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Development and Demonstration of a Customized Truck for Collection of Glass, Metal and Paper Refuse

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DEVELOPMENT AND DEMONSTRATION OF A CUSTOMIZED TRUCK FOR COLLECTION OF GLASS, METAL AND PAPER REFUSE

by

The Is Five Foundation
Toronto, Ontario

for the

Technical Services Branch
Environmental Protection Programs Directorate
Environmental Protection Service
Environment Canada

This project was conducted under the Development and Demonstration of Resource and Energy Conservation Technology (DRECT) Program

DRECT

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et demander

Fabrication et démonstation d'un camion spécialement conçu pour la collecte des déchets de verre, de métal et de papier.

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ABSTRACT

It has been demonstrated that higher material recovery rates can be achieved through curbside collection of refuse then through the depot (drop-off) mode.

Where the curbside collection of newspaper is, in many cases, viable, the same cannot be said for other types of refuse. This project identifies and demonstrates a system that enables profitable collection of more than one type of refuse.

RÉSUMÉ

On a démontré que les taux de récupération des rebuts étaient plus élevés lorsque la collecte se faisait en bordure de rue que lorsque les rebuts étaient déposés dans des bacs.

La collecte des vieux journaux en bordure de rue est souvent une méthode très convenable, mais tel n'est pas le cas pour d'autres types de rebuts. Dans le présent projet, on fait la démonstration d'un système qui permet la collecte de plus d'un type de rebuts avec un bon taux de récupération.

ACKNOWLEDGEMENTS

The Is Foundation would like to thank the staff of DEL Equipment Ltd. for their tremendous assistance in this venture. Particular thanks to Mr. Paul Martin, P. Eng., Mr. Michael Mahoney, and Mr. Richard Olins, P.Eng. In addition, we thank Mr. Stuart Hay, P. Eng., Mr. John Payne, P. Eng., and Mr. David Campbell, P. Eng. of Environment Canada. Without their support this project would not have been possible.

Finally, we must acknowledge the invaluable support of the entire staff of the East York Conservation Centre. It has been their determination to advance the state of the art of at-source recovery in general, through the establishment of a major municipal scale recycling demonstration program, which has provided both the impetus and the fertile ground for this development.

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1 INTRODUCTION

The Is Five Foundation has been directly involved in the development and operation of at-source recovery operations since 1974. One major barrier to the successful implementation of at-source recovery on a broad scale was identified as a lack of suitable collection equipment designed for multimaterial curbside collection of recyclable materials. With the financial support of Environment Canada (through their Development and Demonstration of Resource and Energy Conservation Technology (DRECT) Program), and the technical expertise and creativity of DEL Equipment Ltd. of Toronto, the Foundation has developed a prototype multimaterial collection vehicle. This report outlines the design criteria employed and provides a preliminary evaluation of the prototype vehicle.

This new vehicle was not developed in isolation. It is a product of the hands-on experiences of the Foundation's staff in the operation of municipal recycling programs, and of a broad understanding of municipal waste management requirements. The evaluation presented is based primarily on the operational performance of the vehicle, over a six-month monitoring period, in the East York recycling program. The truck has since been integrated into the ongoing residential glass and newspapers curbside recovery program on a full-time basis. Future plans call for the simultaneous collection of metal containers.

The East York recycling program is operated by the East York Conservation Centre, a project of the Is Five Foundation. The recycling program currently recovers waste newspaper and glass from residential waste, and old corrugated cartons, fine grade papers, glass and wood from industrial, commercial and institutional waste generators throughout the municipality of East York. East York is a member municipality of Metropolitan Toronto, with a population of approximately 104 000. The recycling program has been operating since February 1978.

2 OBJECTIVES

The primary objective of this project was the design, development and demonstration of a collection vehicle to make curbside multimaterial recovery programs more viable.

Specific project goals needed to fulfill this objective included:

- The vehicle must be capable of collecting two or more fractions of the waste stream in a single pass, and storing collected material in separate compartments within the vehicle.
- The loading procedure should be designed to allow for vehicle operation with a two person crew--one driver and one loader--and should reduce the physical effort required to hand load conventional box/stake trucks.
- The vehicle should be capable of automatic off-loading.
- Production costs for this vehicle must be competitive with existing collection vehicles.
- Simplicity of design should be stressed to minimize development costs and maintenance requirements, and to ensure reliability.

3 BACKGROUND

The following subsection develop the reasoning behind each of these design goals and their impact on the final vehicle design.

3.1 Multimaterial Curbside Collection

Numerous recycling operations throughout North America have demonstrated conclusively that higher material recovery rates can be achieved through curbside collection than through the depot (drop-off) mode. Experience has also demonstrated that, to date, the primary impetus for the introduction of recycling services in Ontario municipalities has been their potential for impact on the existing solid waste stream. Therefore, wider adoption of at-source recycling programs would require demonstration of their ability to recover a significant portion of the waste stream.

Furthermore, given the relatively low prices being paid for recoverable material from residential waste, and existing recovery techniques, the separate curbside collection of materials other than newspaper could not be justified economically. The collection costs for materials such as glass and metal, if collected separately, far exceeded potential revenues. However, the economies of scale which would be brought to bear if these materials were collected simultaneously would significantly reduce collection costs.

Experimental programs in the U.S., which collected co-mingled materials from households and separated these materials at a processing facility, were examined. Considerable doubt exists about their economic viability in the U.S. Such a system could not be justified for the Canadian situation given the different waste composition (primarily a lack of profitable aluminum containers) and the different market conditions for recovered materials. Therefore, materials would have to be set out at the curbside in a separate form, and would have to be kept separate in the vehicle.

Recycling programs which have utilized conventional collection vehicles, such as high-bed stake or box trucks, incur excessive collection and handling costs. Such systems generally require two loaders (one on the vehicle and one on the ground); as well, mechanical handling equipment to off-load containers may be required, and often a considerable portion of the storage capacity of the truck is sacrificed to storage containers. Some loading mechanism would need to be developed to overcome these problems.

3.2 Two Person Crew

Labour represents the largest single variable cost in most recycling programs. Given the slim profit margins of at-source recycling in this stage of its development, two-person crews per vehicle are used wherever possible in Is Five collection programs. Collectors pick up materials from both sides of the road in a single pass. Collection time with a single loader is reduced if materials can be loaded into the rear of the collection vehicle, rather than through openings in the sides of the truck. Collection time is also reduced if the loader can ride safely on the rear of the vehicle, rather than jumping in and out of the cab or riding on the running board. These would be primary considerations in the truck design.

Conventional trucks, able to carry 4.5 tonnes of cargo are generally built on high bed chassis, with the floor of the storage bed often 1.5 metres above ground level. As the truck fills, the materials must be lifted 2 to 3 metres into the truck, with the added burden of throwing or re-piling material toward the front of the truck. This factor has accounted for a high turnover of employees in previous programs. Standard vehicles with low beds, i.e. floor of the storage area approximately 0.7 metres above the road, generally have lower cargo carrying capacities, in the range of 1 to 2.5 tonnes. Although these trucks offer considerable advantage to the loader of recyclable materials, the lower carrying capacity necessitates more frequent off-route time to off-load at the market or at an intermediate handling point. Therefore, in addition to a rear-loading capacity, the truck should have a loading system which minimizes the physical efforts of the loader. Ideally this would involve loading materials into a hopper, at a height no greater than the loading height on a conventional compactor truck, with mechanical assistance in loading. In addition, some additional mechanism would be required to ensure even distribution of material within the cargo area. These features would greatly improve the job quality for these workers.

3.3 Automatic Off-loading

Double handling of any recovered material is innately inefficient in terms of time and money for both the recycling program operator and the purchaser of recovered material. The necessity of hand unloading at the end of the collection day, when the crew is most fatigued, also represents a second major deterrent to the quality of a worker's job.

While hydraulic dumping represented an obvious solution, the vehicle would have to accommodate off-loading of each recovered material separately.

3.4 Competive Costs

The costs of conventional vehicles used in recyling programs in Canada range from a low of a few hundred dollars for a used pick-up truck, to as high as $60 000.00 for a new compactor truck. The decision on which type of truck to use has been made primarily on the basis of what was available or what was affordable. Where collection vehicles fed into intermediate handling points central to their collection areas, vehicles with lower carrying capacities--a step van or magnavan-- proved adequate. For programs which deliver recovered materials directly to end-users or dealers/brokers, it is usually more efficient to use trucks with higher cargo capacities (such as a standard 5 tonne capacity stake/box truck). Compactor trucks have been employed primarily because they are generally available in the municipal fleet, though in some cases they have been selected for their high carrying capacity and the automatic off-loading feature. For comparative purposes, Table 1 illustrates the approximate costs of a variety of new trucks.

TABLE 1 APPROXIMATE COSTS NEW TRUCKS - 1980

Carrying Capacity	Type	Cost
1 Tonne	Pick-Up	$ 7 000
2.5 "	Magnavan	11 000
5 "	With Box	18 000
6 "	Compactor	60 000

While the compactor truck offers many of the operational requirements identified above, it is largely over-built for use in a recycling program. This vehicle is designed and built to compact large volumes of garbage under great pressures, resulting in high production costs. Generally, material recovery in a recycling program does not benefit from this capability. In fact, there have been some indications, primarily in the Etobicoke (Toronto, Ontario) recyling program, that continued use of compacting units for high-density materials such as newspaper, leads to excessive wear on the equipment and high maintenance costs. At the same time, many of its advantageous features could be adapted to a less expensive vehicle. A basic decision was made, therefore, to begin with a conventional chassis which would significantly reduce development costs and ensure wider applicability and diffusion of any new body design that could be developed. Given the marginal economics involved, as emphasized earlier, and the fact that recycling must operate on the basis of a conventional business enterprise rather than as an alternative waste management system, an optimal vehicle design which greatly exceeded the costs of conventional vehicles could not be justified for most recycling program operators.

The limited budget for this particular program also required the purchase of a used chassis, although this did not represent a determining factor in the final design of the vehicle.

3.5 Simplicity of Design

A design which, as much as possible, employed conventional equipment and parts, would also assist in keeping down total production costs. By using equipment which was already common in conventional trucks, it would be possible to minimize the inevitable bugs in any prototype developed, and the operating capabilities of the various components would be known. Maintenance work could also be undertaken without uniquely specialized facilities and skills, in order to help reduce operating costs.

It was also felt that a design which appeared to be relatively conventional would achieve a higher acceptance rate among potential operators. In essence, the vehicle would employ conventional, proven operating components, redesigned to fulfill the unique operational requirements of a developing at source recycling industry.

The vehicle design which has been developed, therefore, represents the product of a series of trade-offs between optimum operating criteria and the limitations of available technology and development funds.

4 FINAL DESIGN

Figure 1 represents the specifications for the prototype vehicle produced. The design incorporates a custom-built body on a conventional GMC Series 6000 chassis. The chassis selected represents the best choice available (within budget limitations) which met the key operating requirements: a payload capacity of 6 tonnes, automatic transmission and power assisted brakes. It should be noted, however, that any chassis meeting the specifications listed would be suitable in replicating this vehicle.

The body incorporates several custom-designed features. Fibreglass construction was chosen for the body shell as its light weight allowed for a higher carrying capacity than either wood or metal construction, while providing strength and ease of modification. Three interior storage compartments were created by erecting sheet metal walls on the interior of each side of the body walls. The ratios of each storage area were determined on the basis of proportional volumes of each material (glass, ferrous containers and newspaper) collected during pretesting of a multimaterial curbside collection program. A loading platform was mounted on the rear of the vehicle, consisting of a modified tailgate loader, with buckets located on either side of a loading tray. A hydraulically operated "rake" was mounted at the top of a cargo box to pull recovered newspaper into the cargo storage area.

FIGURE 1 DRECT TRUCK SPECIFICATIONS

CHASSIS AND DRIVE-TRAIN

Make:	G.M.C.
Model:	6000
Engine:	Gasoline, 6 L V8
Transmission:	543 Allison Automatic
Front Axle:	3.6 t
Rear Axle:	9.4 t
Brakes:	Power-assisted drum brakes, hand brake on Trans.
Power Take-off:	Edbro combined PTO and 450 cm^3/s piston pump with TLA cab control and Morse Hoist control

BODY

Make:	Diesel Equipment Ltd.
Model:	Fibreglass custom
Dimensions:	4.9 m (length), 2.6 m (width), 1.9 m (interior height)
Storage Capacity:	Total: 21.7 m^3 News: 12.7 m^3 usable (approx.) Glass: 1.6 m^3 per compartment (2)
Loading:	DEL DD-200 Tailgate (modified) Capacity 1 t Vertical Lift: 185 cm Width: 259 cm Depth: 75 cm Capacity: Newspaper 4 t, Glass 2 t
Packer:	Custom system with a 6.4 cm. Hydraulic Cylinder pulling a reinforced blade through the newspaper section of the loader and into the truck
Unloading:	Two extendable cylinders (total extension lifts body to 55 degrees)
Doors:	Two side doors (91 cm x 107 cm each) for side loading and access. One vertically hinged door on each glass compartment (91 cm x 46 cm each). Two barn-type doors (76 cm x 152 cm each) for newspaper compartment.
Net Weight:	6 t.

5 PROCESS FLOW

Plates 1 through 6 illustate the vehicle in operation. The operating cycle involves three primary stages: collection, loading and unloading.

5.1 Collection

During collection, the loading platform is placed in the fully down position (i.e. approximately 15 cm from the roadbed to the footrests and 60 cm to the loading platform). While the vehicle is in motion, the swamper rides on the rear steps. The driver stops at all material setouts and the swamper dismounts to load. In the case of collection programs which involve three materials, i.e. glass, ferrous containers and newspaper, each of the materials is loaded into a separate component of the loading tray. Newspaper is stacked onto the 1 m^2 section in the centre of the loading platform, and glass is dumped into one of the side buckets and metal into the other. Each of these buckets has a storage capacity of 0.13 m^3. The swamper will collect from both sides of residential streets on the same pass, with the exception of major arterial roads. In cases where there are large volumes of newspaper at a single stop (as often occurs in curbside recovery programs), the driver can also dismount and load newspaper through side door openings located near the cab on either side of the vehicle. In programs such as that operated in East York, where only two materials are currently being collected, glass can be dumped into both side containers.

When loading is completed, the swamper steps up onto the footrests and presses a buttom mounted above the handrails, which activates a buzzer in the cab and signals the driver to continue on the route. This buzzer is also used to signal for additional stops in cases where the driver may miss set-outs more visible to the swamper.

5.2 Loading

When the loading platform is completely filled--approximately 180 kg of newspaper and 60 kg of glass containers--the truck is stopped and the driver engages the PTO unit and runs the engine at high idle (approx. 1 200 rpm). The swamper operates the hydraulic valve controls located at the rear-side of the cargo box. The horizontal rake mounted at the top of the box is extended to its rear-most position while simultaneously raising the loading platform to its fullest height. The horizontal rake is then retracted into the cargo area, dragging the recovered newspaper along with it. To aid distribution

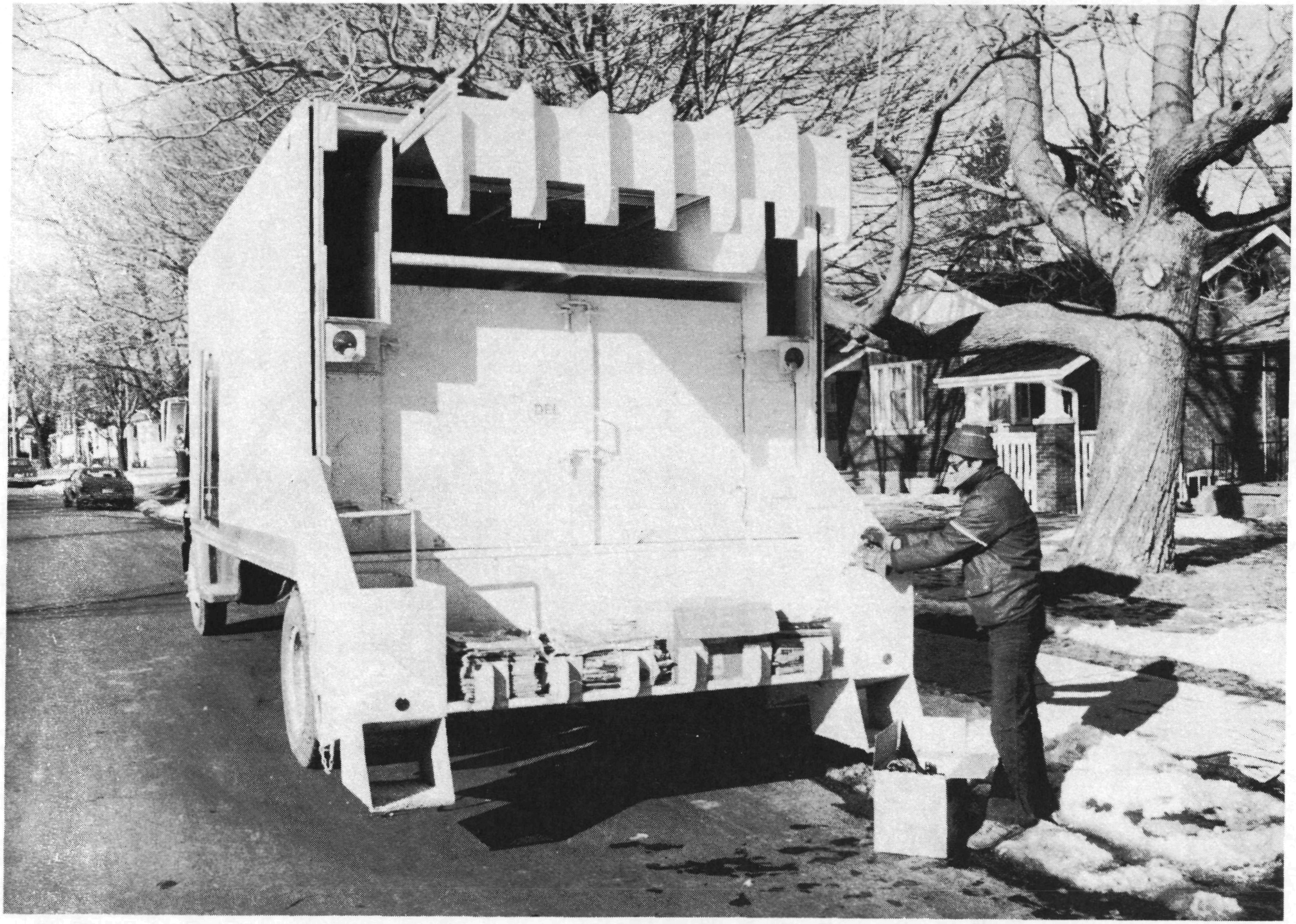

PLATE 1 PAPER IS LOADED ONTO THE CENTRE TRAY. GLASS IS CURRENTLY LOADED INTO BOTH SIDE BUCKETS, BUT ONE BUCKET WILL BE USED FOR METAL CANS IN THE FUTURE. SWAMPER RIDES ON THE REAR STEPS.

PLATE 2 REAR PLATFORM IS RAISED FOR LOADING.

PLATE 3 THE HORIZONTAL RAKE PULLS IN THE NEWSPAPERS AND GLASS DROPS INTO SIDE COMPARTMENTS.

PLATE 4 VIEW FROM THE INSIDE. NEWSPAPER DISTRIBUTION THROUGHOUT THE TRUCK IS HELPED BY A TRAY WHICH EXTENDS FROM THE REAR LOADING AREA. ENCLOSED STORAGE AREAS EXTEND ALONG BOTH SIDES OF THE TRUCK.

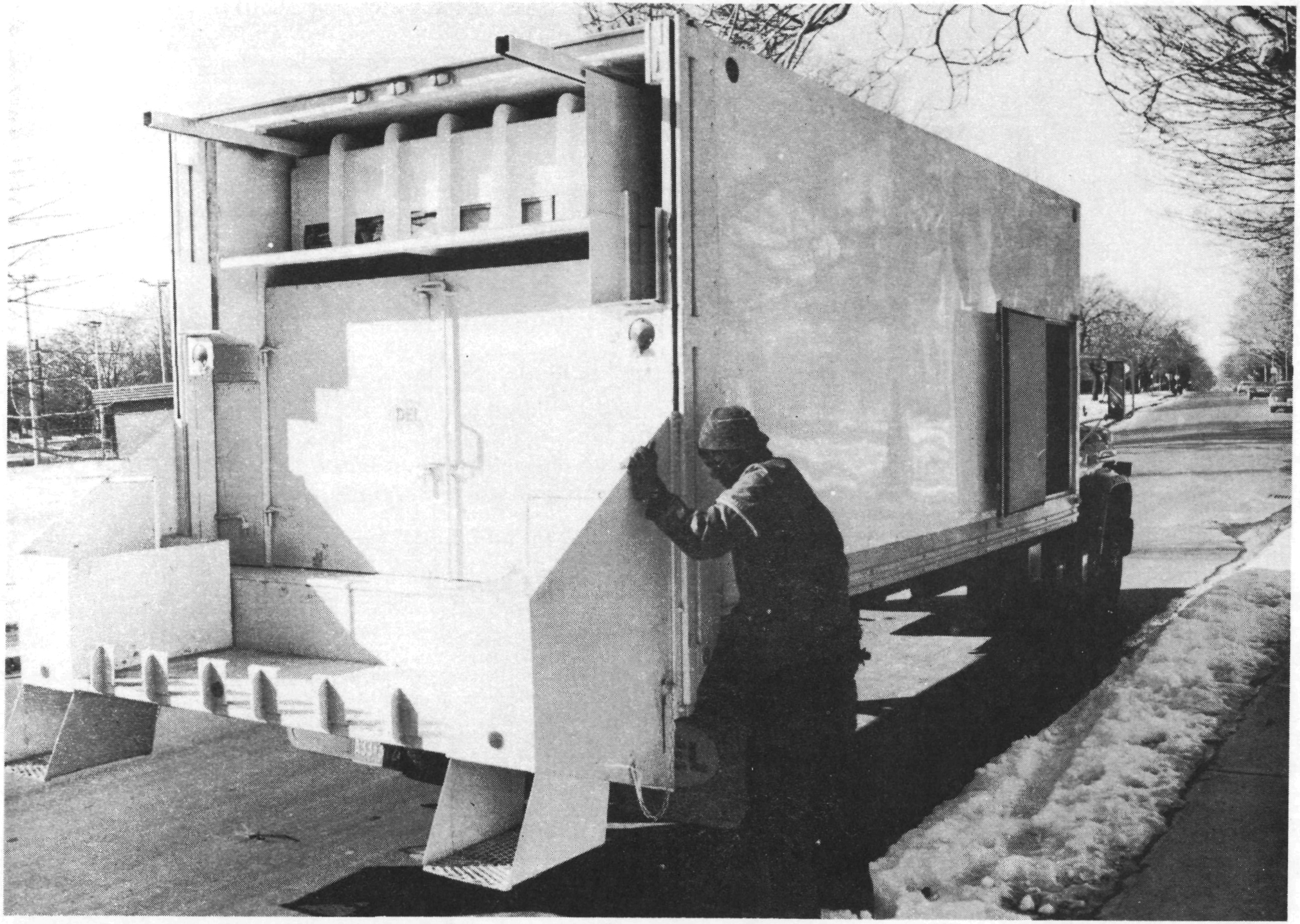

PLATE 5 AFTER MATERIALS ARE UNLOADED, REAR PLATFORM IS LOWERED. NOTE SIDE DOORS (BOTH SIDES) WHICH MAY ALSO BE USED FOR LOADING NEWS.

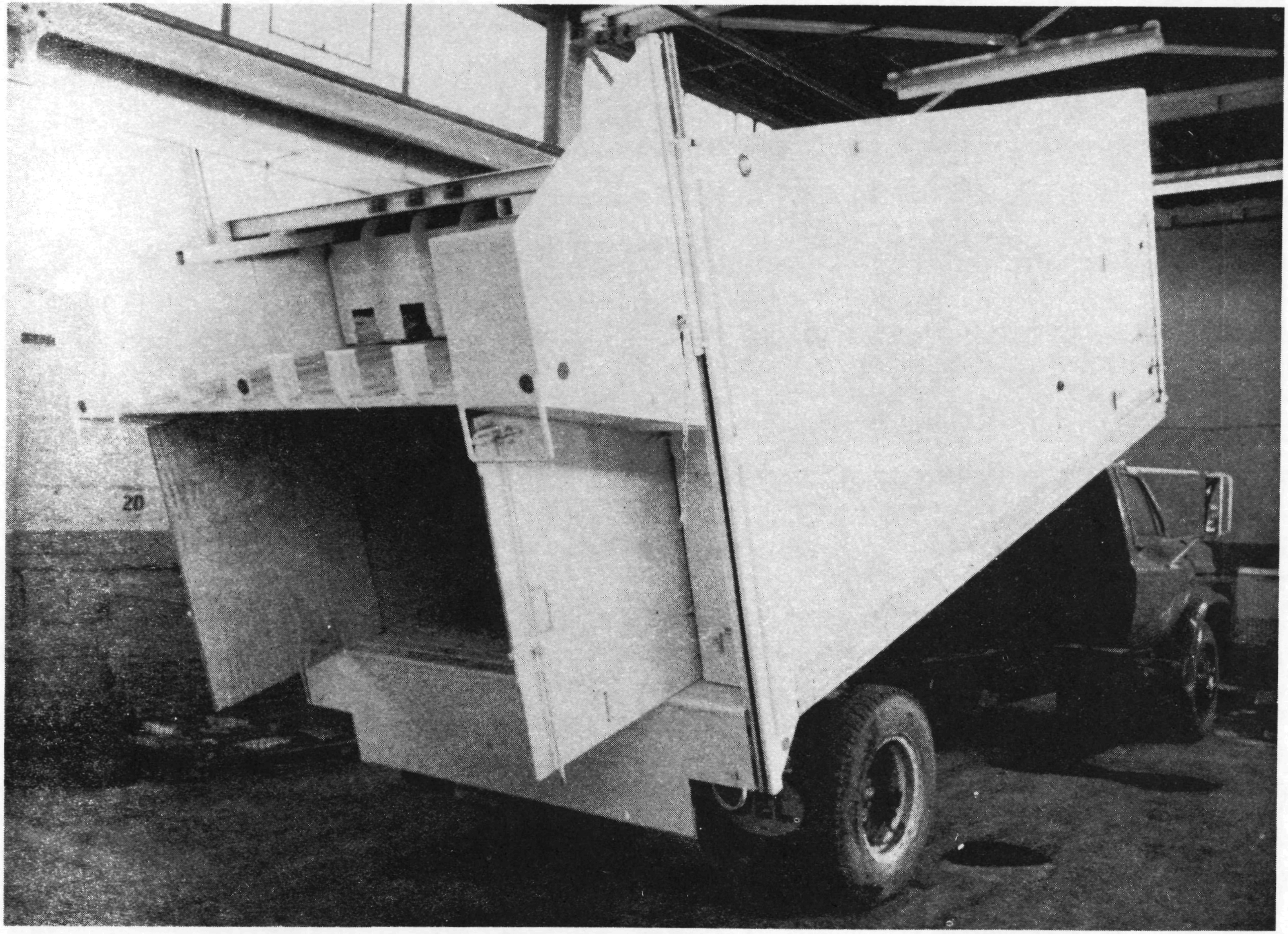

PLATE 6 MATERIALS ARE OFF-LOADED SEPARATELY BY OPENING THE APPROPRIATE REAR DOORS.

of newspaper through the truck, a tray has been installed which extends into the cargo area (see photo No. 4).

The two side buckets are constructed with sloping bottoms. As the platform is elevated, the side buckets line up directly with two openings located at the top of both sides of the cargo box. These openings correspond to the storage bins constructed inside the cargo area. These bins extend into only part of the cargo area, to allow loading of newspaper through the side doors, and their sides are angled to reduce the possibility of paper jamming during the off-loading. Spring-loaded doors on the rear buckets are opened by pulling chain levers that are attached. Their contents are gravity fed into the respective side storage containers. The loading platform is then returned to the down position, the PTO is disengaged, and collection is resumed. On the prototype truck, a separate valve and manual control lever were used for each function, i.e. one lever controls up and down on the vertical loader and the other controls in and out on the horizontal rake. This was done in order to simplify modifications during the evaluation phase; the truck will eventually have electrically controlled pilot valves which will accomplish the sequence automatically.

On average, the DRECT truck must stop after every 15 or 20 pick-ups and go through the loading cycle. This loading cycle usually requires 1.5 minutes to complete.

5.3 Unloading

When the route is finished, or when the truck has been filled, the loading tray is put into the up position and the truck returns to an intermediate handling point. Here the hoist diversion valve is switched to the hoist position and the driver activates and controls the degree of lift from the cab. The "barn" doors to the news storage compartment are opened prior to lifting and news is off-loaded directly onto the warehouse floor. The same procedure is then followed for off-loading the glass, which is dumped directly into larger "roll-off" containers for shipment to market in larger loads.

6 ECONOMIC ANALYSIS

The collection function of a recycling program represents only one component of the overall program. This vehicle has been designed for use in an existing comprehensive municipal recycling program. It includes promotional work, material recovery, intermediate handling and processing, and shipment of the recovered material to industrial end-users. A comprehensive economic analysis of all aspects of the recycling program, which this particular vehicle is a part of, goes well beyond the scope of this report. The economic viability of this particular component can, however, be addressed in isolation, but it must be emphasized that the economic feasibility of any particular recycling program must incorporate many additional factors.

6.1 Operating Costs

As outlined earlier in this report, given a limited budget, a used cab and chassis were purchased for the prototype vehicle. In addition, considerable costs were incurred both by the Foundation and by DEL (the manufacturer of the actual truck body), in research and development work. In order to evaluate the economic viability of this vehicle, only the actual costs of replicating a new version of the same vehicle are calculated. A new cab and chassis of this size and with equivalent features would cost approximately $18 000. DEL Ltd. estimates that the cost of reproducing the body and loading mechanism at approximately $10 600 (including some amortization of R & D costs). Therefore, the estimated costs for purchasing this vehicle would be approximately $29 000 (1980). Therefore, if depreciated on a straight line basis over a period of four years at 25% per annum, a capital cost of approximately $7 250 per annum should be allocated for this vehicle.

Based on the operating performance of this vehicle over a six month period (utilizing one driver and one swamper), this truck can collect an average of 6 tonnes of material per 8 hour working day. Again, however, it must be emphasized that this is more a factor of the overall success of the recycling program itself as opposed to any inherent limitation in the technology of the collection vehicle. That is, the rate of recovery is at least as dependent upon the participation rate as the collection efficiency. By comparison, a single compactor truck with a two-person crew, collecting refuse from every home in a residential community will often handle 10 to 15 tonnes of garbage per day. Given that 100% participation of all households on every collection is not at all likely, such rates could never be achieved in a recycling program.

A driver for a collection vehicle of this size requires a Class D license in the Province of Ontario. An appropriate wage for this worker is approximately $350 per week ($18 200/annum). For the less skilled position of swamper, the wage is approximately $280/week or $14 560/annum.

Fuel usage for this vehicle is about 50 L/100 km in normal collection work. Insurance rates determined in the context of its operators with other vehicles used in the East York recycling program is $565.00 per year. Thus, operating costs for this vehicle, including fuel, maintenance and insurance, are estimated to be approximately $150/week or $7 800/annum.

Therefore, total operating costs for this truck and crew are estimated to be $47 810 (Table 2).

TABLE 2 ESTIMATED ANNUAL OPERATING COSTS

Vehicle Costs	$ 7 250	(based on 25%/annum depreciation)
Driver	18 200	
Swamper	14 560	
Operating Costs	7 800	
Total	$ 47 810	

6.2 Revenues

On average, the ratio of newspaper to glass collected is approximately 3 to 1, by weight. That is, the average daily collection of 6 tonnes consists of approximately 4.5 tonnes of newspaper and approximately 1.5 tonnes of glass. Therefore, on an annual basis, it is expected that this vehicle and crew will collect approximately 1 156 tonnes of newspaper and approximately 377 tonnes of glass.

The market price for recovered waste materials is dependent upon several variables, including the quality of material available for sale, the form in which the material is delivered/collected, and the level of contamination. To evaluate the economic viability of this vehicle in isolation, prices currently being received (July 1980 through November 1980) for loose, unprocessed materials delivered to markets in the Metro Toronto region have been used:

Old newspapers	$49.6/tonne
Glass	$33/tonne

Based on the annual estimated recovery identified above, Table 3 presents the estimates of revenues received from sale of these recovered materials:

TABLE 3 ESTIMATED ANNUAL REVENUES

Newspapers	1 156 tonnes	x	$49.6/tonne	= $57 354
Glass	377 tonnes	x	$33/tonne	= 12 470
Total				$69 824

6.3 Comparison with Other Existing Trucks

In a gross analysis, therefore, when viewed in isolation the expected revenues from operating this vehicle and crew are expected to exceed total operating costs by approximately $22 000 (not including interest charges, wage overhead, etc.). It must be emphasized that this analysis in no way takes into consideration other recycling program operating costs in such areas as promotion, supply development, handling station operation, etc. Thus, to more accurately assess the economic feasibility of this prototype vehicle, it can be compared with another existing vehicle which has been used in this recycling program and is in common use in several other programs.

In addition to the DRECT truck, the Is Five Foundation employs two GMC Magnavans in its curbside collections. These vehicles have a cargo capacity of approximately 2.3 tonnes (with 3.66 m aluminum cargo box construction), and are standard commercial vehicles. While well suited to newspaper collections, they are not effective in multimaterial programs. By adding 200 L drums to the cargo area for glass storage, they have been used in pilot programs in East York, Ontario, and as the primary vehicle in other recycling programs. This system, however, offers a relatively low capacity for glass storage, slows collection significantly given the need to climb in and out of the truck for loading and changing positions of the barrels, and creates serious handling problems where full barrels of glass (weighing 70 to 100 kg) must often be unloaded by hand. This lack of suitable collection vehicles has been the major barrier to the further extension of multimaterial collections in existing urban curbside collection programs. As a result, these Magnavans are used for just newspaper collection, and recover on average approximately 4.5 tonnes of material per day, operating with a two-person crew. Given the more limited carrying capacity of these vehicles (a trade-off with the benefits of operating a low-bed vehicle over conventional high-bed 4.5 tonne trucks), one additional trip to off-load at the handling facility of the market point is required. Therefore, collection time advantages enjoyed by this unit over the DRECT truck, given the fact that only newspaper is being loaded as opposed to newspaper and glass, and without the additional loading cycle required by the DRECT truck, are largely negated.

An assessment of the operating costs and recovery rates for these vehicles follows (Table 4). In general, operating costs are lower given that drivers do not require a special operating license and the vehicles are smaller with higher gas mileage. The new purchase price for this vehicle, with aluminum body, heavy duty springs and axle, and other options is approximately $14 000.

TABLE 4 ESTIMATED OPERATING COSTS

Vehicle Costs	$ 3 500	(based on 25%/annum depreciation)
Driver	15 600	
Swamper	14 560	
Operating Costs	5 200	(fuel, maintenance, insurance, etc. at $100/week)
Total	$ 38 860	

If the same 3 to 1 ratio of newspaper to glass recovered were used with the same rate of recovery currently being achieved for just newspaper, i.e. approximately 4.5 tonnes per day, the following revenue projection can be made if the Magnavan were used in place of the DRECT truck (Table 5).

TABLE 5 ESTIMATED ANNUAL REVENUE

Newspaper	884 tonnes/annum	x	$49.6/tonne	=	$43 846
Glass	295 tonnes/annum	x	$33/tonne	=	9 735
Total					$53 581

Therefore, even if the existing Magnavans were considered to be a suitable alternative as a multimaterial collection vehicle, the surplus of revenues over costs in operating the DRECT truck--approximately $22 000/annum--significantly exceeds the surplus revenue generated by the Magnavans and crew--approximately $15 000. Again, it must be emphasized that the multimaterial capability of the DRECT truck means that the vehicles are not directly comparable, and the comparison becomes even less favourable when the DRECT truck's capacity for adding a third material is taken into consideration.

6.4 Potential Impacts of this Vehicle

A primary barrier to a rapid increase in multimaterial at-source recycling in Canada is the marginal economics involved in such programs. Rapidly rising virgin material and energy costs, however, ensure that secondary materials will continue to become ever more competitive, with recycling becoming increasingly important to the Canadian economy. The speed with which this evolution occurs is primarily dependent upon the market value of specific secondary materials and the costs of collecting, processing, and delivering these materials to end-users. The development of the vehicle outlined in this report may have a significant impact on both of these factors.

As has been demonstrated in the economic analysis, the DRECT truck has reduced the average per tonne collection costs for the East York recyling program when compared to conventional collection vehicles:

DRECT	-	glass and newspaper	31.19/tonne
Magnavan	-	glass and newspaper	32.96/tonne

The ability to collect more than one fraction of the waste stream also increases the total volume of material available for collection, thereby spreading out the overhead burden associated with administration and supply development costs. A multimaterial collection program is also less susceptible to market fluctuations which tend to seriously impact on single material programs. These factors together greatly improve the stability of the recycling program.

The lack of a stable municipal-based at-source recovery industry, able to deliver large quantities of material on a regular basis has had a major negative impact on the prices paid for secondary materials. The lack of a managed or predictable supply mechanism for the recovery of secondary materials from residential sources has made production planning on the part of end-users both difficult and a risky financial proposition. As a result, most end-users, brokers and dealers, offer a standard "public" price for recovered materials which essentially reflects the prices paid for spot supplies of infrequent generators. It is only recently that markets have begun to stabilize for materials such as waste newspaper.

The development of a multimaterial collection vehicle able to build on this relatively stable collection base could have a significant impact on overall material recovery levels.

The potential impact can be assessed by looking at the country as a whole. Currently there are no more than half a dozen recyling programs in operation which are collecting more than one material (usually newspaper) from the curbside. A recent report (Implementation of At-Source Separation Systems in Canada: An Initial Evaluation of the Potential Impacts; Enertask Consultants and Resource Integration Systems; April, 1979) produced for Environment Canada estimates that some form of recycling program exists in most of the major cities in Canada, and that an estimated 257 municipalities with a population in excess of 7 500, i.e. 65% of the population, could support some form of multimaterial collection program. One of the keys to the development of such a program would be the ability to collect two or more materials simultaneously from the curbside.

The distribution of potential markets for secondary materials in Canada varies significantly for different materials. Markets for recovered tin cans, for example, are extremely limited, while the demand for other components of the stream, such as newspaper and glass, is relatively high throughout all regions of the country. Therefore, the DRECT collection vehicle developed could potentially be applied to the collection of at least glass and newspaper in at-source recovery programs in the 257 municipalities identified in the above report. These two materials would provide the common base for such programs, with the potential for adding a third component of the waste stream given favourable local markets and conditions. In order to assess the potential impacts of using such a vehicle in recovery programs throughout the country, this analysis will focus on the potential impact on the recovery of glass and newspaper only from the municipal waste stream, as identified in the Resource Integration Systems Ltd. report (Tables 6 and 7).

The DRECT truck therefore, could potentially be applied to the collection of approximately 518 691 tonnes of waste newspaper and glass in Canada plus additional materials on a regional basis. This does not imply a direct relationship between the development of this vehicle and increased recovery of this amount of material, given that some of this material is already being collected, and most of the additional tonnage couldalso be collected in alternative vehicle types. This vehicle could, however, have a significant impact on the development and stability of such collection programs. The actual recovery of glass from the municipal waste stream in Canada is relatively miniscule at this time. Without the multimaterial capability of this vehicle in a collection

TABLE 6 OLD NEWSPAPER AVAILABLE FOR RECOVERY - TONNES PER YEAR*

Region	% of Waste Stream	Municipal Waste	Total Available	Estimated 41% Recovery
B.C.	10.3	867 735	97 368	39 905
Prairies	8.9	1 343 936	119 797	49 097
Ontario	9.3	4 390 159	409 774	167 940
Quebec	9.8	2 132 079	209 884	86 018
Atlantic	4.4	371 495	16 321	6 689
				346 649

TABLE 7 GLASS AVAILABLE FOR RECOVERY TONNES PER YEAR*

Region	% of Waste Stream	Municipal Waste	Total Available	Estimated 29% Recovery
B.C.	7.7	867 735	67 634	19 604
Prairies	5.4	1 343 936	72 612	21 047
Ontario	6.5	4 390 159	285 322	82 702
Quebec	6.2	2 132 079	132 891	38 519
Atlantic	9.4	371 495	35 087	10 170
				172 042

* Based on Implementation of At-Source Separation Systems in Canada: An Initial Evaluation of the Potential Impacts, R.I.S. Ltd., 1980 for Environment Canada

program, it is unlikely that the maximum potential material, energy and cost savings identified for recycling will ever be achieved.

It is not possible, however, to accurately quantify the actual impacts that could be expected to result from this development, given the interrelatedness of a wider number of factors which impact on the development of a successful recycling program. Only a gross analysis can be provided in this report to indicate the maximum potential benefits that could possibly be achieved in the areas of waste diversion, energy conservation and cost savings. The DRECT truck can potentially affect all of these factors in an existing or potential municipal recyling program.

6.4.1 Material Recovery. Of the 346 649 tonnes of newspaper described earlier as potentially recoverable in Canada, it is estimated that only approximately 69 000 tonnes per year are currently being recovered from stable residential recovery programs in Canada. The current shortfall in supply for domestic end-users in made up primarily through imports from the U.S. Of the 172 042 tonnes of waste glass identified as potentially recoverable from residential sources, all (over and above current estimated recovery of 70 000 tonnes per year) could be utilized by the Canadian glass industry, given that total domestic demand is currently estimated to be in excess of 587 000 tonnes per year. The development of an effective multimaterial collection vehicle, if properly integrated into effectively designed recycling programs, could significantly reduce the gap between current recovery levels and potential recovery levels. Without suggesting in any way that this would be accomplished solely through the development of this or any other multimaterial collection vehicle, the total increase in domestic recovery could potentially reach:

Newspaper:	346 649 t/yr	(potentially recoverable)		
	69 000 t/yr	(existing recovery)	=	277 649 t/yr
Glass:	172 042 t/yr	(additional recovery)	=	172 042 t/yr
Total Material Recovery			=	449 691 t/yr

6.4.2 Energy Savings. Potential energy savings frm a broad application of the DRECT truck would occur in two areas: improved energy efficiency in the collection of materials and through energy savings from increased use of secondary materials in manufacturing industries.

6.4.1 Energy Efficiency in Collection. The objective in this case was to minimize the energy requirement of the truck. For a rolling vehicle, energy is used to overcome the forces of acceleration, air resistance (drag) and rolling resistance. Energy consumption itself can vary greatly depending on a number of factors. Driving style, turns, hills, conditions of road, condition of engine and tires, aerodynamic shape, wind and various vehicle associated equipment (heater, loading mechanisms, etc.), all have an effect on energy consumption. However, all outside variables cannot be addressed in a design. Some of them can be dealt with by establishing efficient driving policies and maintenance programs. This should be part of any collection program and is not within the scope of this report. The only forces which could be dealt with to any extent in the design were the forces of drag and rolling resistance.

Drag is a function of the drag co-efficient and the projected frontal area. We tried to limit the projected frontal area by keeping the truck as low as possible without severely limiting the payload. It can be seen that the height to length ratio of the body is greater than that for most trucks. The drag coefficient for an angular truck such as this one is 0.70 (as opposed to 0.35 for a Porche). This could be lowered by installing spoilers and wind deflectors. This would be done if the truck was required to drive longer distances at higher speeds. At low speeds, however, drag plays a smaller part in the equation for power. Rolling resistance has a greater effect on power requirements at these low speeds.

Rolling resistance is a function of weight and velocity. As velocity is not considered in the actual design, weight becomes the most important parameter in the consumption of energy. Obviously, the less weight the less energy consumption.

The truck was constructed as light as possible. Fibreglass was used for the main body. Because of the nature of the loading mechanism, it was not required to use a large amount of heavy reinforcement. A packer truck, for example, uses a very heavily reinforced steel body. This is required to withstand the tremendous packing forces. When a compactor truck loads, it displaces all the material previously placed in the truck. The DRECT truck essentially lifts the bundles and drops them into the truck, rather than pushing them into the truck from the bottom. The equipment deals only with the forces of gravity and light frictional resistance. It can therefore be much lighter as compared to the packer. In addition to physical weight, the lighter forces encountered require a lower engine speed. The engine, therefore, works less and expends less energy.

6.4.2.2 **Energy Savings Through Increased Use of Secondary Materials.** Given that the current shortfall in the domestic recovery of waste newspaper is made up through imports, significant energy savings would not occur among end-users of secondary materials, as a result of increased Canadian recovery. In addition, some end-users, such as cellulose insulation manufacturers, are not in a position to substitute newspaper for pulp. An increase in the recovery of waste glass and its substitution for virgin materials in the glass production process would, however, lead to direct energy savings.

Where waste glass is substituted for virgin materials in the glass manufacturing process, there are direct energy savings in the production process of approximately 20 to 30%, or an average of 3.5 GJ per tonne. Therefore, if the total potential increase in glass recovery of 172 042 tonnes per year were achieved, a total energy savings of 602 147 GJ per year would occur, or the equivalent of 16.2×10^6 litres of oil per year.

6.4.3 Cost Savings. In the economic analysis undertaken earlier, the DRECT truck was shown to have an advantage over conventional magnavans in the average per ton collection costs for multimaterial recycling programs. If the savings of approximately $1.77/tonne collected as achieved in the East York program are applied to all of the potentially recoverable materials identified in this analysis, i.e.

277 649 t/yr news
172 042 t/yr glass
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446 691 t/yr

total potential savings throughout the system could be calculated as:

446 691 t/yr x $1.77/tonne = $790 643/yr

Again this superficial analysis does not take into consideration the fact that the glass component would not be recovered without the development of such a multimaterial collection vehicle, nor does it consider the potential for recovering additional material simultaneously.

7 CONCLUSIONS

The vehicle developed has fulfilled the operational requirements of the East York recycling program and holds considerable promise for use in other urban multimaterial curbside collection programs. Direct cost savings have been identified in the operation of this vehicle over collection commonly in use in other areas. The development of this vehicle has the potential to impact positively on the rate of adoption of multimaterial at-source recycling programs in Canadian municipalities, with the attendant environmental and conservation benefits to be derived from such a development.