RESEARCH AND DEVELOPMENT FACILITIES
AT THE
ONTARIO CENTER FOR RESOURCE RECOVERY

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ABSTRACT

The Ontario Ministry of the Environment’s $14,100,000 Experimental Plant for Resource Recovery, a production-size research and development facility, is the cornerstone of the Province’s Resource Recovery Program. The topics reviewed include the unit processes and operations within the plant, the Ministry’s comprehensive market development activities, and the unique and innovative features of the Experimental Plant, including process control and monitoring, a data collection system, environmental controls, and provision for visitors.

INTRODUCTION

In October, 1974, the Province of Ontario announced a comprehensive waste management program with the following objectives:
1. To recover, to the greatest degree practicable, the resource value in solid waste.
2. To reduce the quantity of waste produced.
3. To reduce to a minimum the use of land for waste disposal.
4. To achieve these objectives at the least cost to the public.

While the program features many elements of waste management, the cornerstone of the resource recovery aspect is the Experimental Plant for Resource Recovery (ERRP), a $14,100,000 facility designed to process and transfer 900 tons (800 t) of domestic and commercial refuse in a single daily shift. The principal objectives of the plant are:
1. To develop and evaluate processes and equipment for resource recovery.
2. To develop criteria for design and for estimating capital and operating costs.
3. To provide a regular supply of recovered resources for product utilization and market development.

The plant, designed by Kilborn Ltd., retains a capability for a staged or modular progression and contains adequate space and facilities for development programs to be undertaken by either government or industry.

Operation and direct management of the facility is provided on a contractual basis, currently by Browning-Ferris Industries of Toronto Ltd., Resource Recovery Division, under terms of a five-year agreement negotiated with the Ministry of the Environment.

General management of research programs within the plant and market development activities for plant products are provided by the Resource Recovery Branch of the Ministry of the Environment.

Figure 1 is a photograph of the Experimental Plant for Resource Recovery.

GENERAL DESCRIPTION OF FACILITIES

The ERRP is located on a 17 acre (7 hectare) site in the Borough of North York, Metropolitan
Toronto. Through an agreement with Metropolitan Toronto, general municipal solid waste, as collected from residential and commercial sources, is directed to the plant. Hazardous materials, such as pathological or chemical wastes, and non-processable materials, such as demolition wastes, are not received.

The plant comprises the following components:

1. Scalehouse.
2. Receiving, transfer, and paper recovery building.
3. Shredding and air separation and classification buildings.
4. Commodity and energy recovery building.
5. Composting building.

All waste processing, excepting composting, is done on a dry, as received, basis and equipment was designed for an average capacity of 40 tons/hr (36 t/h) with a peak capacity of 60 tons/hr (54 t/h); the plant is also designed to receive an additional 600 tons (550 t) daily, in a single shift, and transfer out this tonnage without processing in 75 yd³ (57 m³) compaction trailers for hauling to landfill sites. The direct transfer facilities not only provide an immediate service to the area, but also increase the overall versatility of the plant.

RECEIVING

For billing purposes, and to ensure conformity with all other municipally operated waste disposal facilities in Toronto, Metropolitan Toronto staff operate the plant scalehouse. All pertinent data, including arrival and departure times, vehicle identification, gross and net weights, type of waste or product, and source or destination are stored in a computer and the information is used to automatically print out weigh tickets and scalehouse reports.

Incoming trucks discharge their loads in a totally enclosed 12,000 ft² (1100 m²) receiving area. This area is ventilated by exhausting 60,000 ft³/min (1700 m³/min) of air and is also provided with in-floor heating. Front and rear loading packer trucks direct dump on apron conveyors feeding either the transfer operation or the resource recovery processing facilities. Direct dumping allows the incoming waste to be immediately processed, eliminates double handling of waste on the receiving floor and maintains some of the higher density obtained during collection. During peak periods of waste receipts, when the capacity of the conveyors may be exceeded, some floor dumping takes place. Other trucks, such as those with drop-off boxes, dump mainly on the receiving floor, both to preclude accidental release of the box onto the conveyor and to provide an opportunity to inspect the load.

Loads with a high corrugated content are discharged beside a belt conveyor located on one side of the main receiving building. Manually sorted cardboard is then conveyed to a double piston baler producing 1500 lb (680 kg) bales. This system has also been used for handling source-separated waste news.

Figure 2 is a materials flow schematic for the receiving and transfer areas of the plant.

At this time, with the facility receiving 1000 tons/day (900 t/day) without undue problems, we feel meaningful design criteria can be established with respect to receiving area requirements. Factors such as waste receipt patterns,
system layout, storage requirements, alternate disposal facilities and methods of material transport must be considered. It is interesting to note the relative absence of such criteria with respect to solid waste handling and processing designs.

TRANSFER OPERATION

The transfer operation consists of a series of three conveyors feeding two compactors; a 12 ft (3.7 m) wide variable speed, hydraulically driven conveyor discharging onto a 6 ft (1.8 m) wide vibrating conveyor, followed by a 6 ft (1.8 m) wide "Z" pan apron conveyor, elevating the waste to a splitter device thus sequentially feeding the 11 yd$^3$ (8.4 m$^3$) hydraulic compactors. Sequential feeding of the compactors provides virtually a continuous output of waste at a rate of up to 100 tons/hr (90 t/h). While simultaneous feeding of both compactors is possible, the high quantities of industrial and commercial waste rule this impractical. Long fibrous materials and bulky items would likely straddle and jam the splitter device. Simultaneous feeding is also inhibited by the limited material flow across the vibrating conveyor.

Most of the operational problems encountered are primarily the result of handling industrial and commercial wastes, in addition to the residential waste. Large and long items can be awkward to move on the inclined conveyor while bulky materials move poorly on the vibrating conveyor. However, in spite of the occasional problem, there has not been any need to closely inspect or remove materials from the incoming waste while routinely transferring out wastes at a rate of approximately 100 tons/hr (90 t/h). Considering the materials handling and vibration transmission problems that have been experienced, the use of a vibrating conveyor in this instance now seems questionable. Some minor problems experienced in having refuse negotiate the right-angle turn from the receiving apron to the inclined apron simply reinforce the empirical axiom of minimizing change in direction of material flow. It appears that a single variable speed apron conveyor to feed the two compactors directly from the receiving floor would have served adequately.

The presence of the transfer operation allows greater flexibility in resource recovery research studies; the blend of domestic and commercial waste may be altered, as required, to establish the effect on the unit processes or conveying systems and the product quality.

RESOURCE RECOVERY OPERATIONS

Waste is fed to the resource recovery processes from either of the 12 ft (3.7 m) wide conveyors to a vibrating conveyor, 6 ft (1.8 m) wide and 50 ft (15 m) long, where the waste is distributed from the 7 ft (2 m) depth on the receiving apron conveyor to approximately 1 ft (0.3 m) to permit visual inspection of the waste at a manual separation station beside the vibrating conveyor.

Past the manual separation station, waste drops from the vibrating conveyor onto a 6 ft (1.8 m) wide belt conveyor, inclined at an angle of 15 deg. to elevate the material to the shredder feed conveyor. A rubber belt is used in this case for raw garbage in order to accommodate a weigh belt that forms an 25 ft (8 m) section of this conveyor. This conveyor also features a variable speed DC drive. The belt speed, and hence the material flow rate, is automatically controlled by feedback from the primary shredder current.

From the belt conveyor, wastes drop onto a 6 ft (1.8 m) wide vibrating conveyor, which provides an even distribution of wastes across the width of the horizontal shaft hammermill. A closed circuit television camera views the shredder feed conveyor to provide the operator a final visual inspection of wastes fed to the shredder.
MAIN SHREDDER

Figure 3 is a process flow schematic for the shredding and air separation/classification phases of the resource recovery facility.

The main shredder is a 1000 hp (746 kW) horizontal shaft hammermill designed to process an average 40 tons/hr (36 t/h) of solid waste with a peak capacity of 60 tons/hr (54 t/h). Shredded wastes, now nominally less than 6 in. (15 cm) in size, discharge through 8 x 11 in. (20 x 28 cm) grate bars onto a vibrating conveyor. Grate bars with smaller openings, 4.5 x 8 in. (11 x 20 cm) will be used in additional studies to establish the effect of grate size on throughput, power consumption, hammer wear, product sizing, the efficiency of downstream unit processes, and the quality of recovered products.

Although the incoming wastes will have been inspected by operating staff several times before being fed to the shredder, the possibility of an explosion still exists. To minimize the risks from such an explosion, the shredder is installed in a separate building, and is operated from a remote control room. The shredder feed hood is equipped with blowout panels and the building has a hinged louvred wall to relieve pressure within the building in the event of an explosion. An explosion suppression system has not been installed because of the questionable effectiveness of such systems in suppressing detonations in shredders handling municipal solid waste. Preventative measures for fires include a sprinkler system over the feed and discharge conveyors and a dump chute at the end of the discharge conveyor where burning materials can be discharged outside of the buildings and subsequently be extinguished.

A vibrating conveyor 4 ft (1.2 m) wide is used to receive the shredded waste both to absorb the impact of material discharged from the shredder and to provide an even distribution of material to the first separation process, air separation. To aid in the research aspects of the plant, this vibrating conveyor is equipped with a pneumatically operated sample gate.

AIR SEPARATOR AND AIR CLASSIFIER

The initial material separation is effected in an air separator and air classifier operated in series resulting in a light product fraction and a heavies fraction for further processing. The light fraction should represent approximately 50 percent of the shredded waste. A venturi is installed in the air separator piping to measure air flow in order to assess the effect of air flow on the material split. Material entrained in the air stream flows through the venturi and the impeller of a 75 hp (56 kW) fan into a cyclone. Part of the cyclone exhaust is recycled to the pickup point of the air separator and the remainder dumped into a plenum chamber of the air classifier where it is subsequently used in the pneumatic conveying system for the light fraction.

The solid material separated from the air stream in the cyclone immediately falls into the air classifier. This density classifier is designed to permit a separation of the heavier materials picked up in the high velocity air stream of the air separator. In this classifier, the material is subjected to a transverse air current, with the lighter materials being blown across to the light fraction pickup point. Heavy items, as they pass the current of air, are affected to a lesser extent than the light materials and slide down the inclined back plate out of the bottom of the unit as a heavy fraction. The light material is pneumatically transported to a 100 ton (90 t) storage bin for in-plant use or shipping. Material is discharged onto a weigh conveyor before entering the fibre storage bin. The 25,000 cfm (700 m³/min) of air used in the pneumatic conveying system is cleaned in a pulse jet baghouse before it is exhausted.

The heavy fractions leaving the bottom of the air separator and the air classifier drop onto a belt
A weigh belt is located in this belt immediately past each heavies discharge to permit monitoring of the flow split.

MAGNETIC SEPARATION

The next unit operation, magnetic separation, has been located after the separation of the light fraction. Although some ferrous metal may initially be picked up in the air separator, it should be returned to the heavies stream in the air classifier. It is felt that a cleaner ferrous product will result because of the reduced burden of material from which the ferrous is removed and the prior removal of the loose paper and plastic that in some installations has been trapped or carried along with the ferrous product.

The combined heavy fractions from the air separator and classifier are conveyed to another building where the heavy fraction is directed to a magnetic separator for removal of ferrous materials. A 150 hp (110 kW) horizontal shaft ring hammermill reduces the ferrous material to less than 2 in. (5 cm) in size. Shredding of the ferrous metal, principally tin cans, should substantially increase the bulk density of the material for shipping. The shredded ferrous material is expected to be in a form still suitable for de-tinning. An air pickup is located over the apron conveyor at the shredder discharge to remove paper, plastic, or other light material liberated from the ferrous during shredding. The clean shredded ferrous material is conveyed to a 2500 ft³ (70 m³) storage bin for shipping.

The process flow schematic for ferrous recovery is shown in Fig. 3.

FURTHER PROCESSING

The process flow schematic for glass and organic recovery is shown in Fig. 4.

The shredded waste, now minus the light and ferrous fractions, is weighed and then enters a revolving screen where fine material, principally glass and organics, passes through the 0.75 in. (1.9 cm) openings of the 6.5 ft (2 m) diameter screen. The screen speed and angle of inclination are adjustable to permit establishing the effect of these variables on screening efficiency.

Lighter organic fines are removed from the glass fines by air classification and are pneumatically conveyed to another 100 ton (90 t) storage bin.

The heavier glass-rich fraction is conveyed to a 2500 ft³ (70 m³) storage bin.

The oversize material from the revolving screen is weighed and then fed into the secondary shredder, a 400 hp (300 kW) horizontal shaft hammermill, which reduces the material to less than 2 in. (5 cm) in size. A secondary air separator immediately follows the shredder and removes the lighter organic material, which is pneumatically conveyed to the organic storage bin. Heavy materials from the air separator are currently considered rejects and are conveyed to a 2500 ft³ (70 m³) bin. Except for a nonferrous metals sampling station prior to screening, the plant has no provision for aluminum recovery. The virtual absence of aluminum cans in Ontario precludes such a recovery system. The potential for recovery of other nonferrous metals, most likely from the rejects stream, will be investigated.

Although this completes the basic separation processes, two additional unit processes are featured in the plant, energy recovery and composting.

ENERGY RECOVERY

A process flow schematic for the loadout and energy recovery systems is shown in Fig. 5.

The energy recovery system consists of a modular starved air incinerator with a waste yeast boiler yielding low pressure hot water for plant heating. Either the light fraction or the organic fraction is used to fuel this unit at a rate of 0.75 tons/hr (0.7 t/h). The automatic fuel feeding and ash discharge systems are provided with load...
cells to monitor the weight reduction through the incineration process. The incinerator stack has been provided with a test platform and sample ports to readily permit emission studies to be conducted. Data obtained from this unit should assist in the market development efforts for the light fraction as a refuse derived fuel.

COMPOSTING

The process flow schematic for the compost system is shown in Fig. 6.

A composting system has been included in the plant to permit a thorough investigation of this process, which may have potential in some areas of the province for land reclamation. A mechanical composting system was chosen to permit greater control of the process conditions than can be achieved in windrow composting.

Either the organic or clean fiber fraction is discharged from the live-bottom storage bins and conveyed to the composting building. Here it is wetted and mixed in a pug mill with digested wastewater sludge to achieve the proper uniform moisture content for composting.

Composting is carried out in an 58 ft (18 m) diameter digester, equipped with 13 bridge-mounted inclined augers on a rotating superstructure. Feed material is deposited at the periphery of the tank while the augers both mix and move the 8 ft (2.4 m) deep mass of composting material toward the center of the tank where it overflows into the discharge well.

To ensure that the compost is maintained at the proper temperature and under aerobic conditions during the digestion period, a 4500 ft³/min (130 m³/min) blower provides air to the process through an air distribution system in the bottom of the tank. The blower is controlled by temperature and oxygen sensors located at various points within the digester.

Compost is discharged onto an adjacent concrete pad for curing or shipping.

ADDITIONAL FEATURES

While many unit operations of resource recovery have been combined into a full scale processing plant that serves as a unique research and development center, the Experimental Plant also features more than these numerous unit operations.

In addition to the basic unit operations such as shredding, air separation, screening, incineration, and composting, many other types of ancillary equipment have been used in the Experimental Plant as an essential part of the resource recovery system. Effective material transport within the plant can be as important as the basic separation processes. The Experimental Plant affords the
opportunity to obtain material handling experience on a wide range of resource recovery products with an equally wide range of material handling equipment such as belt conveyors, vibrating conveyors, steel apron conveyors, screw conveyors, roller conveyors, pneumatic conveyors, bucket elevators, and storage bins with integral unloading mechanisms.

Perhaps one of the greatest problems in handling and processing solid waste is the generation of large quantities of dust, which if not controlled, produces an uninviting and possibly hazardous working environment. In the Experimental Plant, an extensive dust control system has been provided; all major points of dust generation, such as material transfer locations, are enclosed and kept under negative pressure. Baghouses are used to clean the dust-laden air from the pickup points and from the pneumatic conveying systems.

The dust collection system installed in the transfer portion of the plant has been ineffective in completely controlling dust generated from the handling of waste in the receiving and transfer operations. Monitoring of the working environment in these areas is currently being undertaken by the Provincial Ministry of Labor to establish whether the dust loadings or the nature of the dust present a hazard to plant employees. Corrective measures will be taken, as required.

To prevent material spillage from conveyors, extensive use has been made of enclosures, skirting, and return belt scrapers and brushes. In the event of material spillage, adequate space has been provided below all conveyors to readily permit cleanup.

For fire protection, an extensive sprinkler system and fire monitoring system have been installed in the plant. The effectiveness of such systems in minimizing damage has already been proven during a major fire on the receiving floor. This fire also served to demonstrate the need to familiarize the local fire department with the layout of the plant.

While common in industry, the Experimental Plant has several features not commonly found in municipal works facilities. These facilities include an extensive instrumentation system, closed circuit television monitors and a computer for handling process data from belt scales and load cells, power consumption in key areas, and all truck scale transactions and reports.

In order to permit assessment of the plant on an economic as well as a technological basis, a detailed accounting system is being used to record all plant operating and maintenance costs.

Costs are assigned to individual unit processes as well as major plant areas. In addition to the overall costs on these bases, costs are also routinely determined for all major equipment on a unit basis for the tonnage processed and the hours in service. These data will readily permit identification of major cost areas which can then be reviewed in greater detail to effect cost reductions, if possible. The cost-benefit information derived from such evaluations will assist in the design of future resource recovery plants.

A laboratory within the Experimental Plant is used for the routine analysis of samples for evaluations of unit operations. Such analyses include particle size distribution, moisture content, and component analyses. This laboratory also serves to prepare representative samples for other analyses, such as heating values, ash, and elemental analyses, which are conducted in the Ministry's other laboratories.

COSTS

One of the principal objectives of the plant is to develop criteria for estimating capital and operating costs for resource recovery systems. At the time of this writing, only the transfer portion of the plant is in operation; consequently, limited cost data are available. The following are the proposed staffing requirements and the operating budget for the first fiscal year (1978-79) of full plant operation.

The plant operating personnel, excluding administrative staff, numbers twenty-six, five for the transfer operation, twelve for resource recovery operations, and nine split between the two maintenance shifts. The truck drivers for the waste transfer haulage are included in the contract haul costs and are not part of the plant staff.

The plant operating budget for fiscal 1978-79 is $2,250,000. This amount includes the annual transfer operation costs which, based on 600 tons/day (550 t/day), are approximately $1,050,000 and consist of haulage costs of approximately $6.00/ton ($6.60/t) and plant costs of approximately $1.00/ton ($1.10/t). The remaining portion of the budget is for operation and maintenance of the resource recovery facilities, product haul costs, and contract management fees. These costs exclude capital amortization.
The costs of plant operation are borne by the Ministry of the Environment and are relatively independent of revenues from dumping fees and product sales. Since the prime functions of the plant are to provide for technology assessment and market development, it is unlikely that the facility will be economically self-sustaining. The market development objective precludes obtaining long-term contracts for the purchase of all recovered commodities; such materials will be used to develop local markets prior to the construction of resource recovery facilities in other municipalities in the Province.

We feel that this market development approach will greatly assist in satisfying two of our waste management objectives:

1. To recover, to the greatest degree practicable, the resource values in solid waste.
2. To achieve these objectives at least cost to the public.

MARKETING AND MARKET DEVELOPMENT

The marketing efforts of the Ministry involve the identification of existing and potential markets, assessment of the present supply and demand forces and marketing structure for each commodity, development of these markets through education and demonstration projects, and ultimately obtaining commitments for the use of recovered resources. It is in the latter commitment stage that such aspects as product specifications, pricing mechanism, delivery schedules, tonnage levels, and risk allocation are considered.

The main thrust of market development activities to date has been on products expected to be produced at a conventional “front-end” processing facility, including waste newspapers, corrugated materials, municipal ferrous scrap, and an air classified light fraction. Successful market development for these materials obviously has general applicability throughout the Province and confirmation of such markets is an essential prerequisite when a municipality is considering construction of a resource recovery plant.

ENERGY

In the market development of the light fraction, refuse derived fuel (RDF), as an energy source, the Ministry of the Environment is undertaking two major demonstration projects.

One is the ‘Watts from Waste’ project, a study of the applicability of suspension burning of RDF as a supplementary fuel in one of Ontario Hydro’s existing thermal/electric generating stations. This joint project, involving Ontario Hydro, the Ministry of the Environment, and Metropolitan Toronto consists of construction of a solid waste processing plant to provide 500 tons/day (450 t/day) of RDF to allow an initial 10,000 hr of test firing at the Lakeview Generating Station. The design of facilities and equipment is in progress with a projected start-up date of late 1980.

The other major demonstration project involving the use of refuse derived fuel (RDF) is being undertaken by the Ministry of the Environment and Canada Cement Lafarge Ltd. at the Company’s Woodstock plant. The project involves the use of RDF from the Experimental Plant as a supplementary fuel during the period when coal is used as a primary fuel.

As the production of cement is highly energy intensive, and with cement plants generally located near major population centers, the industry as a whole has excellent potential for the use of RDF as an energy source.

Another promising area for the use of the light fraction is in the dewatering of sewage sludge to improve the calorific value of the dewatered sludge allowing autogenous combustion during incineration. Recent full scale studies conducted by James F. MacLaren Ltd. in London, Ontario have indicated that primary fuel reductions of up to 40 percent can be attained by substituting waste newspaper for conventional conditioning chemicals used in the dewatering of sewage sludge by vacuum coil filters. These energy savings are primarily due to the waste paper increasing the calorific content of the dewatered sludge.

FERROUS METALS

The major market development areas for the use of municipal ferrous scrap are the iron and steel foundries, while the de-tinning and dealer industries serve as the traditional markets for this material. The approximately 0.3 percent tin present in municipal ferrous scrap acts as a significant hindrance to the use of this material in the basic steel industry. Although dilution of the municipal scrap charge can be used to overcome this hindrance, the basic steel industry is of the opinion that considerably more quality control would be required to ensure satisfactory steel production.
Trial melts using municipal ferrous scrap have already been conducted in several gray iron foundries and at a steel mini-mill. Test results have been satisfactory to the extent that purchase contracts for this material from the Experimental Plant for Resource Recovery have been placed with the Ministry.

When a new commodity is introduced to the secondary materials market, the question of end effect must be considered. If the new material merely displaces other scrap materials presently being recycled, then little net improvement in resource recovery is attained. In the case of ferrous scrap recycling, Canada now imports over 600,000 tons (550,000 t) of scrap annually and present projections call for an imminent shortage of some 1,000,000 tons (900,000 t) of scrap per year. Recycled municipal ferrous scrap would help fill this gap in scrap requirements.

WASTE PAPER

When considering markets for the various commodities presently recycled, the market for waste paper is generally considered to be the most volatile. In addition to the relatively unstable pricing for waste paper, the overall market is characterized by a strong, steady demand for premium grades, in short supply, and a weak, unstable demand for bulk grades, either in excess supply or very readily generated to produce excess supply. Consequently, the efforts of the Ministry of the Environment are aimed at increasing the supply of premium grades, e.g., through office separation studies, and at increasing the demand for bulk grades through expanding existing markets and developing new uses for these materials. Some of the developmental areas for waste paper usage are: as a raw material in the production of cellulose fiber insulation; as an agricultural bedding substitute; as a conditioning agent in sludge dewatering; and as an energy source. These areas are being developed in conjunction with the traditional markets for waste paper, the building materials industry, and the boxboard and related paper products industry.

OTHER COMMODITIES

The Experimental Plant for Resource Recovery will be producing additional materials such as a mixed glass fraction, compost, and a rejects fraction possibly containing appreciable nonferrous metals. Although intensive market development efforts for these products must await production of the materials themselves, preliminary investigations of potential markets have already begun. With production, material characteristics will be defined and potential uses and users may be fully developed.

SUMMARY

Ontario's Experimental Plant for Resource Recovery will serve as a full scale research and development facility for the technology of resource recovery; in addition, a reliable supply of recovered commodities will be produced to allow market development for these materials. Commitments have already been made for the major plant products to be used in market development demonstration projects.

In addition to developing design criteria for solid waste processing systems, it is hoped that new innovative techniques and equipment studied at the Experimental Plant will result in significant cost reductions for future facilities. Such potential savings may already be apparent with the 12,000 ft\(^3\) (1100 m\(^2\)) receiving area handling approximately 1000 tons (900 t) of refuse per day.

Research activities conducted at the Experimental Plant for Resource Recovery will serve to provide much of the information generally unavailable at present to municipalities seeking economical and environmentally acceptable alternatives to current solid waste management practices. Information generated from the Ministry of the Environment's technology and market development programs will be freely available to all municipalities considering resource recovery as a solid waste management alternative.

Key Words: Energy, Ferrous, Market, Refuse Derived Fuel, Research, Shredding, Technology