as 40% of municipal solid wastes.* However, to be economically viable, post-consumer waste reclamation and recycling must be concentrated in areas of high population density along main traffic routes. The operation absolutely must be close to its markets because of the marginal returns. Even then, mechanical resource recovery does not appear likely to be introduced in a comprehensive way in Canada in the near future. This is due to the generally poor economics of the operation. There are also problems of selling the waste products, or of matching users of the energy derived from burning refuse derived fuels. It is expected that increasing pressure will be brought to bear to accomplish reclamation and recycling. This is despite efforts which will be aimed at source reduction policies. In the United States 90%, by weight, of the post-consumer solid waste generated becomes land-fill.* In Canada, the figure is probably higher. Probably 40% of this weight is packaging material.*

* Boston, Gilbert, Henry Associates Ltd.

Problems are growing rapidly concerning land-fill sites. Public pressure demands more detailed environmental impact assessments before granting site approvals. Land costs for new sites are rising rapidly as older, more accessible sites fill up. Local residents no longer want to have a land-fill site nearby. The heavier traffic and air-borne litter, etc. are held to be a nuisance and reduce property values. The increasing distance municipalities must transport wastes are costly and energy intensive. As land-fill sites become increasingly short in supply and the cost to transport municipal solid waste to them increases, it is inevitable that strong pressures will develop for post-consumer solid waste recovery and reclamation programs.

REFERENCE BASE

In developing a reference base to compare products and packages as to their waste management impact, some common reference base is required. Present analytical techniques suggest that a product isoquant be used. This is an equal quantity of the physical product so that alternate package types may be compared. For example, an isoquant for liquor bottles might be one million 40-ounce bottles. This is the approach used in the resource and environmental profile analysis (REPA) done by Mid-West Research Institute of the United States. The same technique is used by the Ontario Waste Management Board and similar researchers in the waste management field.

The product isoquant seems to be the essential reference base when studying what is required to achieve an environmentally beneficial package, particularly with respect to energy consumption.

ENERGY SAVINGS POTENTIAL

The approach with the greatest anticipated structural short-term benefits is the substitution of one packaging container for another. A good example is the substitution of plastic containers for glass bottles.

Another approach to energy savings is the replacement by refillable containers of throw-away ones. It is necessary in a cost benefit analysis of this approach to recognize the energy requirements for returning, cleaning, and sterilizing the refillable container. These can be substantial. Also, to achieve the benefits of refilling, it is absolutely essential to recognize that a system to encourage container returns and the collection of at least 60% of the containers sold to the consumer is mandatory to make such a system economically feasible.

We have already discussed reclamation and recycling, but under this heading of energy saving, it is important to determine which reclaimed materials can be recycled most easily and economically under today's technologies. Additionally, to make reclamation and recycling feasible, the residual light fractions of the solid waste stream must be captured as composting is not an energy source. Otherwise, "high grading" the solid waste stream for higher value recyclable materials alone will not substantially reduce the problems of solid waste handling and disposal.

CRITERIA FOR PACKAGING OF CONSUMER GOODS

The British Industry Committee for Packaging and the Environment (INCPEN) several years ago developed criteria for the packaging of consumer goods. These are probably the briefest statement of reasonable criteria which packages must meet to satisfy the environmental and energy concerns discussed previously. This simple statement by INCPEN is quoted below.

"The senior management of any business concerned with the design, manufacture, or use of packaging has the responsibility to ensure that such packaging is regularly reviewed for its use of materials and economics throughout the total manufacturing and distribution chain, and disposal, having regard to the following criteria:

1. The packaging must comply with all relevant legal requirements.

2. Packaging must not mislead as to the amount, character, or nature of the product it contains.

3. The package must adequately contain and suitably protect the contents.

4. The package must be constructed of materials which have no adverse effect on the contents.

5. Packaging must be designed to present no undue risk to the user and be convenient in use.

6. The packaging for hazardous products must be designed for safety in distribution and use, and bear proper warnings.

7. The packaging must give the purchaser all necessary information about the product and its use in a clear and intelligible manner.

8. All packaging must be designed with due regard to its possible effect on the environment, its ultimate disposal, to possible recycling, and to reuse where appropriate."

APPLICATION OF PACKAGING CRITERIA

With the first concerns of environmental pollution a decade ago, attention focused on roadside littering, among other things. It was found that in litter over one-third by weight was beverage containers.*

Early in the 1960's, the soft drink industry started promoting the throw-away container. To a convenience-oriented society, this at first seemed to be a good idea. Then the impact of Rachel Carson's "Silent Spring" became widespread.

* Boston, Gilbert, Henry Associates Ltd. estimate.

The environmentalists became vocal. Then, early in the 1970's, governments became active. They took the initiative to improve soft drink packaging. The industry was concentrated. The product was widely used and almost everyone was exposed to the problem. It represented perhaps one of the larger elements, 4% then, of the municipal solid waste stream.

Even today, probably as much as 15% of municipal solid waste derives from beverage containers. Relatively, more research was done and more is known about beverage packages than for any other consumer product. For these reasons, we took, as an initial approach, an examination of beverage packaging examples to consider the effect of applying criteria for the packaging of consumer goods to conserve energy and to minimize waste and environmental pollution.

TABLE 13

BEVERAGE PACKAGES

Candidates for Waste Management Improvement Analysis

Container Types	Carbonated Soft Drinks	Beer	Milk	Fruit Juice	Wine & Spirits
Primary					
Bi-metallic cans	x	x		x	
Aluminum cans	x	x(1)			
Non-refill bottles	x	x		x	x
Refillable bottles	x	x			
PET containers	x(1)(2)				
Plastic refillable			x		
Plastic pouch			x		
Paper carton			x		
Secondary					
Plastic (6-pack)	x				
Cardboard	x	x			
Sack (3-bag)			x		
Tertiary					
Wood	x				
Corrugated	x	x			
Plastic (reusable)	x				
Corrugated, plus Plastic Shrink wrap	x				

NOTES:

(1) United States
(2) Quebec, Manitoba, and Alberta

From the table above, it may be noted that every possible waste management improvement type can be applied to the packaging examples identified. There is a significant data base available on all these products and their various containers. Recycling technology is also highly developed for these beverage packages. For example, the Polyethylene Terephthalate (PET) carbonated soft drink bottle may be used for other purposes. Aluminum cans can be recycled and substituted for tin-free steel cans. Bi-metallic cans may be reclaimed and converted to No. 1 or No. 2-grade steel scrap bundles, but this may be dependent upon detinning of tinned steel cans. Glass bottles may be cleaned and refilled, or broken glass (cullet) may be recycled for the manufacture of new glass bottles.

In the table above, means of waste management energy improvements are also identifiable. The reusable-refillable carbonated soft drink containers and beer containers already are yielding significant energy conservation results. Reusable and refillable wine and spirit bottles were considered. And baby food glass jars could probably be recycled along with a number of other glass containers, especially if standardized sizes became commonplace.

Another energy conservation improvement would be the substitution of renewable materials for packages, especially non-refillable ones, for those made of non-renewable materials. If this were not possible, then the energy recovery from the final solid waste management stream would become increasingly important, especially if recycling of containers made from non-renewable resources was not feasible.

SOME PACKAGING SUBSTITUTION CONSIDERATIONS

There are two important considerations relating to the measurement of the socio-economic impacts of post-consumer solid wastes. Firstly, most measurements do not recognize the "embodied" cost of energy of the packaging material. There are a great many points at which energy enters the packaging

system. They begin at the extraction of raw materials and extend through packaging manufacture, filling operations, transportation, heated storage, lighted display, consumer storage, preparation or use, and finally the potential heat energy lost in post-consumer disposal of combustible packages. All of these energy aspects must be accounted for in judging packaging substitions for energy conservations.

The second measurement problem relates to the resource aspects of packaging materials. The free market economic system throughout the world has not yet agreed on the means of estimating the value of non-renewable resources. As a result, this value is not included in most economic analyses of alternate packaging materials. This means no consideration is given to the impacts of packaging decisions over the long-term life of a particular package choice. These may extend over a 50-year time horizon. What is needed is some recognition of the present value of depleting non-renewable resources. In other words, what is required is a non-renewable resource replacement cost theory. As a simple example of this, one might consider the effect of this new insight which might place, as a minimum, the cost of a ton of tin at some figure well above the present market price of $600. Certainly a figure of $35 to collect and dispose of tin in steel-plated cans is inadequate.

Another important consideration will be "conserver society" changes. In the long run, these will probably be significant, but all too often we ignore some rather important short-run effects. These usually relate to secondary uses of packages which are assumed to be discarded as waste. In fact, the consumer does some informal source separation and directs these packages to new secondary uses. A good example of this is the home reuse of the milk pouch as freezer bags. Similarly, the mother bag is often used by children and adults as a carrying case for lunches, books, and miscellaneous merchandise. The same mother bag and particularly shopping

bags of plastic have virtually replaced the Kraft paper shopping bag for garbage disposal in some households. The significance of these secondary packaging uses on sales of products such as freezer bags and garbage bags has not yet been recognized in the literature of post-consumer solid waste.

In general, plastic film (i.e. pouches) should beat almost every packaging material because of its very small weight, low cost, and total system energy efficiency.

Glass food containers beat plastic ones because as yet the flavor migration problems to plastic have not yet been solved. Also, the attractiveness of clear glass which leaves a highly visible product cannot be duplicated in plastic. (NOTE: The PET bottle may have largely solved the flavor migration problem.)

There will always be a place for cans as food containers because of the highly developed process technology. This leads to extremely low costs for the can as a package. It is expected though that cans will increasingly move to tin-free steel, thinner walled, higher strength, and of two-piece manufacture.

Plastic refillable bottles beat all other containers because of the very high trippage rates. For example, the three-quart milk jug gets an average of 200 trips as compared to approximately 20 for the comparable glass bottle.

Despite these substitution possibilities, there are some system problems which must be recognized. For example, the chain stores do not like the three-quart plastic refillable bottle. The large chains (A & P, Loblaws, Dominion, and I.G.A.) discriminate against its widespread use. They use such simple devices as overcharging for milk in such containers. They do not use the product as a loss leader. Because the stores were designed in a period before the introduction of the three-quart plastic container, they lack the storage space for returns. The chains also object to the need to staff a section in the front of the store for deposit returns

to customers. They also claim that there is a sanitation problem in taking back dirty milk containers which may potentially contaminate other fresh foods in their storage areas. For these reasons, they apply the simplest form of discrimination, namely the refusal to stock the three-quart milk container.

As compared to the chain stores, convenience stores find the three-quart milk container very attractive. These stores were set up as milk stores and designed to be able to receive returned milk containers. They do have the appropriate back room storage space and a convenient front room arrangement to make convenient cash deposits on returned milk containers. There is also another very important factor which makes the operation attractive to them. There is a 60-cent deposit. This is much less than the purchase price of a new milk container. By accepting returned containers, convenience stores get a cheap supply of containers to refill. This means that they buy from the consumer a significant percentage of their container float at below-market prices for new containers. It is estimated that convenience stores receive 10-15% more returns than they actually sell. This represents a significant saving to them.

Four years ago, the Ontario brewers' retail organization studied the use of plastic shells to replace corrugated cartons. It appeared that the pay-back period was 1.5 to 3 years and this would be a good investment. Plastic shells would be re-trippers and would cost approximately ten times as much as the corrugated carton currently in use. It was found that householders might find secondary uses for the plastic shells, so there would be some loss from the system, but not excessive. The four or five large breweries in Ontario would have had to finance the packaging substitution to the extent of maybe $50 million in total. This would create a significant cash flow problem for them. It was on this basis, primarily, we believe, that the decision was made not to proceed with the packaging substitution.

With respect to cans, it is anticipated that they will survive as a specialty container, particularly for carbonated soft drinks and fruit juices. These are a convenient one serving-sized containers. The non-returnable feature is considered desirable by the consumer because there is no extra charge for a deposit, and the current practice is to discard these containers rather than return them. This raises the question of whether the aluminum can should replace the steel can. The reasoning is that it takes only 5% of the energy to recycle a can, as compared to manufacturing it. The potential saving is even greater if you consider the energy cost in the material to manufacture aluminum as opposed to steel cans. Another advantage of the aluminum cans is the fact that they are easily hand-compressible which simplifies reducing the bulk of cans to be returned.

Probably the greatest deterrent to recycling cans is that there is no effective recycling system in existence in most parts of Canada. In Ontario, few cans are recycled. A Hamilton plant is the only one in Eastern Canada. It tends to operate from a monopoly position and discourages acceptance of dirty cans. They cause problems in cleaning because they eat up the cleaning solutions at an excessively fast rate. This makes the cleaning operation very expensive. Also, bi-metallic and tri-metallic cans have, up until recently, caused technical problems with the cleaning solutions. They also represent contaminants in the derived scrap which usually is preferred to be of a single metal only.

From examples such as these, it becomes obvious that any recycling or refilling of containers requires a well-organized and well-developed collection and recycling system.

NECESSARY PACKAGING

Before describing what is considered to be "necessary packaging", it is necessary to consider just what is packaging. Any consumer product is part of a long and complex system. The focal point for the consumer is usually only that stage at which he purchases the product and then transports and stores it for future use and ultimate disposal. But this is only a small portion of the total packaging system.

In many places in this report, we have described the total packaging system. But, once again, it is important to emphasize the many components of the packaging system as is shown in the table below.

TABLE 14

PACKAGING SYSTEM COMPONENTS

Considering packaging as a system, the component parts may be described sequentially as follows:

- Retrieving basic raw materials, such as ore, sand, wood, or chemicals.
- Transporting basic raw materials to a prime converting plant.
- Converting basic raw materials into formable materials, such as steel, aluminum, glass, plastic resin, or paper.
- Converting formable materials into an empty package form ready to accept product (sometimes formed in line with product manufacture), and transportation to filler.
- Filling the package with the product, and processing in some cases.
- Closing the package.
- Checking the package for fill, closure, integrity, etc.

- Placing the filled package in other packaging designed for carrying and transport (shipping containers).
- Combining or unitizing the shipping containers for transport.
- Processing the packaged products through physical distribution, including storage, order selection, placement in transport vehicles, transportation, storage at the customer's warehouse, breakup, redistribution, further breakup, retail placement.
- Retailing, including transmittal of information to the retailer and the consumer.
- Selecting and purchasing by consumers.
- Transporting to the place of final use.
- Storing at the point of final use.
- Retrieving and using product.
- Disposal and/or retrieval.

Packaging is necessary to bring a product to a consumer. Since there are many kinds of packaging, it was found convenient to apply three terms to describe the packaging necessary to bring the product to a consumer.

The primary package is the one that is in direct contact with the contained product. It provides the immediate and primary product protection. Additionally, it may have to serve a number of other purposes as well. Examples are the provision of a measured quantity, protection from moisture or other contamination, ease of handling, prevention of product escapement, or physical damage, etc. Examples of primary packages include: cans, bottles, pouches, etc.

Sometimes a primary package consists of more than one part. A paperboard carton with an inner glassine paper liner for dry cereal is still considered a primary package.

By comparison, the secondary package contains a multiple of primary packaged products. Usually the secondary packages are designed by the manufacturer of the product for the convenience of the wholesaler or retailer who wishes to handle and stock consumer products in convenient multiples, rather than as single units. Examples of secondary packages are paperboard carton holding 24 chocolate bars, or a paperboard carton that unitizes six soft drinks in a single carrier. This secondary package may never be seen by the average consumer. In other situations, it may be very evident to the consumer (e.g. the six-pack of soft drinks).

The tertiary package is the one of prime importance to the physical distribution carrier and the wholesaler or retailer who acquires consumer products in quantity. Most frequently this type of package is a corrugated case. More recently, corrugated trays, plus plastic shrink film, and shrink film alone have become important forms of tertiary packaging. Kraft paper bundling, full palletless loads packaged in shrink film, and bale-strapped pallets are other examples of tertiary packaging. In general, this type of packaging is primarily used by the carriers and is seldom seen by the general public.

Many package forms do not fit clearly into the secondary or tertiary categories. Also, at certain stages in the physical distribution system, it may be necessary for wholesalers to break one form of packaging, perform order selection, and re-package products for distribution to the retailers. The same will also occur at the retail level.

The complexity of this physical distribution system and the requirement for re-packaging at various stages in the system makes it very difficult to define what is truly "necessary" packaging. The consumer may observe the large empty space in the package of dry cereal and assume that there has been a substantial amount of over-packaging or unnecessary packaging. He is totally unaware that this may well be the most cost

efficient way of delivering the product to the retailer's shelf as the total packaging needs were defined more by other stages in the total packaging system. Any other solution to the manufacturer's settling and compacting problems of products like dry cereals might, instead, lead to a different kind of product being offered to the public, such as corn in the form of breakfast cereal other than flakes.

Our opinion is that the easiest answer as to what is "necessary" packaging is that package which, in a strictly functional society, would have as its sole purpose, the efficient conveyance of a product to the consumer. In this situation, the only packaging purpose which might disappear would be the use of packaging for product differentiation purposes in the marketing process. Our preliminary examination of this problem indicates marketing purposes are not a particularly significant user of energy in the total packaging system. There are some noteable exceptions of course. The 10-ounce Coca Cola bottle has a high marketing image. It weighs 14 ounces compared to a strictly functional 10-ounce stubby bottle. Thus, 40% of the package weight is "non-functional". However, we have few examples of product packaging having such a dominant marketing connotation. The more usual examples are the amounts of unnecessary material used in larger and more numerous labels on packages, or the aluminum or lead foil on the top of a beer or wine bottle to indicate a "premium product". In most of these cases, the additonal weight and extra energy involved are insignificant relative to the total packaging energy content.

Our tentative observation is that probably much less than 5% of packaging energy is market oriented. It becomes only significant in consideration of packaging substitutions if this marketing requirement precludes some types of reuseable or recyclable package, or makes these conservation measures more difficult or expensive.

We do, however, foresee significant changes in what will be considered necessary packaging in the future. In one automated food distribution centre, physical damage to grocery products in one year affected 133,000 cases of product and led to a cost of $435,000. Over half this loss was directly attributable to insufficient or defective packaging. As new and more efficient wholesaling and retailing systems evolve, so, also, we will expect the definition of necessary packaging will change. Similarly, changes in consumer life styles will require that necessary packaging for consumer convenience will impose new packaging requirements. Some of these trends are already discernible. It is necessary that they be scrutinized carefully to ensure that the innovations are truly functional (necessary) and energy efficient with regard to the total packaging system.

PHYSICAL DISTRIBUTION

COST OF DISTRIBUTION

In 1975 the keynote speaker at a seminar of the Packaging Institute (U.S.A.) spoke on the subject of, "Physical Distribution - The Last Frontier for Cost Reduction of Consumer Products".[8] At that time, he stated that physical distribution costs represent 30% of the total retail price of most products. The November, 1979 Handling and Shipping Management magazine estimated that between 10 cents and 30 cents of every dollar of consumer product sales at retail was directly attributable to physical distribution costs.[9] Few consumers are at all aware of what physical distribution means to them. It is the hidden transport of resources and raw materials to primary producers, the movement within the plant of goods in process, the collection, warehousing and storage before shipment of finished consumer goods from a manufacturing plant to a customer, to another warehouse or some wholesale or retail outlet where the whole process repeats itself again.

One of the better sources of information on the costs of distribution was a 1976 study by the U.S. National Council of Physical Distribution Management.[10] Some of its findings are summarized in the following tables. We have chosen only those portions of the data appropriate for this study. That is, we selected data on consumer goods manufacturing, and within that group, those related to food and chemicals. We also included data for consumer goods retailing. (See Tables 15 and 16) But, a word of caution. The data are averages from many respondents. Individual firm data on physical distribution costs vary widely. The range for food manufacturing was from 4% to 92% of sales. For consumer goods merchandising the range of costs was 9% to 78% of sales. Nevertheless, the average seems to hold true for other study results.

TABLE 15

SELECTED PHYSICAL DISTRIBUTION DATA - U.S. 1976

Average Cost of Distribution (% Sales)	Food Mfg.	Pharma-ceutical Mfg.	Chem. & Plastic Mfg.	Consumer Goods Merchandising
Inbound Transport	2.5	0.2	3.0	3.7
Outbound Transport	5.6	1.2	3.3	4.4
Administration	0.4	0.7	0.3	1.3
Receiving & Shipping	0.9	0.5	0.6	0.9
Packaging	n.a.	0.1	1.4	0.9
Order Processing	0.2	0.5	0.6	0.5
Warehousing	3.5	1.2	3.3	4.0
Inventory Carrying Cost	0.3	n.a.	1.6	8.5
TOTAL	13.4	4.4	14.1	24.2

n.a. = cost category not generally used by respondents.

Average Shipping Costs (% Freight cost)*				
Plant to Customer	45%	10%	55%	28%
Plant to Warehouses	18	27	19	20
Warehouse to Customer	23	63	29	52

* NOTE: Column totals do not always add to 100% where the average of averages were reported.

SOURCE: NCPDM (10)

TABLE 16

SELECTED PHYSICAL DISTRIBUTION DATA - U.S. 1976

U.S. INDUSTRY Physical Distribution Data	Food Mfg.	Pharma-ceutical Mfg.	Chem. & Plastic Mfg.	Consumer Goods Merchandising
Av. order size ($)	6,500	1,400	3,900	6,300
Order interval (wks.)	2	2.4	3.0	1.8
Stock selection (sku)	250	-	4,700	7,800
Av. shipment (lbs.)	9,000	200	15,000	3,000
Ship to locations (no.)	3,500	24,000	8,500	24,000
Shipping locations (no.)	17	12	29	23
Unitization (% of ship.):				
- palletized (%)	15	-	41	12
- shrink wrap (%)	40	-	22	-
- slip sheets (%)	-	-	10	20
- other (%)	41	-	56	68
Inventory turns (yrs.)	17.4	4.8	14.4	12.0

SOURCE: NCPDM[10]

ORGANIZATION OF THE FUNCTION

The larger and more progressive firms in the last half decade have recognized the tremendous importance of physical distribution costs and the squeeze they can put on profits. But, even then, as the industrial management expert Peter Drucker says, "Industrial engineers are where the machines are, they never poke around in the shipping room".[8] Seldom do you find an organization where a senior vice president is responsible for physical distribution. Yet, if physical distribution costs do represent 30% of the retail price of most consumer products, clearly a new approach is required. Probably this is nowhere more true than in the food distribution business. However, most of the physical distribution costs tend to be "inter-firm" rather than "intra-firm". It, therefore, becomes very difficult for a corporation to take the necessary systems approach which is needed to improve the productivity of physical distribution systems

in the food supply chains, or in some of the other consumer good businesses. What seems to be required is that trade-off on those variables affecting level of customer service, product variety, and packaging variety to improve productivity, and reduce costs. In general, corporations are reluctant to do this. They fear that any trade-offs regarding productivity will adversely affect such things as: sales, profits, service levels, or market share.

There is evidence that the situation is different now than a decade ago. With continuing inflation, it is the first time in decades that consumer buying power is being eroded. This reduction in discretionary buying power is being faced with further pressures as the cost of essentials: food, utilities, automobile transportation, and clothing are rising drastically. Hence, the argument for a new approach is timely, with inter-firm physical distribution being a major area of interest for cost reduction opportunities. The problem is - how to organize the function to achieve the anticipated benefits.

LABOUR AND PRODUCTIVITY

Generally, the food distribution business is labour intensive. It has been reported that as much as 49% of the food distribution and marketing cost after the farm gate is labour costs.(10) Even in the largest and most efficient supermarkets, it is still observed that the stockboy puts peas on the shelf by hand. In the United States, the unions are strongly entrenched in the food trucking and food warehousing operations. The same applies in the giant corporations in the food processing business and at the retail supermarkets. In many of these unions, the jobs require low skills, but wages have become high and are rising fast. The unions in the U.S. have protected about 40% of the workers in this group of industries by cost-of-living adjustment clauses. Simultaneously, in the U.S., retail food industry productivity has been

observed to fall from the 1958 to 1968 average of 2.9% per annum to only 0.3% in the 1968 to 1973 period.[10] More recently, it is believed that the food processing and manufacturing industry's productivity has only averaged a maximum of 2-3% per annum. This was not enough to cover wage increases.

Clearly, it is time to look at physical distribution productivity improvement in the food industry. Again, the greatest opportunities for improvement are likely to be in further mechanization and inter-firm system changes.

IMPORTANCE OF PACKAGING

At each stage in the physical distribution system, packaging plays an important role. Packaging contains and protects goods in transit. It makes things easier to handle. The weight and volume of packages directly affects transportation costs. With rapidly escalating energy and transportation costs, great pressure exists to keep package weight and size as low as possible. Within individual firms, especially the larger ones like the suppliers to retail chains or supermarkets, much has been done to reduce materials handling and warehousing costs. Improved package design has often figured significantly in these intra-firm improvements. One authority estimated that one-quarter of physical distribution costs are for packaging. Others say 30%. Another expert estimates physical distribution costs as 10% to 30% of sales of consumer goods.[9] This is for the entire system - from manufacturer through retailing. Thus, packaging costs could represent from 2.5% to 7.5% of retail prices of consumer goods. Another source states that packaging represents 12% of total food marketing costs.[10]

But no reliable estimate is available to indicate what is the impact on physical distribution productivity of improved package design.

PRODUCT VARIETY

The proliferation and variety of consumer goods available is difficult to imagine. In the United States, the average food manufacturer produces 250 stock-keeping units (sku), a chemical and plastics manufacturer 4,700 sku and the consumer goods merchandiser 7,800 sku. The canning industry alone has been reported as producing 1,400 different items in the U.S. Supermarkets stock 8,000 different products. Of these, 500 to 700 may be frozen products alone. Even then, they do not stock a full list of consumer products available. This probably is well in excess of 10,000 according to one estimate. For instance, supermarkets in the U.S. are estimated to carry about 25,000 different products.[11] Again, the implications of this variety on packaging is equally enormous. One grocery warehouse in the U.S. reported that they had to cope with 2,500 different sizes and shapes of shipping cartons. For fruit and vegetables alone, there were 1,400 container sizes.[8] It is noteworthy that in Europe, the common market has now standardized on four fruit and vegetable container sizes. Another estimate in the U.S. is that as much as 2-3 cents per case could be saved in warehousing operations, if standardized cartons and modularized shipping were developed. In Canada, Consolidated-Bathurst Packaging recently reported that it now has 10,000 customers and can produce 100,000 configurations of packaging.[1] Surely, some packaging simplification, standardization, and cost reduction opportunities do exist. But, largely, it is the inter-firm area where these economies will largely be realized.

DISTRIBUTION PLANNING TRENDS

Some recent trends are putting great pressure on physical distribution planning for the individual firm. The cost of transportation energy will rise with gasoline possibly moving to $2 to $3 per gallon. This may well make drastic changes in intermodal transportation competitive advantage. For convenience, truck

transportation will likely continue to dominate consumer goods transportation market share. However, the lower costs of rail and water shipping will increasingly become a factor on long hauls of over 200 miles. Greater use is likely to be made of full car and truck load shipments, despite the fact that this might increase inventory carrying costs, especially with record high, and rising, interest rates. A combination of these factors will mean that greater efforts will be made to stock products close to the customer. This will be especially true for retailers who will seek locations where high customer density exists, and customer ease of access is designed into the shopping facility.

Another major trend developing is the man-power supply question. As we move closer to a zero population growth, it is likely to be found that there will be more work for fewer people to do, or that fewer people are prepared to work at the low-skill level jobs for low pay which involve the traditional physical distribution methods. This trend will create greater pressure on "in-plant" material handling mechanization. Enlightened firms will seek competent, young staff to train. Then these firms will seek innovative ways to hold their experience within the firm, to operate the more sophisticated automated warehousing operations.

RETAILING TRENDS

United States

At the retail level, some major changes are beginning to become evident. Construction costs for new shopping centres have increased 8-10% annually over the last five years. In the U.S. and Canada, it is reported that there are about 19,000 shopping centres.[12] Some 61% of these are 14 years of age, or older. Consequently, many are ripe for modernization, expansion, and rehabilitation. As these moves take place, it looks as though there may be more women's apparel shops, more fast foods restaurants, and a much larger percentage of merchandise specialty outlets.

In the United States in 1958, the average shopping centre had a total of some 300,000 square feet, and 80 stores with the average store size being about 4,800 square feet. To be economically viable, there were usually two supermarkets and three anchor retail stores dedicated before the shopping centre construction ever started. By 1979, due to higher construction costs and the need to maintain return on investment with much higher interest rates, shopping centre size had dropped to about 160,000 square feet. Average store size had dropped to 2,000 square feet. There is usually only one supermarket, a total of about 125 shops, and probably only a single dedicated chain retail store.(12)

Many shopping centres, to cut costs, have focused on energy saving programs. It has been reported that parking areas at some centres have cut outdoor lighting as much as 75%. Reducing air-conditioning chilling water demands saved another 12% to 39% of air-conditioning energy requirements. The net result is that the total electricity bill in some shopping centres has been reduced as much as 3% to 10%. But such savings made little difference to the way in which retailers have performed. Utilities for them cost between 10 cents and 40 cents a square foot gross floor area. Thus, even though supermarkets may have anywhere from 50,000 to 500,000 square feet of gross floor area, the savings have not been significant.

The dominant change in retailing appears to be the rapid rise of the "box store".(13) These are the small specialty stores which probably carry as few as 600 products, none of them perishable. It costs little to equip such stores ($60,000) or to stock them ($40,000 inventory). Many occupy floor areas as small as only a few hundred square feet. In many cases, these retail outlets are part of a franchising operation. They are based upon excellent physical distribution systems which often are the heart of their merchandising plan and resulting success. As this trend continues to develop, it is expected to put increasing pressure on supermarkets and large department stores as market share is stolen from them.

It would appear that the only way that the supermarket chains will be able to survive profitably in the future, is by development of automated warehouses and further vertical integration back into the food supply system, even into the farming operations themselves, and at all stages along the line. Increasing pressure will be put upon improving the inter-firm physical distribution of cost reduction opportunities.

Canada

The Canadian situation is somewhat different. The averages referred to above obscure details of changes which are occurring in Canada. Shopping centres are moving into the smaller communities and urban centres. They too are becoming smaller. But there is not the same cut-throat competition between centres as in the United States. Planning and government control seem to be more significant here. Thus, the fight for approval of a shopping centre may be longer and tougher in Canada. Once granted, though, virtually a monopoly position tends to be assured. Consequently, profit margins are higher in Canada than in the U.S. Also, only the larger developers can survive the long project approval delays, and absorb increasing construction costs. They are national in scope and powerful. About half of all the large North American developers are Canadian firms.

Similarly, in Canada, the big supermarket chains are large and powerful. There is substantial concentration in the industry. But, competition is fiercer. Price cutting tends to be the rule and profit margins very low. Additionally, fast food and food specialty stores have grabbed a significant market share. Supermarkets have fought back by adding in-store snack food bars, small restaurants, bakeries, and delicatessans. They have added more non-food items where profit margins are higher. All this has happened even in supermarkets of 80,000 to 100,000 square feet.

But, another change is coming. Larger convenience store chains are emerging. They are moving in to fill the gap between large supermarkets and the small convenience store. They seek out locations of high urban population concentration. They carry more convenience items, food, and non-food lines, where convenience will bear a higher profit margin.

The result is that, although supermarkets are national in Canada and concentrated, they may be little motivated to institute inter-firm distribution system improvements. It has been observed that many managers in the industry have been promoted up from the floor. They are conservative and relatively unsophisticated. They are judged on monthly profit performance. There is little inducement to introduce even internal changes which will not pay off for, say, three years.

The situation in Canada for large department stores seems somewhat similar as for the supermarkets. One difference is that they do not seem to have organized as effective a lobbying group.

Much of what is said in this sub-section is based upon hearsay and conjecture. Nevertheless, there is evidence that the Canadian situation is different from that of the U.S. More research on the physical distribution of consumer goods in Canada is essential, with particular reference to the impact of packaging and system improvements.

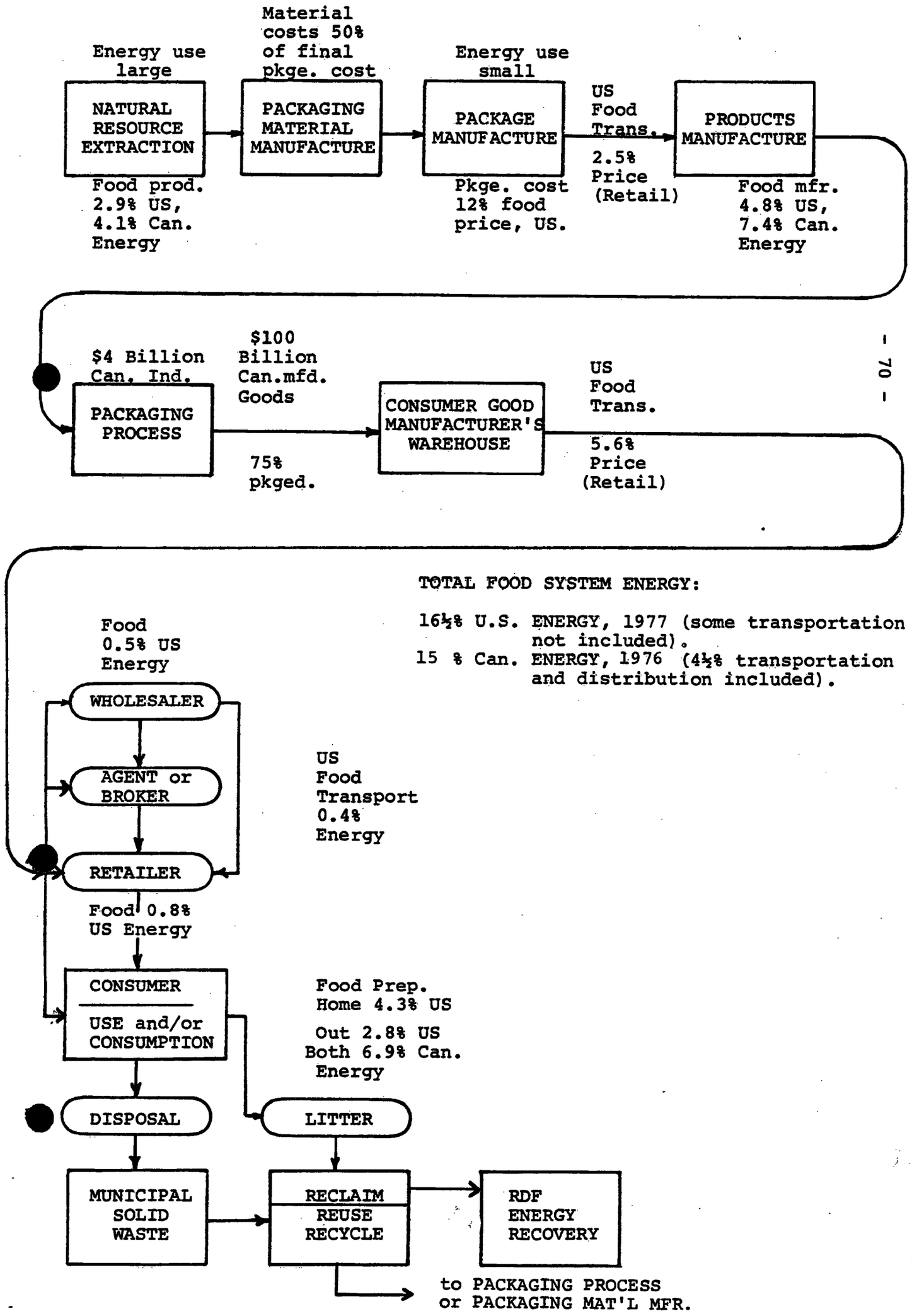
PHYSICAL DISTRIBUTION FLOW CHART

From the preceding material, we produced a simplified physical distribution flow chart. We attempted to highlight the relative importance of packaging and energy consumption in the food products industry. Where data were available, we attempted a comparison between Canadian and U.S. statistics. It soon became obvious that adequate data was not readily available. Figure I is a summary of relationships and readily available data useful to include in a guide for a planning study such as this one.

FIGURE I

SIMPLIFIED PHYSICAL DISTRIBUTION FLOW CHART

CANADIAN FOOD PRODUCTS SECTOR WITH
COSTS AND ENERGY CONSUMPTION HIGHLIGHTED



CONSUMER PRODUCT TRENDS

Thirty-six American packaging experts provided the magazine "Food and Drug Packaging" with their forecasts of the industry's developments through to 2000 A.D.[14] Their predictions are summarized in the section which follows. Boston Gilbert Henry Associates Ltd. do not necessarily agree with all these U.S. forecasts, but they do reflect current industry thinking.

SOCIETY'S CHANGING NEEDS

It is expected that the trend to more one and two occupant households will increase. There will continue to be an increasing number of working mothers. Increased leisure and life style based upon this fact will become increasingly important. The "better life" will become increasingly important and ego gratification will become an important aspect of life style. The trend to more convenience will be very noticeable in food and other consumer products. The baby boom is passing through the mature adult phase to the geriatic age group. With this adult dominance in the population, it is likely that consumers will become more sophisticated. Diversity of interests and personal tastes are expected to lead to an astounding number of product variations. At the same time, the move to no-frill products and standard packages will become an important marketing factor. But, consumer boredom with identical products is not anticipated, due to the tremendous variety of products expected to be available in the market place.

In 1978, the U.S. market penetration of micro-wave ovens was about 10% of all households. By the year 2000 A.D., it is expected that saturation will be achieved and 80-90% of all households will have a micro-wave oven. Simultaneously, it is forecast that shopping by telephone or by use of a t.v./computer/telephone communication system will develop to facilitate household shopping. These equipment developments are

expected to lead to marketing and distribution systems which will be specially designed to cater to urban householder demands for low-cost and convenient shopping.

It is expected that special interest groups will continue their efforts to protect individuals from the imperfections of the manufacturing and distribution system. Regulations will be sought to provide for risk-free living. Demands will increase for regulations concerning: carcinogenic materials, increased labelling information, wage and price controls, restrictive employment practices so far as manufacturers are concerned, control of emissions and waste products of all types. It is likely that trends in packaging and distribution systems will increase the number and size of the multi-national corporations. This will lead to increased trade between countries and a sharing of world problems. As trade barriers tend to fall away in time, cultural differences and prejudices are expected to decrease. All industrialized countries are likely to share common marketing techniques. The move to metric sizes will become universal and bilingual and multi-lingual labelling will become common.

No longer will food be packaged primarily for the sake of marketing (packaging for product identification). Increasingly, packaging will be for the maintenance of the quality of the product and its protection during distribution and marketing. Escalating costs and the impact of continued consumerism will swing packaging to meet society's needs, not its wants.

INCREASED ENERGY COSTS

There seems to be little doubt that the cost of energy in all its forms will escalate substantially in the next decade. The traumatic rise in crude oil costs will cause a similar jump in the cost of all plastic materials. Also, due to rising energy costs, it is expected that replacement of many conventional containers and packages by those made of other materials

will appear quite rapidly. Glass bottles will be replaced by plastic PET and PVC bottles. Heavy Kraft wrappings will be replaced by thin multiple layer flexible films of plastic. Multi-layer plastic packages will replace glass, steel, and paper packages of all sorts. Aluminum containers will tend to disappear. Alloyed materials, particularly those made of powdered metal coatings, are expected to become much more common. Smaller households (one and two persons) prefer the smaller package sizes. Such consumers may resist the trend to larger, more energy efficient and less costly package sizes.

Transportation energy costs will become increasingly important. A trend has already begun to lighter weight, less expensive packages. The industry will attempt to reduce the transporation space required by products in transit. This will accelerate the move to flexible packaging. These particular types of packages will have to be designed with the ability to withstand high pressures due to stacking, as well as for the binding of packages in bales or on pallets.

In general, a trend is already identifiable of the move away from energy intensive packaging. A greater emphasis on packaging materials that are readily available will become more evident. To minimize solid waste disposal problems, there will be an emphasis on the development of reusable/recyclable packages. Environmental pressures against packaging will further emphasize this trend.

The consumer too will be concerned about the cost of energy as it relates to shopping. There is already discernibly a trend towards householders wanting to bring more products home per trip. But real developments in this area are likely to come only from radical changes in shopping systems.

PACKAGE DESIGN TRENDS (14) (15) (16)

Although it is expected that glass containers and cans will continue to have the lion's share of container markets, there is a strong trend in the United States towards the development of large plastic bottles. This is expected to continue.

For food use, the retortable pouch is the most important new development. These pouches are likely to be made flexible and perhaps entirely of plastic. The base will be free of aluminum for micro-wave cookery. The polyester-coated paperboard tray seems to be the answer for this type of oven use. In general, for all types of food and non-food products too, the trend is to lighter and stronger - jars, cans, closures, paperboard, corrugated, rigid, and flexible containers. Increasingly, packaging will be made of composite materials, designed to especially meet packaging and consumer needs.

There will be a move to fewer disparate shapes. The demand for standardized containers will arise more frequently.

There are to be many changes in pouch packaging operations. The use of form, fill, sealing of such packaging at high speeds, will become common place. These speeds are expected to soon approach those of canning operations. Faster packing will facilitate in-line package manufacturing and filling. The filling of flexible packages will be done in controlled atmospheres, either in a vacuum or with an inert gas. There will be a move away from conventional adhesives to extrusion laminating. Within a decade, it is expected that 75% of all thermoplastic structures in packaging will me made by coextrusion. Packages will be gas flushed and then sealed. Soon all food products are expected to have open-date coding.

With changes in shopping systems expected, the need for research and development on identifying graphics will become increasingly important. So, also, development will be of pollution-free colouring materials. Further development in low oxygen-permeable food wrapping films will occur.

With all these anticipated changes, it is argued that corporate conglomerates tend to stifle the incentive for research and development. They tend to have pressures on them to integrate systems improvements into the corporate empire and not share profits. However, the very diversity and number of firms in the North American packaging industries virtually ensures abundant ability and a marked ease to adapt to cost reduction changes which meet society's needs.

PACKAGING, DISTRIBUTION, AND MARKETING SYSTEM CHANGES[14][15][16]

For the above-indicated changes to come about, it is of paramount importance that an interactive systems emphasis be developed by all the industries involved with packaging, processing, distribution and retailing. Large corporations, to survive, must develop an interactive corporate system which emphasizes an integration of - marketing, research and development, engineering, purchasing, operations, and physical distribution. Europe and Japan have led in this kind of approach. The reason for this is that energy, materials, and labour were generally more expensive and less available for several decades prior to this being a factor in North America.

In North America, retailing will cease to be on the basis of price alone. Pressures will increase on vendors to improve their operating efficiency and to blend their operations into the physical distribution system. To meet non-food packaging needs, increased emphasis on high-speed automatic blister packaging is anticipated. With micro-wave ovens in widespread general usage, foods are expected to be largely prepared in an entirely different way. Many food products will be irradiated, freeze-dried, compressed into retortable pouches which will allow for reconstitution in micro-wave ovens. This will lead to further development of food analogs. All package design will emphasize ease in handling, low storage, and lower transportation costs.

Computer control of production and distribution operations is just in its infancy now. Almost unbelievable sophistication is soon to come. Supermarkets will tend towards having a small front room. These will have single product displays. The consumer will choose his products, communicate his choice to a computer which will then arrange to select and dispatch products for pickup at a check-out counter. With t.v. and telephone communication, it is anticipated that this type of shopping can be converted entirely to a household operation with either household delivery or consumer pickup options.

To meet these new packaging systems, it is expected that food producers will also make radical changes. Increasingly, integrated harvest and packaging operations will become feasible on the farm. One estimate has it that at least 90% of all fresh beef and pork will be provided boneless, in aseptic-filled bags or boxes. Also, about 50% of these products are expected to be centrally prepackaged in flexible, multi-ply films, having low-oxygen permeability and be vacuum-packed.

To meet the changes in the supermarket described above, food and non-food manufacturers will supply their product in specially-designed, factory-packed bulk modular containers. These will be suitable as aisle displays for retail use, or in automated wholesale warehouses. The system is already well-developed in Europe, but is in its infancy in North America.

In parallel with the production, packaging, and retailing developments, it can be expected that an increasing emphasis will be placed upon recycling and reclaiming solid wastes of all types. In fact, it is highly likely that closed systems to return these materials to packaging manufacturers or product manufacturers will become almost mandatory by law or economics. In the food systems, further concentration in the processing industries will be encouraged, if only to facilitate the economic recovery of food processing wastes on a large scale.

All the developments above are well-identified and described in the literature. Many prototype projects are already operating successfully throughout the world. Some of the more sophisticated proposals are technically feasible now, but have not really been put into commercial application (e.g. t.v./computer shopping). The important question then is: how long is it expected before some of the developments referred to above become common place in North America. Industry specialists can only point to the time for other similarly important changes to have occurred. For example, in the United States, the plastic beverage bottle was first introduced in 1965. However, it was not until 1978 that the first year of significant commercial production really developed.

REGULATION[14]

The packaging industry is greatly concerned about the demands of special interest groups to protect society from its imperfections. The industry sees strenuous demands for increasing regulation to provide for risk-free living. They expect that this will lead to impossible demands and attendant exorbitant costs to provide extraordinary consumer protection. The industry argues that man has always lived in an adverse environment. His life has been sub-optimal and imperfect. Man through his fight to survive has evolved, expanded, and improved his approach and his standard of living. The packaging industry has many strong advocates of a government laissez-faire attitude towards them. They encourage the free enterprise profit motive as a means to cause the above changes to come to place in a reasonable time in North America. The reasonableness of this claim needs to be examined in considerable depth.

REVIEW OF SOCIETAL FACTORS[17],[18],[19]

There seems to be general agreement amongst demographers in Canada that the substantial shifts which have taken place in the structure of the Canadian population will continue through to the year 2000. In the post-war era, younger age groups generally predominated. This gave our population pyramids a "bottom-heavy" appearance. This effect intensified and, by 1961, 42% of the Canadian population was under age 20, compared with 37% in 1946. Recently, declining birth rates have significantly changed this picture. By the turn of the century, less than 30% of Canada's population will be under 20. Instead, the 35 to 45-year age group will predominate.[17]

As this change in population composition progresses, Canadian consumers will become older and more sophisticated. Through the 1980s, as this change occurs, we will have a maturing population, growing slowly at around 1% per annum. The population will tend to be better educated with a more experienced work force supporting fewer dependents. Birth rates declined in recent years and the percentage of women in the work force increased. Average household size has decreased significantly. There has also been a marked increase in what is known as "non-family households". This means a household maintained by a single man or a single woman. In some communities, such households are now 25% of the total, representing a significant market.

Another factor of enormous impact is the large number of married couples who both work. Even when women get married and have children, they create markets of a new kind. It seems they no sooner have a child or two, then they go back to work again. The new demand for associated services and convenience goods is another growing market area.

What is foreseen then are hordes of busy people, large numbers living in our urban communities who are holding jobs. They will be moving into the central age brackets, often

splintering into smaller working households. Many of these households will be of novel types, with more women on their own. Particularly, more adults are expected, with a keen appetite for consumer goods and money to spend on luxuries and on leisure activities. Many econometricians believe that real disposable income per family is likely to rise. But how people will spend their income is likely to be quite different than in the past. For a long time, the trend was toward bigger and more elaborate automobiles, appliances, etc. As energy gets more expensive, it is expected that the demand will be for stripped-down models. But that stripped-down version will be expected to work and be of high quality. Busy people cannot afford to wait at home for a service man, or to put up with the inconvenience of things that don't work in the way that they should do so. This will be particularly true of the high disposable income families and of individuals who will be expected to be shopping in the market place of the future.

With time the most precious commodity, most everyone agrees "convenience" will be the big demand of the next decade. It does not necessarily follow, however, that working women will interpret convenience as TV dinners. They may prefer fresh food or gourmet meals. These changes in consumer tastes for food and other products will have significant implications for packaging. Just how these changes will impact upon packaging is difficult to forecast.

Up until now, the Canadian packaging industry has virtually taken it is a matter of "human right" that Canadians may purchase consumer products in an extraordinarily wide range of package sizes and types. Consumer good manufacturers have chosen to establish brand identification by putting their products in packages or containers markedly different from those of their competitors, in size, colour, shape, and as many other ways as they can find to distinguish their product and to increase its convenience for the consumer. There have been few signs that this is changing. The Canadian Government has

begun its move to convert Canada to the metric system. A number of consumer products are now coming out in metric-size packages and containers. Consumers have not seen this as a matter of convenience, nor have consumer goods manufacturers. In fact, it has led to substantial extra costs for a number of them. One container manufacturer has indicated that his firm invested $250,000 in one year on metric conversion of packaging which amounts to a sunk cost with no visible return. There has been little benefit to consumers also because, when it might have been possible to move to standard sizes at the same time, no effort was made to combine these concepts to the advantage of the consuming public and the Canadian manufacturers.

By comparison, a more effective example of change in consumer attitudes was the result of the public outcry against environmentally-degrading milk containers. Since 1945, these have evolved from glass bottles, to paper cartons, to plastic jugs, and then to plastic bags. Ultra-high temperature (UHT) treatment of milk in what are known as retort containers, (e.g. tetrabrik) will lead to a further refinement of milk packaging. Refrigeration will no longer be required.

At the present time, most consumer good manufacturers see retortable pouches as the packaging change which is most likely to evolve over the next decade. Thus, food and beverage manufacturers will probably develop retortable products to respond to the changing demographic make-up of Canada and the shifting consumer tastes. Other packaging and consumer product developments will increase the multiplicity of new products available to the consumer annually. Most of these will be novel package designs. Thus, the proliferation of product types, sizes, and package variety is likely to continue unabated unless some form of government regulation develops. This is much feared by the consumer manufacturers and packaging industries in Canada and the United States, but so far, little evidence of self-regulation has been evidenced. Inter-firm

rivalries for market share, particularly in slow growing market areas, do not lead to standardization, or the reduction of inter-firm physical distribution system inefficiencies. Only giant, vertically integrated firms are likely to make these moves unless some new ultra-efficient merchandising competitor appears on the scene. Small "box" store franchise operations are increasingly appearing in the market place. These may be one of the emerging factors which will lead to product variety rationalization, package size standardization, and related physical distribution system improvements.

From the consumer's point-of-view, a new breed is appearing in the market place. This individual will have attitudes which combine qualities from several of the former basic life styles. He will have many of the achievement drives related to such goals as: accomplishment, recognition, prosperity, etc. He will also likely place a high value on tradition, but will recognize the fact that the world is changing. From this, he will derive some excitement in the sense of recognition if he is able to be in tune with such groups as the consumer advocates, social critics, environmentalists, etc. Finally, as a private citizen, the individual will likely opt for an inner seeking for that sense of: serenity, wisdom, or accomplishment which is necessary for the building of a person-centred society. In some ways, this type of individual is characterized by what Stanford Research Institute in the past has referred to as a "voluntary simplicity" life style. It is also similar to that group of individuals who espouse the concepts which describe the "conserver society".

Some public opinion polls in Canada indicate that this segment of the consumer market is expanding. Some forecasts in the United States have indicated that, by the late 1980s, such attitudes might be held by as many as one-third of American consumers. Should this be the case, the emerging consumer of the future will be a more frugal, person-centred, experience-seeking, inward-looking, ecologically-aware buyer.

That being so, one can foresee a strong pressure from consumers advocating simpler packaging, not over-packaging. They would also demand more energy-efficient and less polluting packaging. These demands are likely to be expressed in two ways. Firstly, consumer advocate groups are likely to seek government assistance in achieving their goals. A larger segment is likely to merely refrain from purchasing those commodities which they do not find satisfying, even though the unit costs of the alternatives may, in fact, be somewhat higher.

Again, many of the points made in this section are based on various Canadian and American studies. There is much conjecture as to how the inter-related variables of: demography, life styles, merchandising techniques, product design, and packaging will evolve. We have given, in this and in an earlier section, our best opinion of what will come.

CONCLUSIONS

1. During the course of this study, it became apparent that there were many sources of useful information. A great many studies have been done on packaging and on energy and resources used in packaging. Significant studies done in the U.S. have been adjusted to apply to Canadian circumstances. In general, we have found close agreement in the various studies and the differences in results, numerically, have generally proven to be insignificant.

2. Our greatest difficulties with information deficiencies relate to food systems energy content, and packaging requirements throughout the physical distribution system. At this time, it does not appear that there is an adequate information base available for planning requirements in either area.

3. Although not quite so significant as in the food system, packaging in the non-food industries may represent significant opportunities for energy conservation through packaging substitutions. Here, we are referring specifically to such products as: soap, cleaning compounds, tobacco, miscellaneous chemicals, pulp and paper products, toilet products, paint, and pharmaceuticals. As a further example, we found that 20% of the non-foods are concentrated in ten Canadian manufacturing industries, including those just listed previously.

4. Much is known about the energy consumption and packaging requirements for milk and beverages. By comparison, much less information is available on vegetable products. Further study is definitely warranted on such vegetables as peas and carrots supplied to the market, either in cans, frozen, or in retortable packages.

5. Any study of packaging of food products should not be done on an isolated segment of the total food distribution system. We have found that any one Canadian food system and the related packaging requirements from the farm right through to the householder's use and final disposal of the package and/or organic wastes is a very complex problem. Furthermore, it does not appear to be well understood or generally documented for public information purposes.

6. Any packaging energy savings appear to be able to be accomplished only through a product-by-product, industry-by-industry initiative. Savings are most likely to accrue through product and package standardization, with emphasis on refillable containers and a system to collect them. The greatest chance of success will be where a wide network of physical distribution exists which is strong and probably closely controlled by relatively few suppliers.

The best example in Canada is probably the Ontario beer industry, although some other provinces are attempting to duplicate the breweries' warehousing systems for products other than beer.

7. The most significant energy savings opportunities through packaging changes appear to be difficult to implement. There are grave problems of convincing consumers, distributors, and producers to change well-established ways. There are significant problems to be overcome regarding equity in the management of deposits on refillable containers. There are also important problems of cash flow for an industry trying to convert from one packaging system to another. This implies the need for financial assistance in some cases to achieve goals which appear strong in the public interest.

8. Milk distribution systems and packages are highly energy efficient. Plastic jugs (refillable) require only 1.4 million BTU's per 3,000 quarts delivered. Even the worst package, paper cartons, require only 4.1 million BTU's for the same isoquant.

By comparison, carbonated soft drinks, beer, and juices require 18.7 million BTU's for the best container, a refillable glass 10-trip bottle, and 68.9 million BTU's for a disposable, aluminum can with the same isoquant as for milk listed just previously. Similarly, the best and worst cases for wines and spirits are the 12.8 million BTU's for a refillable plastic 20-trip container and 64.8 million BTU's for a non-refillable glass container, a gain for the 3,000-quart isoquant.

9. Recycling beer bottles and soft drink bottles are energy intensive due to the need for label removal. Not only is there a high energy requirement, but the labels are also heavy consumers of caustics in the label removal process.

10. The recycled family-size soft drink container of glass saves 25% of the energy embodied in the container. The U.S. plastic non-refillable container saves 30% of the energy embodied in the package. By embodied energy, we refer to the energy required to obtain the resource material, produce the package, and take it right through the physical distribution system and the consumer and land-fill site for ultimate disposal.

11. Some package types, such as the TetraBrik, at first, appeared to be bad from an energy requirement if only the packaging is considered. If, however, a credit is given for the contained product not requiring refrigeration and a lower cost of storage and handling throughout the physical distribution system, a quite different conclusion may be

reached. At the present, we have been unable to quantify the energy conservation for this particular packaging type.

It should also be noted that the consumer may consider that milk supplied in a form requiring refrigeration is quite different and perhaps more acceptable than milk processed quite differently and aseptically packaged.

12. There are a number of important corporate economic justifications for not instituting energy conservation substitutions at the present time. The institutional barriers deterring energy saving packaging changes require further study.

13. It is believed that, in Canada, the aluminum can is a worthwhile package for certain products. However, this is true only if the aluminum in the can is recycled to recover the high energy content. Even then, this type of container can only be justified with very high recovery rates of, say, 90%, or more.

14. Aluminum foil appears to be a preferred packaging material from a total systems energy viewpoint. This seems to be particularly true where aluminum foil is used in composite packaging materials.

15. Security of supply of aluminum for packaging materials in Canada is an important question. All Canadian aluminum manufacture is based upon cheap hydro-electric power. As the cost of liquid hydrocarbon fuels rise dramatically in the future, it may be that the Canadian aluminum industry may convert to the distribution of electrical energy, rather than the manufacture of ever increasing quantities of aluminum. The import of this question with regard to aluminum for Canadian packaging material manufacturing should be explored.

16. This study indicates that plastics have advantages for energy-conserving packages and containers. This appears to be a preferred use of a product (plastics) derived from liquid hydrocarbons and natural gas products. It may become necessary to develop policies that ensure a continued supply of raw materials for plastics to manufacture energy-conserving packaging.

17. The retortable pouch appears to a good substitute for many of our present packages. It appears to be, generally, energy conserving as compared to other package types, such as cans or frozen foods. Since the pouch tends to be flat, it takes less cooking energy than is required to cook and pasteurize the contents of a can right through to its centre. There is, therefore, less energy used during processing than for other package types. It is also argued that, because of the process, the product actually has a higher quality and tastes more nearly like frozen vegetables. Again, the retortable pouch requires less energy for processing and preservation than do packages of frozen vegetables.

The retortable pouch is said to use less energy in cooking, whether or not a micro-wave or a conventional oven is used. There is also the advantage that no refrigeration is required for the retortable pouches.

At the municipal solid waste disposal, the retortable pouch burns to almost nothing. Most of the contained energy can be recovered, either as refuse-derived fuel or as heat recovered through incineration.

18. Any packaging changes can have truly significant effects on the municipal solid waste stream. The lead foil cover on the neck of a wine or beer bottle may appear insignificant as a packaging or labelling design detail. However, it can become a major contaminant in glass cullet, sufficient to make the cullet unsuitable for reuse.

Another example is that an incremental change in one industry, such as the substitution of a plastic pouch for a box-board soap container, could ruin a market for recycled, low quality paper. The energy saving might be only 20% on the particular packaging substitution, but the impact on the secondary use of the product and on resource conservation could be substantial.

19. The whole question of over-packaging appears to be misunderstood and the amount substantially over-stated. It can be concluded by marketing and distribution experts that all packaging is necessary. The only question of over-packaging relates to the use of the container as a marketing tool. The examples of over-packaging we have looked at appear to be a trivial opportunity for energy conservation. Any savings would be very difficult to accomplish. This is despite some obvious environmental benefits which would result.

20. Our best estimate of the maximum potential packaging energy conservation is to recover all packaging energy from the municipal solid waste stream. If all packaging energy were recovered as refuse-derived fuel, the maximum saving would be 42% of the total Canadian packaging energy (0.07×10^{15} BTU's).

If in addition to refuse-derived fuels, all plastic, glass, and metal were recycled, the maximum potential energy saving would be 61%, or 0.10×10^{15} BTU's.

This estimate is for current packaging practices. No adjustment was made for packaging reduction or substitution because of the long lead times to realize significant benefits.

This packaging energy savings estimate is an impossible target. It is only given as a current upper limit of what is theoretically possible. The best case for energy conservation in packaging in the short term will probably derive from the: milk, carbonated soft drink, wines and/or spirits industries in Canada.

21. The gross assumption of energy savings potential in packaging for the milk, soft drinks, wine and spirits industries is for two-thirds of the system packaging energy. To achieve this best saving figure, it would be necessary to go to a plastic refillable container. Also implied is a high degree of industry concentration and a sophisticated product distribution system and container redemption system.

22. Substantial packaging energy conservation opportunities appear in the food and non-food processing industries by the adoption of standardized containers, bottles, and cans. If a system could be devised whereby these containers could be reused by any manufacturer anywhere in Canada, the energy conservation benefits would be substantial. There are serious impediments to the accomplishment of this aim in a reasonably short-term of years.

23. Packaging seriously affects food system energy requirements during processing, transportation, distribution, and home preparation. Although only 2% of total Canadian energy requirements go for food packaging, the type of package and total food system energy requirements affected appear to involve as much as eight times the total energy attributable to the package itself.

24. Substitution of one package for another must consider the total system multiplier effect as regards energy requirements.

25. The foreign trade aspects of packages used by Canadian manufacturers cannot be ignored. Distillers in Canada have a high export volume of business. It is believed that a standard package might provide a disadvantage in foreign markets. This consideration needs to be examined.

By comparison, the carbonated soft drink manufacturers have few exports and are little affected by imports. For them, a standardized package might have little foreign trade effects. For wine, there is a high percentage of imports into Canada. The same applies to fruit processors. This factor of imports makes standardization of packaging or substitution of energy-conserving packaging far more difficult to deal with because of the system externalities.

26. Recent negotiations internationally have led to tariff reductions on as many as 3,000 to 5,000 food products imported into Canada. Any emphasis on packaging or other energy conservation changes which adversely affect Canadian production costs will make it increasingly hard for small producers of these products to survive the expected increase in foreign competition.

27. Retail chains, whether supermarkets or department stores, potentially, could have a strong impact on packaging substitution for energy conservation. This applies probably equally to food and non-food products. Any significant savings are likely to accrue from inter-firm co-operation, but, at the present time, there does not seem to be sufficient incentive to cause the retail chains with narrow profit margins to assume this challenge. Only vertical integration within the related processing and physical distribution industries or government initiatives are likely to cause these changes to come about.

Our conclusion at this time is that we just do not know enough about packaging at the retail level and to what extent major corporations are prepared to become change agents with respect to energy conservation through packaging substitution.

28. We have observed that current Canadian consumer life styles are complex and are changing at a fast rate. This affects packaging. It affects the ease with which new products can be introduced to the consumer and the time span over which changes from one product or package to another will occur.

The opportunities for package substitution to derive energy conservation benefits are definitely a function of changes in consumer preferences which reflect changes in consumer attitudes and behaviour.

More work needs to be done to understand how the consumer will respond to the future, adapting life styles to take advantage of recent technological innovations regarding packaging and consumer products.

29. We have been unable to locate a comprehensive analysis of how consumers use energy in the household. Some work has been done in the U.S. and by Agriculture Canada on energy conservation in cooking and food preparation. It would appear that there is an opportunity for much more to be done in learning about how consumer products used in the average Canadian household affect energy consumption.

30. For the first time since the 1940's, real net disposable income in Canada is declining. This is a new factor to many families, one with which they have had no direct experience. This could signal a time for a new approach. As cost awareness increases, the tendency towards a conserver society could increase. Similarly, the attitude towards throwaway packaging could alter. The impact of this new factor on consumer product marketing requires further analysis.

31. The mode of retailing dramatically can affect packaging needs. Similarly, retailing can have significant energy conservation potential. The speed with which some of the radical innovative retailing approaches will be introduced into Canada and accepted by the consumer requires consideration.

32. Secondary and tertiary packaging may have reusable options in the physical distribution systems. These require further investigation.

33. Inadequate information is available concerning inter and intra firm costs for the Canadian physical distribution systems. Also lacking are data on inventory control and packaging aspects of consumer product movements through manufacturing and wholesaling to retailing. A survey should be done in Canada comparable to that done in the U.S. by the National Council of Physical Distribution Management.

RECOMMENDATIONS

Based upon our analysis, observations, and conclusions, we have prepared the following recommendations. These all relate to a requirement for further planning studies, and research regarding energy conservation opportunities relating to consumer product packaging.

1. Prepare a detailed framework for analysis of the Canadian packaging industry as a planning guide to formulate strategies for energy conservation.

We see this as an extension of the energy conservation opportunities regarding consumer product packaging in the food and beverage industries of Canada outlined briefly in this report. (Cost Estimate: $100,000)

2. (a) Review of Federal Government options under existing laws and regulations to induce consumer product packaging changes.

   (b) Examine Federal Government opportunities to co-ordinate the efforts of others regarding energy conservation in consumer product packaging. Here we refer to inter-provincial and inter-government liaison, as well as ways of obtaining industry and consumer co-operation.

   (c) Consideration of the effectiveness of the government's role in using educational and promotional programs to achieve its energy conservation objectives regarding packaging. We would see these programs being aimed at at least two audiences, the general public and industries involved with consumer product packaging systems.

   (d) Review of existing Federal Government policy tools and initiatives relating to consumer product packaging and energy conservation. Additionally, relevant departmental program objectives should be analysed for coherence or gaps as they relate to the topic.

(Cost Estimate: $30,000)

3. Use the Canadian beverage industry to test the analytical framework referred to in Recommendation 1 and the opportunity for applying government initiatives to accomplish the desired objectives as per item 2. (Cost Estimate: $30,000)

4. Preliminary input/output analysis of Federal Government policy options regarding consumer product packaging. Here we are particularly concerned with the inter-industry reactions and the multiplier effect of consumer product packaging substitutions to affect energy conservation objectives. We would also want to look at the total multiplier effect on the Canadian economy and any foreign trade ramifications readily identifiable. (Cost Estimate: $20,000)

5. Examination of trends in packaging design and consumer product marketing, with particular reference to Canada. What is to be sought is the most probable time for significant changes in packaging to be introduced and the estimated rate at which such changes could occur. Both short-term and long-term changes should be considered. Two typical examples might be the standard size vegetable containers, larger size soft drink containers, substitution of plastic containers for glass bottles, home availability of draft beer, home production of soft drinks from concentrates, bulk packing of boxed beef, retortable pouches for specific products, etc. (Cost Estimate: $20-100,000)

6. Study of packaging needs and trends for fast food outlets. The study should also include the possibility of reuse, reclamation, and source separation of wastes. (Cost Estimate: $20,000)

7. Analysis of total systems energy saving regarding the use of the retortable pouch for several food products (e.g. main course entree dishes, vegetables, milk, pet foods,

fish products, baby foods). We see this as a phased project which would concentrate on one food product at a time. The analysis would probably require three iterations to obtain satisfactory conclusions. (Cost Estimate: $100,000)

8. Creation of a research facility for Canadian food processors wanting to test retortable pouch packaging and products. This would be a pilot project production line, having sufficient capacity to allow food processors to test market retortable pouch consumer products. (Cost Estimate: $300,000)

9. Technological assessments, including market and impact analysis of new packaging products involving significant substitution effects. Examples are the German spherical plastic beer container, the Swedish Tetra Brik container for milk and juices, retortable pouch use, composite package materials for oven-ready cooking, etc. (Cost Estimate: Assumed four at $20,000 each = $80,000)

10. Detailed review of non-food consumer product industry packaging for energy conservation potential. (Cost Estimate: Preliminary $10,000)

11. Review of industrial concentration in Canada of major manufacturers and distributors of consumer products. (Cost Estimate: Preliminary $10,000)

12. Examine the potential for the use of standardized containers for secondary and tertiary packaging purposes. This we see as a review of the needs of wholesalers and retailers, including package manufacturers respond to the challenge. (Cost Estimate: $30,000)

13. Study energy conservation potential in the Canadian food distribution system. What is required here is a detailed study comparable to what has been done in the beverage industries. This study should be oriented instead to a processed food (e.g. peas, carrots, or corn) and a fresh food (e.g. beef or a fresh vegetable). (Cost Estimate: $40,000/each
Total: $80,000)

14. Identify opportunities for the introduction of standard, reusable containers in the food and beverage industry.

(a) Plastic shells for beer (Cost Estimate: $15,000)
(b) Standard wine bottles (Cost Estimate: $10,000)
(c) Standard glass food jars (Cost Estimate: $10,000)

15. Examine whether the aluminum can is a viable alternative for soft drinks, beer, fruit juices, and vegetables. This study would assume a recyclable can. This study would also have to consider alternate collection and recycling systems sufficient to assure can recovery rates in excess of 80%
(Cost Estimate: Preliminary
Study : $10,000)

16. Investigate the possibility of Canadian distilleries going to standardized refillable containers for spirits.
(Cost Estimate: $20,000)

17. Study the impact on Canadian package manufacturers of industries going to standardized containers (e.g. manufacturers of corrugating medium, fold and set-up box manufacturers, producers of glass bottles, etc.).
(Cost Estimate: $15,000)

18. Examine the role of retail chains, both food and department stores), as change agents with regard to packaging substitution for energy conservation.
(Cost Estimate: $25,000)

19. Long-range planning study of future Canadian life style scenario, giving the most probable picture of the long-term effects of changes in: retailing methods, personal disposable income, consumer purchasing habits, attitudes towards conservation, and the role of packaging as it relates to changing demands for consumer products. (Cost Estimate: $40,000)

20. Market research on consumer acceptance of new food items. This would involve consideration of not only the product, but the packaging as well. We believe that several such foods should be considered. (Cost Estimate: $50,000/ product)

21. Market survey of the propensity of people to conserve energy in home food preparation. This study could possibly be extended to include other aspects of energy conservation concerning non-food consumer products as well. (Cost Estimate: $30,000)

22. Market analysis of consumer trends to bulk buying in urban centres. Consideration should be given to recent expansion in the number of farmers markets, bulk specialty food outlets, potential bulk distribution of automobile oil, etc. (Cost Estimate: $25,000)

23. A general review of current public acceptance of the conserver society concepts. It would be necessary to define these concepts succinctly for the purpose of this review so that a two-phased study may be required. (Cost Estimate: Preliminary Study : $15,000)

24. Market survey investigation of reuses of non-returnable packages (e.g. plastic pouches, mother bags, plastic shopping bags, paper shopping bags, rigid plastic containers, glass jars, plastic soft drink shells, plastic cleaners bags, cardboard from folded laundered shirts, corrugated and other boxes, etc.). (Cost Estimate: $50,000)

25. Demonstration project for the introduction of standard containers for, say, soft drinks or wine. Such a project would need industry, as well as local support. The demonstration would use a multi-phased approach which would include such aspects as the design of the demonstration, the preparation and supply of the product to the consumers, project management and evaluation of the project.

As a first step, we would propose a feasibility study.

(Cost Estimate: $30,000)

Depending on the extent of industry and community support, the cost of the demonstration could vary greatly.

(Cost Estimate: $150,000?)

26. Research on the nutrient value of new food products for which previous research referred to above has indicated considerable consumer acceptance. Examples might be ultra-high temperature processed food products and, more conventionally, processed retortable pouch food products. We assume that approximately four products would be studied.

(Cost Estimate: $100,000)

27. Research on the nutrient value of food prepared in the home by alternative cooking processes (e.g. conventional ovens, stove-top cookery, micro-wave ovens, and convection ovens). (Cost Estimate: $100,000)

28. Further review of waste management options to determine their probable effect regarding energy conservation in the short-term of the next five years. By this, we refer to the possibility of widespread introduction in Canada of household source separation of wastes, municipal incineration of municipal solid wastes for heat recovery, and the use of refuse-derived fuels for energy recovery purposes. This work should be done with particular reference to the potential for the recovery of energy from consumer packaging materials.

(Cost Estimate: $20,000)

29. Undertake an exercise to priorize a planning approach whereby strategies to accomplish energy conservation through packaging improvements could be introduced over a reasonable time horizon of five years, with consideration of a second five-year period. (Cost Estimate: $20,000)

A P P E N D I X 1

PACKAGING MATERIALS ENERGY

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TABLE 1

Energy Content of Packaging Materials

	10^6 BTU/ton
Tin Plate	43.5
Aluminum Foil	233
Paper Board	21 (57*)
Corrugated	24 (60*)
Kraft Paper Bags	20-25 (56-61*)
Glass (as bottles)	15-20
LDPE Film	102
HDPE Resin	89
Wood	≈2 (38*)

Source: Ontario Research Foundation.

* The figures in parentheses assume that trees are an energy source, and therefore their use to produce cardboard must be counted as depleting the overall energy supply.

TABLE 2

TOTAL PACKAGING MATERIAL ENERGY IN LAND FILL WASTE

Package Type	Proportion of Total Energy Associated with Material
Non returnable glass bottle	81
Returnable glass bottle 1 trip	87
10 trips	41
20 trips	26
Bimetallic Can T&G opening	86
BD opening	85
All Steel Can	78
All Aluminum Can	89
Plastic Film Pouches	97
Plastic Milk jug 1 trip	72
20 trips	46
200 trips	11
Plastic Cases 1 trip	78
100 trips	50
Corrugated Cardboard	85
Plastic Coated Paper Board	88

Source: Ontario Research Foundation

TABLE 3

TOTAL PACKAGING MATERIAL ENERGY IN LAND FILL WASTE

	Materials Energy Content 10^6 BTU/ton	% of Total Represented by Material	Total Energy in Waste 10^6 BTU/ton
Tin Plate	43.5	78%	56
Aluminum	233	89%	262
Corrugated	24	85	28
Paper Board	21	88	24
Kraft Paper Bags	22	88	25
Glass N/R	17	81	21
Returnable 1 trip	17	87	19.5
10 trips	17	41	41.5
20 trips	17	26	65.4
LDPE film	102	97	105
HDPE Milk Jug 1 trip	89	72	124
20 trips	89	46	193.5
200 trips	89	11	809
Plastic Cases 1 trip	89	78	114
100 trips	89	59	178
Wood	≈2	75	≈2.7

Source: Ontario Research Foundation

TABLE 4

WASTE DISPOSAL STATISTICS, U.S.A.

POST-CONSUMER NET SOLID WASTE DISPOSED OF, BY MATERIAL AND PRODUCT CATEGORIES, 1971-75*

(As-generated wet weight, in millions of tons)

Materials and products	1971	1972	1973	1974	1975
Material composition:					
Paper	39.1	42.5	44.2	43.4	37.2
Glass	12.0	12.7	13.2	12.9	13.3
Metal	11.8	12.1	12.4	13.0	12.2
Ferrous	(10.6)	(10.8)	(11.0)	(11.5)	(10.8)
Aluminum	(0.8)	(0.9)	(1.0)	(1.0)	(0.9)
Other	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)
Plastics	4.2	4.7	5.0	4.5	4.4
Rubber and leather	3.3	3.4	3.6	4.1	3.3
Textiles	1.8	1.8	1.9	2.1	2.1
Wood	4.6	4.7	4.9	4.8	4.9
Total nonfood product waste	76.9	82.0	85.3	84.8	77.5
Food waste	22.0	22.2	22.4	22.6	22.8
Total product waste	98.9	104.2	107.7	107.4	100.3
Yard waste	24.1	24.5	25.0	25.5	26.0
Miscellaneous inorganics	1.8	1.8	1.9	1.9	1.9
Total	124.8	130.5	134.6	134.8	128.2
Product composition:					
Newspapers, books, magazines	10.3	10.9	11.3	11.5	9.8
Containers and packaging	41.7	45.1	46.8	45.4	41.7
Major household appliances	2.1	2.1	2.1	2.1	2.3
Furniture and furnishings	3.2	3.3	3.4	3.3	3.4
Clothing and footwear	1.2	1.2	1.3	1.3	1.3
Other products	18.4	19.5	20.4	21.1	18.9
Total nonfood product waste	76.9	82.0	85.3	84.8	77.5
Food waste	22.0	22.2	22.4	22.6	22.8
Total product waste	98.9	104.2	107.7	107.4	100.3
Add: Yard and misc. organics	25.9	26.3	26.9	27.4	27.9
Total	124.8	130.5	134.6	134.8	128.2

*Office of Solid Waste, Resource Recovery Division, and Franklin Associates, Ltd. Revised February 1977. Details may not add to totals due to rounding.

TABLE 5

WASTE DISPOSAL STATISTICS, U.S.A.

MATERIAL FLOW ESTIMATES OF RESIDENTIAL AND COMMERCIAL POST-CONSUMER NET SOLID WASTE DISPOSED OF, BY MATERIAL AND PRODUCT CATEGORIES, 1975*†

Material category	Product category (In millions of tons, as-generated wet weight)*‡							Totals			
								As-generated wet weight‡		As-disposed wet weight§	
	Newspapers, books, magazines	Containers, packaging	Major household appliances	Furniture, furnishings	Clothing, footwear	Food products	Other products	Million tons	Percent	Million tons	Percent
Paper	9.8	19.1	tr.	tr.	–	–	8.3	37.2	29.0	44.9	34.9
Glass	–	12.2	0.1	tr.	–	–	1.0	13.3	10.4	13.5	10.5
Metals		5.9	2.1	0.1			4.0	12.1	9.6	12.6	9.8
Ferrous	–	(5.2)	(1.8)	(0.1)	–	–	(3.7)	(10.8)	(8.6)		
Aluminum	–	(0.7)	(0.1)	tr.	–	–	(0.1)	(0.9)	(0.7)		
Other nonferrous	–	–	(0.2)	tr.	–	–	(0.2)	(0.4)	(0.3)		
Plastics	–	2.7	0.1	0.1	tr.	–	1.5	4.4	3.4	4.9	3.8
Rubber and leather	–	tr.	tr.	tr.	0.7	–	2.6	3.3	2.6	3.4	2.6
Textiles	–	0.1	tr.	0.6	0.5	–	0.9	2.1	1.6	2.2	1.7
Wood	–	1.8	tr.	2.6	–	–	0.5	4.9	3.8	4.9	3.8
Total nonfood product waste	9.8	41.7	2.3	3.4	1.2	–	18.9	77.5	60.5	86.5	67.3
Food waste	–	–	–	–	–	22.8	–	22.8	17.8	19.1	14.9
Total product waste	9.8	41.7	2.3	3.4	1.2	22.8	18.9	100.3	78.3	105.6	82.2
Yard waste								26.0	20.2	20.9	16.3
Misc. inorganics								1.9	1.5	2.0	1.6
Grand total								128.2	100.0	128.5	100.0

*Office of Solid Waste, Resource Recovery Division, and Franklin Associates, Ltd., revised January 1977.

†Net solid waste disposal defined as net residual material after accounting for recycled materials diverted from waste stream.

‡"As-generated" weight basis refers to an assumed normal moisture content of material in its final use prior to discard, for example: paper at an "air-dry" 7 percent moisture; glass and metals at zero percent. Total waste, including food and yard categories, estimated at 26 percent moisture.

§"As-disposed" basis assumes moisture transfer among materials in collection and storage, but no net addition or loss of moisture for the aggregate of materials. Based on estimates in: Niessen, W. R., and S. H. Chansky. The nature of refuse. *In* Proceedings; 1970 National Incinerator Conference, Cincinnati, May 17-20, 1970. New York, American Society of Mechanical Engineers. p. 7-8.

Note: Details may not agree with totals due to rounding.

TABLE 6

Energy Content of U.S. Packaging Waste 1975

	10^6 tons/year	Energy Content 10^6 BTU/ton	Energy in the Waste 10^{12} BTU
Paper Products	19.1	25	477.5
Glass	12.1	24	290.4
Ferrous Metal	5.2	56.0	291.2
Aluminum	0.7	262.0	183.4
Plastics & Textiles	2.8	125.0	350.0
Wood	1.8	2.7	5.0
	41.7		1,597.5
Canada by ratio 0.107 x USA	4.46 x 10 tons		0.17 Quads

Source: Ontario Research Foundation.

TABLE 7

CANADIAN WASTE GENERATION STATISTICS, 1977[4]

COMPONENT	(ANNUAL) NATIONAL AS GENERATED			AS RECEIVED		
	WET WT (%)	S.E.*	MOISTURE CONTENT (%)	WET WT (%)	S.E.*	MOISTURE CONTENT (%)
PAPER	36.45	2.40	7.0	42.30	2.29	19.20
KRAFT PAPER	9.11	1.62		10.14	1.67	17.01
NEWSPRINT	8.54	1.18		9.66	1.25	17.30
FINE PAPER	6.00	1.14		6.18	1.08	10.79
OTHER PAPER	12.80	0.88		16.31	1.09	26.04
GLASS	6.61	0.69	0.0	6.72	0.67	0.82
BEER CONTAINERS	0.20	0.11		0.21	0.11	
RETURNABLE SOFTDRINK	0.28	0.11		0.28	0.11	
NON-RETURN SOFTDRINK	1.06	0.43		1.05	0.42	
LIQUOR AND WINE	1.43	0.30		1.47	0.31	
CONTAINERS FOOD	2.23	0.32		2.27	0.32	
CONTAINERS OTHER	0.34	0.11		0.35	0.12	
FLAT AND CULLET	1.08	0.21		1.09	0.21	
FERROUS METALS	6.06	0.69	0.0	6.32	0.73	2.88
BEER CANS	0.04	0.05		0.04	0.05	
SOFTDRINK CANS	0.66	0.15		0.68	0.16	
FOOD CANS	2.77	0.32		2.88	0.34	
OTHER	2.59	0.67		2.71	0.72	
NON-FERROUS METAL	0.57	0.14	0.0	0.65	0.15	12.57
ALUMINUM	0.53	0.13		0.60	0.13	
OTHER	0.05	0.02		0.05	0.03	
PLASTICS	4.65	0.27	2.0	5.4	0.34	15.11
CONTAINERS	0.86	0.10		1.01	0.11	
SHEET FILM OTHER	3.78	0.28		4.46	0.34	
CERAMICS RUBBLE	1.80	0.81	0.0	1.90	0.82	4.51
LUMBER	4.18	1.06	15.0	4.08	1.00	12.80
PUTRESCIBLE	27.59	2.69	70.0	20.65	1.91	58.61
TEXTILES LEATHER RUBBER	4.26	0.54	4.0	4.64	0.56	10.76
YARD WASTES BRUSH	6.09	2.09	50.0	5.31	1.68	31.95
FINES	1.18	0.36	2.0	1.41	0.42	17.89
PETROLEUM CHEMICAL MIX	0.56	0.48		0.57	0.47	
TOTAL WEIGHTED MOISTURE CONTENT (%)			25.82			24.43

(4) Source: Bird & Hale.

* Standard Error.

TABLE 8

Energy Content of Canadian Packaging Waste

1977

	Quantity 10^6 tons/year	Energy Content BTU/ton	Total Energy 10^{12} BTU
Kraft Paper	1.01	25	25.25
Cardboard	1.42	28	39.75
Glass, returnable	0.031	≈41	1.27
Glass, non-returnable	0.621	21	13.04
Ferrous Metal	0.385	56	21.56
Aluminum	0.059	262	15.46
Plastic Sheet or Film	0.420	105	44.10
Plastic Containers	0.095	≈150	14.25
Wood	0.333	≈2.7	0.9
Total	4.374		175.6

Source: Ontario Research Foundation.

TABLE 9

Comparison of Materials Categories in U.S. and Canadian Packaging Waste

	U.S.A. 1975 % of Total Packaging Wastes	Canada 1977 % of Total Packaging Wastes
Paper Products	45.8	55.5
Glass	29.0	14.9
Ferrous Metal	12.5	8.9
Aluminum	1.7	1.3
Plastics & Textiles	6.7	11.8
Wood	4.3	7.6
	100	100

Source: Ontario Research Foundation.

TABLE 10

Potential Energy Savings through Recycling of Materials

Material	1977 Canadian Packaging 10^6 tons	Total Energy 10^{12} BTU	Approximate Savings through Recycle %	Potential Savings 10^{12} BTU
Paper Products	2.43	65	20	13.0
Glass	0.652	14.31	5	0.7
Ferrous Metals	0.385	21.56	10	2.2
Aluminum	0.059	15.46	95	14.7
Plastic	0.515	58.35	60	35.0
Wood	0.333	0.9	?(90)	0.8
Total				66.4

Source: Ontario Research Foundation.

TABLE 11

Recoverable Energy from
Packaging Waste through its use as a Fuel

Material	1977 Canadian Packaging 10^6 tons	Available Energy 10^6 BTU/ton	Potential Energy from Waste 10^{12} BTU
Paper Products	2.43	20	48.6
Glass	0.652	-	-
Ferrous Metal	0.385	-	-
Aluminum	0.059	-	-
Plastic	0.515	38	19.6
Wood	0.333	18	6
			74.2

TABLE 12

Maximum Potential Energy Savings Annually
Using Preferred Alternative of Recycling or Energy Recovery

Material	Energy Savings Recycling (10^{12} BTU)		Energy Recovery Used as Fuel (10^{12} BTU)		Maximum Potential Energy Savings (10^{12} BTU/Yr)
Paper Products	--		48.6		
Glass	0.7		--		
Ferrous Metal	2.2		--		
Aluminum	14.7		--		
Plastic	35.0		--		
Wood	--		6.0		
Total	52.6	+	54.6	=	107.2

APPENDIX 2

PACKAGING ENERGY CONTENT

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TABLE 1

PACKAGING ENERGY REQUIREMENTS TO DELIVER 3,000 QUARTS OF MILK

	Source	No. Trips	Energy Required
(a) Returnables			
3-Quart Plastic Jug	ORF	200 trips	1.4×10^6 BTU
	WMAB	100 trips	1.46×10^6 BTU
1-Quart Glass	ORF	20 trips	3.5×10^6 BTU
		50 trips	2.25×10^6 BTU
		100 trips	1.89×10^6 BTU
	WMAB	20 trips	4.00×10^6 BTU
1-Pint Glass	O.U.	25 trips (U.K.data)	2.0×10^6 BTU
(b) Non-Returnables			
3-Quart Plastic Pouch	ORF		3.6×10^6 BTU
	WMAB (R)		2.543×10^6 BTU
2-Quart Carton	ORF		4.1×10^6 BTU
	WMAB (R)		3.9×10^6 BTU
1-Quart Carton	ORF		4.1×10^6 BTU
	WMAB (R)		4.0×10^6 BTU
1-Litre Tetra Brik	WMAB		5.8×10^6 BTU
	WMAB (Refrig. credit)		2.7×10^6 BTU
1-Pint Polyethylene Bottle	O.U. (U.K. data)		8.15×10^6 BTU

WMAB (R) is a modified energy figure developed by the Waste Management Advisory Board to take account of reuse of packaging by the householder, thus displacing purchase of other plastic bags, etc. Rate based on survey of 400 households.

TABLE 2

The Effect of Container Type on the Energy Required to Deliver Milk to the Consumer's Retail Outlet

ITEM	Energy Required Million BTU's per 3000 Quarts			
	3 Quart Containers		1 Quart Containers	
	Plastic Jugs	Pouches	Cartons	Glass
Raw Material Acquisition and Transport	0.089	1.86	0.066	0.315
Fabrication of Basic Material and Transport			2.408	1.718
Container Fabrication	0.032	0.28	1.171	
Filling	0.023	0.053	0.131	0.071
Closure	0.120	1.14	-	0.091
Auxilliary Packaging	0.33	0.26	0.25	0.25
Distribution and Collection	0.054	0.031	0.034	0.209
Washing	0.64	-	-	0.8
Float Adjustment	0.10	-	-	-
Disposal in Landfill	0.001	0.01	0.035	0.033
Total*	1.4	3.6	4.1	3.5
Comparison Ratio Based on Plastic Jug	1.0	2.6	2.9	2.5
Potential Energy Recoverable by Incineration	0.040	1.28	2.12	0

* Results rounded to two significant figures

Source: Ontario Research Foundation.

TABLE 3

ENVIRONMENTAL IMPACT OF SELECTED PRIMARY[1] MILK CONTAINERS FOR PACKAGING 3000 QUARTS USING ASSUMPTIONS FAVOURABLE TO THE THROWAWAY CONTAINERS

		Weight of Waste		Volume of Waste Incl. Void		Energy Use	
	Trips	lbs.	Comparison Ratio[2]	Cu.Ft.	Comparison Ratio[2]	10^6BTU	Comparison Ratio[2]
3 Qt. Plastic Jug	200	6.1	1.0:1	0.4	1.0:1	1.5	1.0:1
3 Qt. Pouch	1	42.9	7.0:1	0.7	1.8:1	2.5	1.7:1
2 Qt. Plastic Jug	200	8.4	1.4:1	0.4	1.0:1	1.5	1.0:1
2 Qt. Glass	20	174.9	28.7:1	2.5	6.3:1	1.8	1.2:1
2 Qt. Carton	1	202.3	33.2:1	9.1	22.8:1	3.9	2.6:1
2 Qt. Pouch	1	46.8	7.7:1	0.8	2.0:1	2.7	1.8:1
1 Qt. Plastic Jug	200	14.7	2.4:1	0.5	1.3:1	1.8	1.2:1
1 Qt. Pouch	1	32.5	5.3:1	0.6	1.5:1	2.0	1.3:1
1 Qt. Glass	20	235.2	38.6:1	2.9	7.3:1	4.0	2.7:1
1 Qt. Carton	1	203.6	33.4:1	9.1	22.8:1	4.0	2.7:1
1 L. Tetra Brik	1	158.3[3]	26.0:1	8.0	20.0:1	2.7	1.8:1
20 oz. Carton	1	266.2	43.6:1	10.3	25.8:1	4.8	3.2:1
8 oz. Carton	1	432.7	70.9:1	10.7	26.8:1	7.7	5.1:1

1 - Energy figures include secondary packaging

2 - Based on three quart refillable plastic jug

3 - An additional 105.8 lbs./isoquant is produced by secondary packaging

Source: Waste Management Advisory Board

TABLE 4 (a)

BEVERAGE CONTAINERS: ENERGY TO DELIVERY
3,000 QUARTS IN 10- OR 12-OUNCE CONTAINERS

Data Source	Returnable Glass 10 trip, 10^6 BTU	N/R Glass 10^6 BTU	Bi-metallic Can 10^6 BTU	Aluminum Can 10^6 BTU	N/R Plastic Bottle 10^6 BTU
Hannan	18.41*	56.0	45.0	62.1	-
MRI	20.5	60.8	51.0	71.3	59.4
CSMRI	22.6	55.8	47.8	73.3	54.9
Haller	13.5	42.0	43.2	75.8	45.6
Berry & Makino	19.35	47.8	42.0	64.0	-
Owens-Illinois	15.34	51.3	42.3	56.7	51.1
Food & Drug Admin.	10.23**	49.2	48.7	72.3	40.7
American Can	25.95	48.1	39.0+	65.0	49.7
Testin	21.97	67.0	52.3	74.2	67.5
Monsanto	17.00	42.0	43.0	69.0	44.0
Average	18.54	52.0	45.4	68.4	51.6
Average, ignoring highest & lowest	18.66	51.4	45.4	68.9	50.8

* 19 trips

** 15 trips

\+ D and I all-steel can

TABLE 4 (b)

REFERENCES FOR TABLE 4 (a)

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TABLE 5

WINES AND SPIRITS PACKAGING
CONTAINER ENERGY ANALYSIS FOR A BEVERAGE ISOQUANT
OF 3,000 QUARTS (120,000 FLUID OUNCES)

Acronym		Number of Trips	Container Energy To Deliver 3,000 Quarts 10^6 BTU
NRG	Non-Refillable Glass	1	64.8
PRG	Proprietary Refillable Glass	5	84.5
		5	37.5
		10	31.7
		20	28.7
SRG 1	Standard Refillable Glass I	1	76.3
		5	35.0
		10	29.8
		20	27.3
SRG 2	Standard Refillable Glass II	1	66.0
		5	30.2
		10	25.8
		20	23.6
NRP	Non-Refillable Plastic	1	40.1
RP	Refillable Plastic	1	49.2
		5	18.6
		10	14.7
		20	12.8
NRPG	Non-Refillable Plastic/Glass	1	53.0

Source: Based on Stevenson & Kellogg Wines and Spirits Packaging in Ontario report to WMAB, Oct. 1976.

Table 6

WINE AND SPIRITS PACKAGING
CONTAINER ENERGY ANALYSIS FOR A NORMAL BEVERAGE ISOQUANT
OF 25,000 FLUID OUNCES WITH END-USE LANDFILL

CONTAINER TYPE CODE	TRIPPAGE	CATEGORY I CONTAINER MANUFACTURING ENERGY (NM1 to NM4)	CATEGORY II: CONTAINER USE ENERGY				TOTAL CATEGORIES I and II	CATEGORY III LANDFILL	TOTAL CONTAINER ENERGY	COMPARISON RATIOS
			Secondary Packaging and Closure (NU5, NU6)	Bottling and Transportation (NU7, NU8)	Returned Refillables (NU9, NU10)	Total (NU5-NU10)		(NL11, NL12)		Base: 5 Tr (PRG)
		10^3 BTU's	10^3 BTU's				10^3 BTU's	10^3 BTU's	10^3 BTU's	
NRG	1	10,005	1,923	1,404	n/a	3,327	13,332	117	13,449	1.7:1
PRG	1	13,165	2,318	1,669	300	4,287	17,452	154	17,606	2.3:1
	2	6,583	2,318	1,669	842	4,829	11,412	77	11,489	1.5:1
	5	2,633	2,318	1,669	1,167	5,154	7,787	31	7,818	1.0:1
	10	1,317	2,318	1,669	1,276	5,263	6,580	15	6,595	0.8:1
	20	658	2,318	1,669	1,330	5,317	5,975	8	5,983	0.8:1
SRG(1)	1	11,585	2,318	1,555	300	4,173	15,758	135	15,893	2.0:1
	2	5,793	2,318	1,555	785	4,658	10,451	68	10,519	1.3:1
	5	2,317	2,318	1,555	1,076	4,949	7,266	27	7,293	0.9:1
	10	1,159	2,318	1,555	1,173	5,046	6,205	14	6,219	0.8:1
	20	580	2,318	1,555	1,222	5,095	5,675	7	5,682	0.7:1
SRG(2)	1	10,005	1,923	1,404	300	3,627	13,632	117	13,749	1.8:1
	2	5,003	1,923	1,404	710	4,037	9,040	59	9,099	1.2:1
	5	2,001	1,923	1,404	955	4,282	6,283	23	6,306	0.8:1
	10	1,001	1,923	1,404	1,037	4,364	5,365	12	5,377	0.7:1
	20	501	1,923	1,404	1,078	4,405	4,906	6	4,912	0.6:1
NRP	1	6,556	1,138	686	n/a	1,824	8,380	11	8,391	1.1:1
RP	1	8,097	1,138	711	300	2,149	10,246	13	10,259	1.3:1
	2	4,049	1,138	711	363	2,212	6,261	7	6,268	0.8:1
	5	1,619	1,138	711	401	2,250	3,869	3	3,872	0.5:1
	10	810	1,138	711	413	2,262	3,072	1	3,073	0.4:1
	20	405	1,138	711	420	2,269	2,674	1	2,675	0.3:1
NRPG	1	8,081	1,663	1,202	n/a	2,865	10,946	88	11,034	1.4:1

Source: Table E-4. Energy input codes are identified in the text of this appendix, Stevenson & Kellogg Ltd. "Wines and Spirits Packaging in Ontario" prepared for the Ontario Waste Management Board, October 1976.

APPENDIX 3

PACKAGING IN THE MANUFACTURING INDUSTRIES OF CANADA

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1. An Overview of the Role of Packaging in the Manufacturing Industries of Canada

In 1977 Canadian manufacturing industries spent about $2.5 billion on containers and packaging supplies. This represented 2.26% of the value of shipments of goods of own manufacture reported by all manufacturers, and 3.9% of the cost of all the materials used at the manufacturing level.

Comparing strictly expenditures, these percentages had declined from 2.46% of value of shipments and 4.44% of cost of materials in 1972. However, when the 1977 expenditures are examined in 1971 dollars, it is discovered that the decline in these percentages are somewhat more modest. This can be explained by comparing the relative changes in the prices of packaging materials and other manufactured goods. Table 2 provides a weighted price index for the major types of packaging consumed at the manufacturing level. This index is slightly lower than the one computed for the major package consuming industries in Table 3. If these relative changes in prices are taken into account, it is seen that expenditure on packaging had declined from 2.46% in 1972 to only 2.32% in 1977 of all shipments, compared with the adjusted decline from 2.46% in 1972 to 2.26% in 1977. Similarly, the decline in packaging expenditure as a percentage of cost of all materials can be adjusted by the price indices for again packaging materials and all other materials. This adjustment indicates that packaging expenditure had declined to 4.16% of all cost of materials, instead of to 3.9% calculated in 1977 dollars.

In summary, it can be said that packaging represents a smaller portion of the total costs of all materials used by the manufacturing industries of Canada than it did in 1972. However, this modest decrease appears to be even less significant in physical quantities of packaging materials than what the financial picture suggests.

TABLE 1

PACKAGING CONSUMPTION BY THE MANUFACTURING INDUSTRIES

(Millions of Dollars)

Year	Cost of Packaging ($ million)	Total Shipments of Goods of Own Manufacture ($ million)	Packaging as % of Shipments	Cost of All Materials Used By Manufacturing Industries ($ million)	Packaging as % of Cost of Materials
1972	1,383	56,191	2.46	31,138	4.44
1973	1,563	66,674	2.34	37,601	4.16
1974	1,890	82,455	2.29	47,500	3.98
1975	2,024	88,427	2.29	51,177	3.95
1976	2,284	98,281	2.32	56,982	4.01
1977	2,455	108,856	2.26	62,981	3.90
1977 (1971$)	1,449	62,453	2.32	34,835	4.16

SOURCE: Statistics Canada, Consumption of Containers and Other Packaging Supplies by the Manufacturing Industries, 31-212, 1977.

TABLE 2

1977 PRICE INDEX FOR PACKAGING MATERIALS

(1971 = 100)

Package Type	Price Index	Share of all Package Consumption	Weighted Index
Corrugated Boxes	161.1	.194	31.25
Metal Cans	172.1	.181	31.15
Folding & Set-up Boxes	169.2	.133	22.50
Glass Bottles	150.4	.092	13.84
Transparent Film (bags and sheets)	179.7	.062	11.14
Paper (bags & other)	185.4	.053	9.83
Other	174.3	.285	49.68
		1.000	169.40

Source: Boston, Gilbert, Henry Associates Ltd.

TABLE 3

1977 PRICE INDEX FOR MAJOR PACKAGE CONSUMING INDUSTRIES

(1971 = 100)

Consuming Industry	Price Index	% of All Package Consumption	Weighted Index
Food and Beverage	185.9	.570	105.96
Chemicals and Chemical Products	175.8	.128	22.50
Paper and Allied Industries	193.5	.057	11.05
Tobacco Products	146.0	.034	4.96
Electrical Products	147.3	.024	3.54
Metal Fabricating	172.1	.023	3.96
Non-metallic Mineral Products	186.7	.022	4.11
Other	174.3	.142	24.75
		1.000	180.8

Source: Boston, Gilbert, Henry Associates Ltd.

2. Breakdown of Package Consumption by Major Industry Groupings

A further breakdown of expenditures clearly indicates that packaging consumption is not evely distributed among all the manufacturing industries (Table 4). About 86% of the total $2.5 billion spent on packaging is concentrated in seven major industry groupings. Food and Beverage Industries alone account for 57%, while these industries only represent 17.3% of the value of all shipments of own manufacture. The next major consumers of packaging are Chemical and Chemical Products Industries with 12.8% of the total, followed by Paper and Allied Industry accounting for another 5.7%.

Comparing the ratios of packaging both to value of shipments and cost of all materials, Tobacco Products Industries rank the highest (8.9% and 16.5%), followed by Food and Beverage Industries (7.4% and 11.1%), and Chemical and Chemical Products Industries (4.9% and 9.6%). Of all the other major consumers, only Non-metallic Mineral Products Industries have a slightly higher ratio of packaging expenditure to cost of all materials, than the average for all the manufacturing industries of 3.9%.

TABLE 4

PACKAGING CONSUMPTION
BY TYPE OF MANUFACTURING INDUSTRY (1977)

Industry	Cost of Packaging ($ million)	% of Total Package Consumption	Shipments of Goods of Own Manufacture ($ million)	% of Total Shipments	Packaging as % of Shipments	Cost of all Materials ($ million)	Packaging as % of All Cost of Materials
Food & Beverage Industries	1,399	57.0	18,872	17.3	7.4	12,620	11.1
Chemical and Chemical Products Industries	314	12.8	6,437	5.9	4.9	3,284	9.6
Paper & Allied Industries	141	5.7	8,938	8.2	1.6	4,238	3.3
Tobacco Products Industries	84	3.4	946	0.9	8.9	508	16.5
Electrical Products Industries	58	2.4	4,860	4.5	1.2	2,285	2.5
Metal Fabricating Industries	56	2.3	7,232	6.6	0.8	3,605	1.6
Non-metallic Mineral Products Industries	55	2.2	2,991	2.7	1.8	1,158	4.7
Other Manufacturing Industries	348	14.2	58,582	53.8	0.6	35,283	4.0
TOTALS:	2,455	100.0	108,852	100.0	2.3	62,981	3.9

SOURCES: Statistics Canada, 31-212
Statistics Canada, 31-203

3. Breakdown of Package Consumption by Type

A breakdown of total expenditure at the manufacturing level by package type (Table 5) indicates that "corrugated boxes" and "metal cans" are the major items representing 19.4% and 18.1% of total consumption respectively. These are followed by "folding and set-up boxes" and "glass bottles" accounting for 13.3% and 9.2% of the total respectively. The other two major items identified for the purposes of this study are "transparent film" (in sheets and bags) and "paper" (in bags and all other forms). The expenditures on all the other items are very small and together account for the remaining 28.5% of the total consumption (see Table 6).

Glass bottle, folding/set-up box, and transparent film consumption is largely concentrated in Food and Beverage Industries, which account for 77-87% of the total consumption of these three items. It is also worth noting that the six package types identified as major items constitute a larger share of Food and Beverage Industries' consumption (82%) than the other industry groupings. Chemical and Chemical Product Industries and Paper and Allied Industries, on the other hand, consume a larger share of the miscellaneous items. (Also, see Table 7 for a more detailed breakdown of package consumption by type.)

TABLE 5

CONSUMPTION OF PACKAGING (BY TYPE)
BY THE MANUFACTURING INDUSTRIES
($ million and percent)

Package Type	Consumption ($ million)	% of Total %	Food and Beverage $ m	Food and Beverage %*	Chemical & Chemical Products $ m	Chemical & Chemical Products %	Paper and Allied Industries $ m	Paper and Allied Industries %	Tobacco Products $ m	Tobacco Products %	Electrical Products $ m	Electrical Products %	Metal Fabricating Industries $ m	Metal Fabricating Industries %	Non-metallic mineral products $ m	Non-metallic mineral products %	Other manufacturing Industries $ m	Other manufacturing Industries %
Corrugated Boxes	476.4	19.4	212.8	44.7	40.1	8.4	31.3	6.6	4.5	0.9	26.8	5.6	28.8	6.1	22.5	4.7	109.2	22.9
Metal Cans	445.2	18.1	364.0	81.8	55.4	12.4	0.5	0.1	4.5	1.0	--	--	--	--	--	--	20.5	4.6
Folding and Set-up Boxes	326.8	13.3	178.6	54.7	22.0	6.7	17.2	5.3	45.5	13.9	9.9	3.0	5.8	1.8	0.8	0.2	47.2	14.4
Glass Bottles	225.6	9.2	196.9	87.3	28.7	12.7	--	--	--	--	--	--	--	--	--	--	0.4	0.2
Transparent film (bags and sheets)	151.9	6.2	117.9	77.6	5.5	3.6	4.5	3.0	6.6	4.3	--	--	--	--	2.7	1.8	14.8	9.7
Paper (bags and other)	128.7	5.3	70.0	54.3	12.8	9.9	3.7	2.9	--	--	--	--	3.0	2.3	12.6	9.8	26.9	20.9
Other	700.8	28.5	258.8	37.0	149.5	21.4	83.8	12.0	22.9	3.3	21.3	3.0	18.4	2.6	16.4	2.3	128.9	18.4
Total	2455.4	100.0	1399.0	57.0	314.	12.8	141.	5.7	84.	3.4	58.	2.4	56.	2.3	55.	2.2	348.	14.2

*% of total consumption of the package type

TABLE 6

CONSUMPTION OF OTHER PACKAGE TYPES
($ million and percent)

	Consumption $ million	% of all package consumption	Food and Beverage* $ m	%	Chemical & Chemical Products $ m	%	Paper and Allied $ m	%	Tobacco Products $ m	%	Electrical Products $ m	%	Metal fabricating $ m	%	Non-metallic mineral products $ m	%
Wooden Boxes	24.4	1.0	5.9	24.2	-		-				3.2	13.1	2.7	11.1	4.6	18.9
Crating lumber, wooden pallets, etc.	40.7	1.7	-	-	-		5.0	12.3			4.4	10.8	6.7	16.5	2.4	5.9
Metal Barrels, drums, etc.	20.2	0.8	1.3	6.4	13.5	66.8	-		-							
Metal Staples, Strapping wire	41.2	1.7	-		-		13.4	32.5	-							
Lead, tin, aluminum foil	44.6	1.8	26.7	59.9	-		-		17.9	40.1			2.0	4.5	1.1	2.5
Metal and Plastic closures	60.2	2.5	51.1	84.9	6.2	10.3	2.0	3.3	-		-		-		-	
Plastic bottles and carboys	33.6	1.4	1.1	3.3	31.5	93.8										
Plastic containers	43.0	1.8	36.1	84.0	4.4	10.2										
Cans, drums: paper & fibre	7.3	0.3	1.7	23.3	5.6	76.7	-									
Cones, cores, tubes & spools	37.2	1.5	-	-	6.9	18.5	15.5				3.5	9.4	1.3	3.5		
Labels, tags, wrappers	126.8	5.2	72.7	57.3	9.5	7.5	28.9		1.5	1.2	1.5	1.2	-			
Textile bags	12.9	0.5	12.9	100.0	-		-		-		-		-			
Misc.	35.9	1.5	12.6		7.5		2.3		1.1		0.8		0.8		1.0	
Not specified	172.9	7.0	36.9		63.3		16.8		2.0		6.1		6.1		5.5	

*% of the total consumption of the package type

TABLE 7

MANUFACTURING INDUSTRY PACKAGE CONSUMPTION BY TYPE
($ million and percent)

Industry	Package Type	($ m) Consumption	% of Industry Consumption	($ m) Industry Consumption	% of All Manufacturing Consumption
Food & Beverage	Metal cans	364.0	26.0		
	Corrugated boxes	212.8	15.2		
	Glass bottles	196.9	14.1		
	Folding set-up box	178.6	12.8		
	Transparent film	117.9	8.4		
	Labels, tags, etc.	72.7	5.2		
	Paper	70.0	5.0		
	Metal & plastic closures	51.1	3.7		
	Plastic containers	36.1	2.6		
	Lead, tin, aluminum foil	26.7	1.9		
	Textile bags	12.9	0.9		
	Wooden boxes	5.9	0.4		
	Cans, drums (paper & fibre)	1.7	0.1		
	Metal barrels; drums	1.3	0.1		
	Plastic bottles; carboys	1.1	0.1		
	Other, misc., unspecified	49.7	3.6		
	TOTALS:		100.0	1,399.4	57.6
Chemical & Chemical Products	Metal cans	55.4	17.6		
	Corrugated boxes	40.1	12.8		
	Plastic bottles, carboys	31.5	10.0		
	Glass bottles	28.7	9.1		
	Folding set-up boxes	22.0	7.0		
	Metal barrels; drums	13.5	4.3		
	Paper	12.8	4.1		
	Labels, tags, wrappers	9.5	3.0		
	Cores, cones, tubes, spools	6.9	2.2		
	Metal & plastic closures	6.2	2.0		
	Cans, drums (paper & fibre)	5.6	1.8		
	Transparent film	5.5	1.8		
	Plastic containers	4.4	1.4		
	Other, misc., unspecified	71.8	22.9		
	TOTALS:		100.0	313.9	12.8

TABLE 7 (Cont'd.)

MANUFACTURING INDUSTRY PACKAGE CONSUMPTION BY TYPE
($ million and percent)

Industry	Package Type	($ m) Consumption	% of Industry Consumption	($ m) Industry Consumption	% of All Manufacturing Consumption
Paper & Allied Industries	Corrugated boxes	31.3	22.1		
	Labels, tags, wrappers	29.4	20.8		
	Folding, set-up boxes	17.2	12.2		
	Cores, cones, tubes, spools	15.5	11.0		
	Metal staples, strapping wire	13.4	9.5		
	Crating lumber, wooden pallets	5.0	3.5		
	Transparent film	4.5	3.2		
	Paper	3.7	2.6		
	Metal & plastic closures	2.0	1.4		
	Other, misc., unspecified	19.4	13.7		
	TOTALS:		100.0	141.4	5.8
Tobacco Products	Folding, set-up boxes	45.5	53.9		
	Lead, tin, aluminum foil	17.9	21.2		
	Transparent film	6.6	7.8		
	Corrugated boxes	4.5	5.3		
	Metal cans	4.5	5.3		
	Labels, tags, wrappers	1.5	1.8		
	Other, misc., unspecified	3.9	4.6		
	TOTALS:		100.0	84.4	3.4
Electrical Products	Corrugated boxes	26.8	45.8		
	Folding, set-up boxes	9.9	16.9		
	Crating, lumber, pallets, etc.	4.4	7.5		
	Cores, cones, tubes, spools	3.5	6.0		
	Wooden boxes	3.2	5.5		
	Labels, tags, wrappers	1.5	2.6		
	Other, misc., unspecified	9.2	15.7		
	TOTALS:		100.0	58.5	2.4

TABLE 7 (Cont'd.)

MANUFACTURING INDUSTRY PACKAGE CONSUMPTION BY TYPE
($ million and percent)

Industry	Package Type	($ m) Consumption	% of Industry Consumption	($ m) Industry Consumption	% of All Manufacturing Consumption
Metal Fabricating	Corrugated boxes	28.8	51.0		
	Crating lumber, pallets, etc.	6.7	11.9		
	Folding/set-up boxes	5.8	10.3		
	Paper	3.0	5.3		
	Wooden boxes	2.7	4.8		
	Metal staples, strapping wire	2.0	3.5		
	Cores, cones, tubes, spools	1.3	2.3		
	Other, misc., unspecified	6.2	11.0		
	TOTALS:		100.0	56.5	2.3
Non-metallic Mineral Products	Corrugated boxes	22.5	41.1		
	Paper	12.6	23.0		
	Wooden boxes	4.6	8.4		
	Transparent film	2.7	4.9		
	Crating lumber, pallets, etc.	2.4	4.4		
	Metal staples, strapping wire	1.1	2.0		
	Other, misc., unspecified	8.9	16.2		
	TOTALS:		100.0	54.8	2.2
Other Manufacturing Industries				346.5	14.1
All Manufacturing Industries				2,455.4	100.0

4. Analysis of Package Consumption at the Level of 3-4 Digit Manufacturing Industries

At the level of 2-digit SIC's, Food and Beverage Industries are identified as by far the largest package consumers accounting for 57.6% of the total consumption of the manufacturing level. This, of course, warrants a more detailed examination of these industries. Table 8 provides a breakdown of packaging expenditures for 3 and 4-digit Food and Beverage Industries, as well as the ratios of package consumption to total shipments and to cost of all materials for each industry.

Fruit and Vegetable Canners and Preservers, Dairy Product Industries, Miscellaneous Food Processors, and Soft Drink Manufacturers are the largest package consumers. In addition to these industries that can be singled out on the basis of the shear magnitude of their packaging expenditures, there are those industries which spent a very high proportion of their total outlay on materials on packaging. These industries are mainly Wineries, Distilleries, and Biscuit Manufacturers. As will be discussed later, these industries can be selected as the prime candidates for further study to determine opportunities for package reduction and/or substitution. Since these industries already spent a significant portion (as high as 50% in the case of Breweries) of their total material outlays on packaging, they themselves have strong incentives to reduce their expenditure on packaging.

The packaging consumption in all the other 2-digit SIC's are not fully broken down, but Table 9 identifies all the 3-4 digit industries that have spent more than $10 million in 1977 on packaging. As the ratios in Table 9 indicate, Toilet Preparations, Soap and Cleaning Compounds, Glass, and Tobacco Product manufacturers are the other industries which spend significant portions of their material outlays on packaging.

TABLE 8

PACKAGE CONSUMPTION
IN LEADING FOOD AND BEVERAGE INDUSTRIES

($ million)

SIC	Industry	Package Consumption ($ m)	% of Total Food & Beverage (%)	Value of Shipments ($ m)	Pckg. Consumption % of Shipments (%)	Cost of Materials ($ m)	Pckg. Consumption % of Materials (%)
1031	Fruit & Vegetable Canners & Preservers	214.4	15.3	893	24.0	538	39.8
104	Dairy Products	188.1	13.4	3,083	6.1	2,329	8.1
1089	Misc. Food Processors	179.1	12.3	1,997	9.0	1,217	14.7
1091	Soft Drink Manufacturers	166.9	11.9	775	21.4	382	43.5
1093	Breweries	126.3	9.0	816	15.4	251	50.2
1011	Slaughtering & Meat Processors	92.9	6.6	4,258	2.2	3,400	2.7
1092	Distilleries	85.0	6.1	567	15.0	209	40.7
1072	Bakeries	56.9	4.1	871	6.5	383	14.9
1081	Confectionery Manufacturers	51.6	3.7	527	9.9	264	19.3
102	Fish Products	45.4	3.2	966	4.7	595	7.6
10	Leading Industries		85.6				
	% of Total Package Consumption		48.8				

TABLE 8 Cont'd)

PACKAGE CONSUMPTION
IN OTHER FOOD AND BEVERAGE INDUSTRIES

($ million)

SIC	Industry	Package Consumption ($ m)	% of Total Food & Beverage (%)	Value of Shipments ($ m)	Pckg. Consumption % of Shipments (%)	Cost of Materials ($ m)	Pckg. Consumption % of Materials (%)
1071	Biscuit Manufacturers	39.3	2.8	275	14.2	141	27.7
105	Flour & Breakfast Cereal Products	35.9	2.7	617	5.8	427	8.4
106	Feed Industry	36.6	2.6	1,367	2.7	1,089	3.3
1011	Poultry Processors	25.2	1.8	680	3.7	518	4.8
1094	Wineries	22.5	1.6	95	23.2	45	48.9
1032	Frozen Fruit & Vegetable Processors	18.5	1.3	208	8.7	112	16.1
1082	Cane and Beet Sugar Processors	10.4	0.7	437	2.4	326	3.2
1083	Vegetable Oil Mills	4.2	0.3	438	1.0	393	1.1

TABLE 9

PACKAGE CONSUMPTION IN OTHER MAJOR INDUSTRIES
($ million)

SIC	Industry	Package Consumption ($ m)	% of All Manu-facturers (%)	Value of Shipments ($ m)	Pckg. Consump-tion % of Shipments (%)	Cost of All Materials ($ m)	Pckg. Consump-tion % of Materials (%)
271	Pulp and Paper	90.5	3.7	6,637	1.4	2,911	3.1
153	Tobacco Product Manufacturers	83.3	3.4	715	11.6	315	23.2
376	Soap & Cleaning Compound Mnfg.	76.4	3.1	565	13.5	281	27.2
377	Toilet Preparations	60.6	2.5	337	18.0	106	57.2
374	Pharmaceuticals and Medicines	51.1	2.1	758	6.7	281	18.2
3799	Miscellaneous Chemical Industries	50.5	2.1	839	6.0	453	11.1
375	Paint & Varnish Producers	35.5	1.4	534	6.6	286	12.4
274	Miscellaneous Paper Converters	29.2	1.2	793	3.7	426	6.9
165	Plastic Fabricating	28.0	1.1	1,102	2.5	589	4.8
325	Motor Vehicle Parts & Accessories	24.8	1.0	3,790	0.7	2,072	1.2
3561	Glass Manufacturers	23.5	1.0	312	7.5	91	25.8
2513	Sawmills and Planing Mills	20.8	0.8	3,673	0.6	1,925	1.1
2619	Household Furniture	18.0	0.7	759	2.4	357	5.0
3783	Industrial Chemicals (organic)	13.6	0.6	1,391	1.0	834	1.6
			24.7				

5. Energy Content of Packaging

Table 10 outlines the conversion of packaging expenditures by the Canadian manufacturers, obtained from Statistics Canada publications and examined in some detail above, to energy values. First, estimates of cost of packaging materials per weight were obtained from Ontario Waste Management Advisory Board. Since these figures were reported in 1974 dollars, they were converted to 1977 dollars by using the appropriate price indices for different packaging materials. Then, using estimates of the energy content of materials per weight, Btu's per dollar cost of packaging were computed for each material type. Finally, multiplying the total expenditures with Btu's/$, energy equivalents of all the packaging consumed by Canadian manufacturers were estimated.

These calculations show that the energy content of all packaging consumed at the manufacturing level in 1977 was 0.12 Btu x 10^{15}. The previously identified six major package types account for 77% of the total energy - which is even higher than the 71.5% calculated from the expenditure figures. About 30% of the total energy is embodied in metal cans which represented only 18% of the total expenditure on packaging. Folding and set-up boxes contain significantly less energy than what the consumption statistics suggest 6.3% of energy compared with 13.3% of total expenditure). Corrugated boxes are in a similar position, while Transparent Film and Glass Bottles account for a larger share of the total energy than their share of total consumption.

A breakdown of the energy content of packaging by major industry groupings (Table 11) confirm the dominant role of Food and Beverage Industries, now accounting for even a larger share of the total (63%) than the previously calculated 57% based on consumption statistics. With the exception of Chemical and Chemical Product Industries, for all the other industry groupings the shares of total energy are slightly lower than the shares of total consumption.

TABLE 10

ENERGY CONTENT OF PACKAGING CONSUMED
BY THE MANUFACTURING INDUSTRIES (1977)

Package Type	1974$/ Ton (000's)	Price Index	1977$/ Ton (000's)	Ton/$ 10^6	Btu/ Ton 10^6	Btu/$	x10^6$	Btux10^{12}	%
Corrugated Boxes	0.60	1.18	0.71	1,412	28	39,536	476	18.83	15.3
Metal Cans	0.75	1.39	1.04	962	84	80,808	445	35.97	29.2
Folding Boxes	0.87	1.16	1.01	990	24	23,760	327	7.77	6.3
Glass Bottles	0.25	1.30	0.33	3,030	21	63,630	226	14.36	11.7
Transparent Film	1.55*	0.96	1.49	671	106	71,126	152	10.81	8.8
Paper	0.50*	0.98	0.49	2,041	25	51,025	129	6.57	5.3
Wooden Boxes	0.12	1.12	0.13	7,692	3	23,076	24	0.55	0.4
Crating lumber, etc.	1.00	1.52	1.52	658	3	23,076	41	0.95	0.8
Metal Barrels & Drums	0.50	1.23	0.62	1,613	50	80,650	20	1.73	1.4
Metal Staples, wire, etc.	1.00*	1.23	1.23	813	50	40,650	41	1.67	1.4
Lead, tin, alum. foil	2.00	1.31	2.62	382	150	57,300	45	2.58	2.1
Metal & Plastic Closures	1.50*	1.22	1.83	546	65	35,490	60	2.13	1.7
Plastic Bottles	1.65	1.11	1.83	546	124	67,704	34	2.30	1.9
Plastic Containers	1.47	1.18	1.73	578	124	71,672	43	3.08	2.5
Cores, Cones, etc.	1.04	1.22	1.27	787	30	23,610	37	0.87	0.7
Labels and Tags	0.75*	1.10	0.83	1,205	25	30,125	127	3.83	3.1
Textile Bags	1.22	1.10	1.34	746	50	37,300	13	0.48	0.4
Misc. & Unspecified	1.00	1.22	1.22	820	50	41,000	216	8.86	7.2
TOTAL - Energy Content of Packaging Consumed at the Manufacturing Level (Btu x 10^{12})								123.32	100.2

* Estimated

SOURCES (1) Ontario Waste Management Advisory Board
(2) Statistics Canada
(3) Statistics Canada, 31-212

TABLE 11

BREAKDOWN OF ENERGY CONTENT
OF PACKAGING BY INDUSTRY (1977)

(BTU x 10^{12})

Industry	Corrugated Boxes	Metal Cans	Folding/ Set-up Boxes	Glass Bottles	Transparent Film	Paper	Other	Total	% of Total
Food & Beverage	8.41	29.41	4.24	12.53	8.39	3.57	10.97	77.52	62.9
Chemical and Chemical Products	1.59	4.48	0.52	1.83	0.39	0.65	7.38	16.84	13.7
Paper & Allied	1.24	0.04	0.41	-	0.32	0.19	2.79	4.99	4.1
Tobacco Products	0.18	0.36	1.08	-	0.47	-	1.24	3.33	2.7
Electrical Products	1.06	-	0.24	-	-	-	0.68	1.98	1.6
Metal Fabricating	1.14	-	0.14	-	-	0.15	0.57	2.00	1.6
Non-metallic Mineral Products	0.89	-	0.02	-	0.19	0.64	0.57	2.31	1.9
Other Manufacturing	4.31	1.67	1.12	0.02	1.05	1.38	4.80	14.35	11.6
TOTALS:	18.82	35.96	7.77	14.38	10.81	6.58	29.00	123.32	100.0

Table 12 presents the energy content of packaging in those industries already identified in Tables 8 and 9 as spending more than $10 million on packaging in 1977.

TABLE 12

ENERGY CONTENT OF PACKAGING CONSUMED BY 3-4 DIGIT INDUSTRIES

S.I.C. Code	Industry	Energy Content (Btu x 10^{10})	Value of Shipments of Goods ($ x 10^6)	Energy/Value Ratio (Btu/$ x 10^4)
GROUP 1	Food & Beverage	7760.1	18,871.7	0.41
GROUP 19	Chemical & Chemical Products	1686.9	6,431.5	0.26
1031	Fruit & veg. canners & preserv.	1465.2	892.6	1.64
1091	Soft drink manufacturers	1153.1	775.0	1.49
1089	Misc. food processors	953.0	1,997.3	0.48
104	Dairy Products	922.9	3,082.7	0.30
1093	Breweries	586.2	815.6	0.72
1011	Slaughtering & meat process.	497.6	4,258.4	0.12
GROUP 10	Paper & Allied Industries	495.3	8,937.7	0.06
1092	Distilleries	450.4	567.1	0.79
376	Manufact. of soap & cleaning	348.6	565.3	0.62
GROUP 2	Tobacco Products Industry	333.0	945.6	0.35
153	Tobacco products manufact.	329.1	715.1	0.46
3799	Misc. chemical industries	312.4	839.0	0.37
1072	Bakeries	295.9	870.5	0.34
271	Pulp and paper mills	295.1	6,636.5	0.04
377	Manufact. of toilet paper	289.6	337.0	0.86
102	Fish products	259.9	965.8	0.27
375	Paint & varnish manufact.	258.6	534.2	0.48
374	Manufact. of pharmaceuticals	247.4	758.4	0.33
1081	Confectionary manufacturers	232.6	526.7	0.44
GROUP 17	Non-Metallic Minerals	227.4	2,290.9	0.10
106	Feed	214.3	1,366.7	0.16
GROUP 13	Metal Fabricating Industry	200.4	7,232.2	0.03
GROUP 16	Electrical Products Industry	198.6	4,860.0	0.04
1071	Biscuit manufacturers	173.1	275.2	0.63
105	Flour & breakfast cereal	143.9	617.4	0.23
1094	Wineries	122.0	97.4	1.25
165	Plastics fabricating	114.2	1,225.9	0.09
1012	Poultry processors	112.8	680.1	0.17
274	Misc. paper convertors	108.4	792.8	0.14
1032	Frozen fruit & veg. processors	98.9	208.2	0.47
2513	Sawmills & planing mills	91.5	3,672.7	0.02
3561	Glass manufacturers	87.7	312.1	0.28
325	Motor vehicle parts & access.	77.7	3,790.2	0.02
2619	Household furniture manufact.	70.8	759.4	0.09
3783	Manufact. of industrial chemicals	56.7	1,391.1	0.04
1082	Cane & beet sugar processors	45.1	437.0	0.10
1083	Vegetable oil mills	28.0	437.9	0.06

6. Selection of Key Package Consuming Industries

Twenty-nine industries were identified in Section 4 for spending more than $10 million on packaging in 1977. Energy contents of packaging in these industries were then calculated in Section 5. This section makes an attempt to further scrutinize these industries and select those that offer the greatest opportunities for reduction and/or substitution of packaging, and hence those that deserve a closer examination in the future stages of the study.

The following criteria are used in the final selection of key industries:

1. Significance as major consumers:
   - (a) total package consumption;
   - (b) ratio of packaging expenditure to cost of materials.
2. Energy content:
   - (a) total energy contained in packaging;
   - (b) ratio of packaging energy to value of shipments of own manufacture.
3. Suitability for selective action:
   - (a) Concentration of consumption in a limited number of package types;
   - (b) homogeneity and size of the consuming industry.

Table 13 presents a preliminary ranking of leading industries according to these criteria. Soft Drink Manufacturers, Breweries, and Distilleries are the obvious first choices. Wineries can also be included in this category, even though their consumption is only a very small portion of the total. Fruit and Vegetable Canners are the leading industry in terms of total consumption and energy content, and even though the consumption in this industry is heavily concentrated in high energy items as metal cans and glass bottles, the industry itself may present serious problems due to its size, heterogeneity,

and wide-range of products. The other two major package consuming industries, Dairy Products and Miscellaneous Food Processors, suffer from the same problems, and further they also lack the immediate incentive to reduce their consumption due to their low ratios of package consumption to cost of all materials. Nevertheless, it is felt that, in spite of these problems, these three major consumers deserve further attention and must be selected as important candidates for future action to reduce package consumption.

On the basis of the above criteria, another ten industries are selected. Although these do not appear to be as clear choices as the first group, some of them have high ratios of package consumption to cost of all materials, and energy content to value of shipments, and they seem to be suitable for selective action on the basis of the third set of criteria.

At the end of the list in Table 13, two other industries appear as significant consumers. Slaughtering and Meat Processors and Pulp and Paper Industries, but the package consumption of both these industries is very low in relation to both the cost of all their materials and value of their shipments (lower than the average for all manufacturing industries: 3.9% and 2.26% of cost of materials and of value of shipments respectively). Thus, they do not appear to be likely candidates for further consideration.

TABLE 13

SELECTION OF KEY INDUSTRIES FOR FURTHER CONSIDERATION

Industry (SIC)		Criteria 1a	1b	2a	2b	3a	3b
GROUP 1							
1091	Soft Drink Manufacturers	4	4	2	2	H	H
1093	Breweries	5	2	5	6	H	M-H
1092	Distilleries	6	5	7	5	H	H
1034	Wineries	22	3	21	3	H	H
1031	Fruit & Vegetable Canners	1	6	1	1	H	L
104	Dairy Products	2	19	4	17	L	M
1089	Misc. Food Processors	3	15	3	10	L	L
GROUP 2							
377	Toilet Preparations	11	1	13	4	L	M
153	Tobacco Products	9	10	9	12	H	H
376	Soap & Cleaning Compounds	10	8	8	8	M	M
1071	Biscuit Manufacturers	17	7	19	7	M	M
1072	Bakeries	12	4	11	15	H	L
1081	Confectionery Manufacturers	13	11	17	13	M	M
102	Fish Products	15	20	14	19	H	M
374	Pharmaceuticals & Medicines	14	12	16	16	M	L
3561	Glass Manufacturers	25	9	27	18	H	M
375	Paint & Varnish Products	18	16	15	9	H	M
1011	Slaughtering & Meat	6	L	6	L	L	M
271	Pulp and Paper	7	L	12	L	L	H

7. Identification of Package Consumption Items with Significant Energy Contents

In the previous sections, the industry expenditures on packaging were examined in some detail, and having estimated the energy content of package materials, a number of key industries were selected. This section makes an attempt to break down the energy content of packaging by type and also to further specify key areas for reduction and substitution in terms of the individual package consumption items of leading industries.

The consumption of corrugated boxes is widely spread over quite a number of industries (Table 14). The leading 11 industries only account for less than 50% of the total consumption. Hence, it may be difficult to concentrate future efforts in a few selected industries. The only obvious candidates for selective action appear to be Breweries and Miscellaneous Food Processors, and due to the complex and heterogenous nature of the latter, Breweries may be the only industry that may offer immediate prospects for reduction or substitution.

A more effective strategy in the case of corrugated boxes may be to concentrate future efforts at the level of Corrugated Box Manufacturers, rather than the individual consuming industries themselves. Due to the largely "tertiary" nature of packaging in corrugated boxes, its function in most industries is likely to be uniform and relatively easy to identify. This factor further suggests that opportunities for material substitution, or reuse, may be explored more effectively at the level of actual manufacturing.

Metal can consumption, on the other hand, is heavily concentrated in two industries: Fruit and Vegetable Canners and Soft Drink Manufacturers together accounting for 58% of all metal cans (Table 15), and about 17% of energy contained in all packaging consumed by the manufacturers. Both industries spent a very high proportion (24-27%) of their material outlays

TABLE 14

CORRUGATED BOX CONSUMPTION BY INDUSTRY

Industry	(SIC)	Package Consumption ($ million)	Energy Content BTUx10^{10}	% of All Corrugated Boxes	% of Industry's All Pckg. Consumption	% of Industry's Cost of All Materials
3-4 Digit SIC Categories						
1093	Breweries	36.4	143.9	7.6	28.8	14.5
1089	Misc. Food Processors	34.4	136.0	7.2	19.2	2.8
1011	Slaughtering....	27.1	107.1	5.7	29.2	0.8
376	Soap & Cleaning	21.3	84.2	4.5	27.9	7.6
1031	Fruit & Veg. Canners...	20.4	80.7	4.3	9.5	3.8
104	Dairy Products	20.1	79.5	4.2	10.7	0.9
165	Plastic Fabricating	18.3	73.1	3.8	65.4	2.8
3561	Glass Manufacturing	17.2	68.0	3.6	73.2	18.9
274	Misc. Paper....	13.7	54.2	2.9	49.9	3.2
2619	Household Furniture	12.4	49.0	2.6	68.9	3.2
102	Fish Products	11.9	47.0	2.5	26.4	2.0
		(233.2)	(922.0)	(49.0)		
2-Digit SIC Categories						
1	Food & Beverage (Other)*	62.5	247.1	13.1	11.3	
13	Metal Fabricating	28.8	113.9	6.1	51.0	
16	Electrical Products	26.8	106.0	5.6	45.8	
19	Chemical Prod. (Other)*	18.8	74.3	3.9	7.9	
10	Paper & Allied (Other)*	17.6	69.6	3.7	15.8	
20	Misc. Manufacturing	16.0	63.3	3.4	43.7	
5	Textiles	12.9	51.0	2.7	29.7	
	Other Industries	59.8	236.4	12.5		
TOTAL CORRUGATED BOXES		476.4	1,883.4	100.0		

* Excluding the 3-4 Digit Industries accounted for above.

TABLE 15

METAL CAN CONSUMPTION BY INDUSTRY

Industry (SIC)		Package Consumption ($ million)	Energy Content BTUx10^{10}	% of All Metal Cans	% of Industry's Package Consumption	% of Industry's Cost of Materials
3-4 Digit SIC Categories						
1031	Fruit & Veg. Canners	131.9	1,065.9	29.6	61.5	24.5
1091	Soft Drink Mnfg.	103.9	839.6	28.3	62.3	27.2
375	Paint & Varnish	28.0	226.3	6.3	78.9	9.8
1089	Misc. Food Processors	25.9	209.3	5.8	14.5	2.1
104	Dairy Products	21.7	173.4	4.9	11.5	0.9
102	Fish Products	20.1	162.4	4.5	44.3	3.4
3799	Misc. Chemicals	18.0	145.5	4.0	35.6	4.0
1093	Breweries	17.4	140.6	3.9	13.8	6.9
1011	Slaughtering.....	16.0	129.3	3.6	17.2	4.7
106	Feed	15.8	127.7	3.6	43.2	1.5
3651	Petroleum Refining	13.4	108.3	3.0	76.6	0.2
		412.1	3,330.1	92.6		
	Other	33.1	267.5	7.4		
	TOTAL METAL CANS:	445.2	3,597.6	100.0		

on packaging and hence immediate incentives exist for the industries to reduce their consumption. Further, especially in the case of Soft Drink Manufacturers, there are obvious opportunities for substitution. The energy content of metal cans consumed by the next major nine industries also represent significant items worthy of further consideration (each between 100-225 Btu x 10^{10}).

Glass bottle consumption is also concentrated in a few industries (Table 16). Distilleries is the leading industry consuming 24% of the total, and also offer a good opportunity for reduction with a high ratio of packaging to cost of all materials, and with a very high concentration of its total package consumption in glass bottles. Soft Drink Manufacturers and Wineries are also obvious candidates for future action. Fruit and Vegetable Canners, and Miscellaneous Food Processors are also significant consumers of glass bottles, but they present serious difficulties due to their heterogeneity and the wide range of their products. Soft Drink Manufacturers and Wineries are also good candidates in terms of their potential to reduce consumption. Breweries are also important consumers, but they have probably exhausted the opportunities for further reduction through extensive standardization, reuse, and relatively high trippage rates. These industries together with three others (Pharmaceuticals and Medicine, Dairy Products, Toilet Preparations) account for almost 100% of glass bottle consumption by the manufacturers.

As already indicated, folding and set-up boxes do not account for a significant share of the energy content of all packaging. There are only two industries which represent more than 100 Btu x 10^{10} embodied in folding/set-up boxes, together accounting for about 31% of the total consumption, and hence of the energy contained in this package type. Dairy Products Industries have a low ratio of folding/set-up box consumption to cost of all materials, but there certainly are obvious

TABLE 16

GLASS BOTTLE CONSUMPTION BY INDUSTRY

Industry (SIC)		Package Consumption ($ million)	Energy Content BTUx10^{10}	% of All Glass Bottles	% of Industry's Package Consumption	% of Industry's Cost of Materials
1092	Distilleries	54.7	348.1	24.2	64.4	26.2
1091	Soft Drink Mnfg.	35.1	223.3	15.5	21.0	9.2
1031	Fruit & Veg. Canners	34.1	217.0	15.1	15.9	6.3
1089	Misc. Food Processors	23.8	151.4	10.5	13.3	2.0
1093	Breweries	20.5	130.4	4.1	16.2	8.2
1094	Wineries	15.3	97.4	6.8	68.0	34.0
374	Pharmaceuticals & Medicines	14.9	94.8	6.6	29.2	5.3
104	Dairy Products	13.4	85.3	5.9	7.1	0.6
377	Toilet Preparations	10.7	68.1	4.7	17.7	10.1
		225.5	1,432.3			
	Other	0.1				
	TOTAL GLASS BOTTLES	225.6	1,432.3	100.0		

TABLE 17

FOLDING/SET-UP BOX CONSUMPTION BY INDUSTRY

Industry	(SIC)	Package Consumption ($ million)	Energy Content BTUx10^{10}	% of All Folding/ Set-up Boxes	% of Industry's Package Consumption	% of Industry's Cost of Materials
104	Dairy Products	58.6	139.2	17.9	31.2	2.5
153	Tobacco Products	45.5	108.1	13.9	54.2	14.4
1089	Misc. Food Processors	17.4	41.3	5.3	9.7	1.4
1081	Confectionery Mnfg.	14.0	33.3	4.3	27.1	5.3
1093	Breweries	13.3	31.6	4.1	10.5	5.3
1072	Bakeries	13.0	30.9	4.0	23.4	3.4
1071	Biscuit Mnfg.	10.7	25.4	3.3	27.2	7.6
		172.5	409.9	52.8		
	Other	154.3	366.6	47.2		
	TOTAL BOXES	326.8	776.5	100.0		

opportunities for substitution (e.g. plastic containers). Tobacco Product Industry may appear to have a strong incentive, but opportunities for substituting alternative package types are not very promising.

About 60% of all Transparent Film consumption is concentrated in four industries (Table 18), but only Bakeries may have some incentive to reduce consumption by substituting paper bags for plastic ones, but even then the scope for this substitution appears to be limited, and the marginal savings of energy are not likely to be very significant.

Paper consumption is widely spread over many industries (Table 19). Further, this packaging material only accounts for as little as 5% of the energy content of packaging consumed by all the manufacturers.

Table 20 provides a list of all packaging consumption items, each representing more than 100 Btu x 10. Only four of these items are not included in the six major packaging types "(Lead, tin, aluminum foil" consumed by Miscellaneous Food Processors and Tobacco Products, "Plastic Containers" by Dairy Products, and "Plastic Bottles" by Soap and Cleaning Compounds Industries), while all of them are covered by the 31 major package consuming industries identified in the previous section. Of these 29 items, 11 are metal cans, 5 glass bottles, 4 transparent film, 3 corrugated boxes, and 2 folding/set-up boxes. The 29 items together contain 61.66 Btu x 10^{12}, or 50% of the total energy contained in the packaging consumed by all the manufacturing industries.

TABLE 18

TRANSPARENT FILM CONSUMPTION BY INDUSTRY

Industry (SIC)		Package Consumption ($ million)	Energy Content BTUx10^{10}	% of All Trans-parent Film	% of Industry's Package Consumption	% of Industry's Cost of Materials
1072	Bakeries	29.0	206.3	19.1	51.0	7.6
104	Dairy Products	23.9	170.0	15.7	12.7	1.0
1011	Slaughtering.....	21.9	155.8	14.4	23.6	0.6
1089	Misc. Food Proc.	13.9	98.9	9.1	7.8	1.1
		88.7	630.9	58.4		
	Other	63.2	449.5	41.6		
	TOTAL	151.9	1,080.5	100.0		

TABLE 19

PAPER (BAGS & OTHER) CONSUMPTION BY INDUSTRY

Industry	(SIC)	Paper Consumption ($ million)	Energy Content BTUx10^{10}	% of All Paper Consumption	% of Industry's Package Consumption	% of Industry's Cost of Materials
105	Flour & Breakfast Cereal Products	15.4	78.6	11.9	43.0	3.6
1071	Biscuit Mnfg.	11.4	58.2	8.8	29.0	8.1
		26.8	136.7	20.7		
	Other	101.9	519.9	79.3		
	TOTAL PAPER	128.7	656.6	100.0		

TABLE 20

PACKAGE CONSUMPTION ITEMS WITH HIGH ENERGY CONTENTS

SIC	Industry	Package Type	Btu x 10^{10}
1031	Fruit & Vegetable Canners	Metal cans	1,065.9
		Glass bottles	217.0
1091	Soft Drink Manufacturers	Metal cans	839.6
		Glass bottles	223.3
1089	Misc. Food Processors	Metal cans	209.3
		Glass bottles	151.4
		Corrugated boxes	136.0
		Lead, tin, aluminum foil	116.3
		Transparent film	98.9
104	Dairy Products	Metal cans	173.4
		Transparent film	170.0
		Plastic containers	162.7
		Folding/set-up boxes	139.2
1093	Breweries	Corrugated boxes	143.9
		Metal cans	140.6
		Glass bottles	130.4
1011	Slaughtering & Meat Proc.	Transparent film	155.8
		Metal cans	129.3
		Corrugated boxes	107.1
1092	Distilleries	Glass bottles	348.1
375	Paint & Varnish Producers	Metal cans	226.3
153	Tobacco Products	Folding/set-up boxes	108.1
		Lead, tin, aluminum foil	102.6
1072	Bakeries	Transparent film	206.3
102	Fish Products	Metal cans	162.4
3799	Misc. Chemical Industries	Metal cans	145.5
106	Feed Industry	Metal cans	127.7
376	Soap & Cleaning Compounds	Plastic bottles	120.5
3651	Petroleum Refining	Metal cans	108.3

APPENDIX 4

ANALYTICAL USES OF INPUT-OUTPUT TABLES

Source: The Input-Output Structure of the Canadian Economy, 1961, Volume 1, Section 1.2, p. 17 & 18, Statistics Canada Cat. No. 15-501.

ANALYTICAL USES OF INPUT-OUTPUT TABLES

As a description of the production, expenditure, and international trade of the economy, Input-Output Tables are useful to business, academic, and government analysts because they provide the only comprehensive and detailed presentation of the origin and disposition of individual commodity groups and of the cost structures of individual industries. They are also used as the basis for models of the operation of the economy. The accounting relationships embodied in Input-Output Tables describe the structure of demand and of productive activity in a particular year. It has been found that many of these relationships have considerable stability even when the conditions under which they were first observed change.

The construction of economic models based on the information contained in Input-Output Tables rests on the observation that the process of production, in modern technological societies, is roundabout. To produce an automobile, for example, requires the efforts not only of those who are in the automobile industry, but also of those who are concerned with the production of steel, aluminum, rubber, textiles, and the myriad of other materials and services which are embodied in automobiles. In turn, the production of steel, aluminum, rubber, etc. is only possible if yet other materials and services have been produced and are available. Thus, the production of automobiles, and indeed of any other product, implicates a long chain of production which links many of the human, material, and technological resources of the economy.

Now, if the human, material, and service inputs into automobiles are stable in relation to the output of automobiles, and, if, in turn, the requirments for producing steel, aluminum, rubber, etc., are stable and so forth, then, through mathematical models based on Input-Output Tables, it is possible to estimate the impact of the demand for automobiles, not only

on the production of the automobile industry, but also on the production of all the other industries which are involved, however indirectly, in the production of automobiles; similar estimates can be made for any other commodity. Input-Output models thus make it possible to study technological inter-dependence and to trace the propagation of demand through the economic system. Moreover, these models can be formulated so that the incomes and revenues generated by industrial activity in turn determine the level and composition of a large proportion of final demand. In this way, Input-Output models can be made to simulate the circular flow of economic activity.

Of course, Input-Output models present a simplified account of economic inter-dependence. Since their inception, they have undergone many changes designed to make them more realistic, but it is inevitable that they will continue to be very simple constructs compared to the complexity of economic systems. In this they are not unique; all models of economic behaviour represent a simplification of reality.

Because Input-Output models present economic relations in a highly disaggregated form, they lend themselves to analyses which are not possible with aggregative models, particularly where the inter-dependence of sectors of the economy is being studied. They have been used throughout the world for a variety of analytical purposes by governments, businesses, and universities.

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