JOURNAL OF THE TRANSPORTATION RESEARCH FORUM

Volume XXXI Number 2 1991

TRANSPORTATION RESEARCH FORUM

Solid Waste By Rail: A Research Opportunity

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Most of us in the transportation research community are familiar with the bleak rail freight traffic prospects of North American railways. With remarkably few exceptions, such as the surge in bulk traffics in Western Canada a few years ago and the growth in carriage of low-sulphur Powder River Basin coal in the U.S., the trend in rail market share, commodity after commodity, has been depressingly downwards for over forty years. It is therefore a refreshing change to report on the impending rise of an important new market opportunity for railways – one which is a significant research opportunity as well.

The efficient transportation of solid wastes produced by post-industrial Canada and the U.S. represents tremendous opportunities for rail carriers struggling to improve their financial returns. In addition, it poses intriguing and complex challenges to public policy makers, equipment suppliers and transportation researchers.

Solid waste is an ideal candidate for movement by rail; it fits perfectly into the traditional traffic profile:

1) increasingly, large volumes are moving long distances;

2) waste movements are relatively heavy, especially if compacted; and

3) the commodity is so low in value that time is not critical.

Given these characteristics, it is not surprising that there are several existing and more planned waste-by-rail systems in Canada and the U.S., some of which are described on the following pages.

THE DEMAND DYNAMIC

The volume of solid waste now being generated in North America is immense. Estimates of the U.S. volume of trash alone ranges upwards from 160 million tons annually.1 Such figures are so incomprehensible that it is easier to express them in analogous or unit terms. For example, "The year 1985 was ... the first time in the region's history, annual per capita waste generation exceed one ton for every man, woman and child in Southeastern Virginia."[2]

By far the largest and most visible waste stream element is commonly referred to as garbage. "Each of us contributes an average of 1,300 pounds a year to the growing mountain of garbage...."[3] Household garbage production is influenced by a number of factors, especially affluence, culture and population density. So it is not surprising that residents of New York City in a recent year produced almost four pounds of garbage per person per day, an amount almost one-third more than that attributed to the more densely packed residents of Tokyo and almost four times as much as citizens of Calcutta, India (1.12 pounds) or Kano, Nigeria (1.01 pounds).[4]

The waste stream flows from numerous sources. Measured by weight, the major components of the municipal solid waste (MSW) stream in 1986 in the U.S. (and by inference, Canada) were:

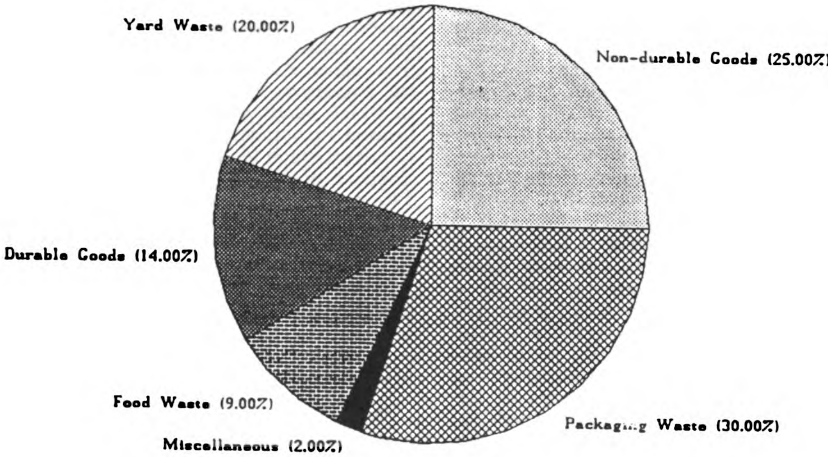
- Container and packaging waste - 30 percent (comprised primarily of paper and paper board, glass, plastics, steel, wood packaging and aluminum, etc.);
- Non-durable goods - 25 percent (comprised primarily of newspapers, office papers, books and magazines, commercial and printing paper and other non-packaging paper, etc.);
- Yard waste (leaves, grass, twigs, etc.) - 20 percent;
- Durable goods - 14 percent (comprised primarily of miscellaneous durable furniture and furnishings, major appliances, rubber tires, etc.);
- Food waste - 9 percent
- Miscellaneous organic and inorganic wastes - 2 percent[5]

The U.S. distribution of solid waste by type is set out in Figure 1.

Journal of the Transportation Research Forum
Volume XXXI, Number 2, 1991

FIGURE 1

Total Solid Waste By Weight



Source: U.S. Environmental Protection Agency.

The volume of solid waste is not only immense, it is growing. While Canadian and U.S. business and political leaders express increasing concerns about lagging productivity increases, there is one sector where both total and per capita production keeps rising, namely the rate at which both nations are producing garbage. For example, "[I]t is estimated that solid waste generated in the United States will grow at an average of 1.8 percent per year between 1980 and 2000. While two thirds of this will be due to population growth, a third will come from the increased amount of garbage generated per individual."[6] Since Canadians share the same material culture, it is assumed here that these numbers are not inapplicable to Canada.

A radical shift is beginning to take place in major Canadian and U.S. urban areas as increasing volumes of solid waste flowing into the waste stream conflict with a landfill capacity decline of even greater magnitude. Last year it was noted, "[F]rom an available pool of 20,000 landfills a few years ago, US capacity to dispose of MSW has declined to some 5400 landfills today and by next year Wisconsin alone will close 800 landfill sites."[7] Since 1984, "... the number of landfills for municipal solid waste in the United States has dwindled by 30 percent.... According to the 1973 report of the U.S. Conference of Mayors, over half our cities will run out of landfill capacity by 1990."[8]

More critical than the exhaustion of existing landfills is that regulations are retarding the permitting of new landfills and constraining the development of mass burn plants both of which are major alternatives to landfilling. In addition, "not in my backyard" concerns prevent landfill siting in urban areas and likewise severely restrict new mass burn facility construction. "No effort illustrates better how difficult it has become to build large public works than the city's [New York's] plans for disposing of its garbage. In 1979, the [Mayor] Koch administration proposed to build eight large incinerators. Ten years later, construction has yet to begin.... The plan has been delayed by environmental, technological, legal and political concerns."[9]

In the short term, the combination of more waste and fewer disposal and mass burn sites, especially in and near heavily populated areas is resulting in skyrocketing tipping fees.[10] For example, New York City, concerned that the capacity of its major landfill, the Fresh Kill facility on Staten Island, was being used up too rapidly, deliberately sought to divert approximately one-quarter of its usual waste stream by increasing tipping fees from $18.75 to $40.00 (U.S.) per cubic yard (2 compacted cubic yards = 1 ton) in one rate increase.[11]

It is not surprising then that heavily and densely populated provinces, cities and states in North America are exporting garbage to other locales. Canadian solid waste is shipped by rail and truck to mass burn facilities and landfills in northern New York, while New Jersey sends half its waste to Pennsylvania, West Virginia and Ohio.[12] Because of the long lead times necessary to develop landfills, permitted rural landfills with spare capacity are experiencing a seller's market.

High tipping fees are encouraging the development of new landfills in rural areas. This activity should cause an intermediate term glut (albeit perhaps a temporary one) of rural landfill capacity which, in turn, should encourage waste-by-rail activity. In the longer term, increased recycling and mass burning in combination with moderating tipping fees may slow the growth in long distance waste rail hauls.

The saying that one man's waste is another man's wealth is now becoming a reality, with transportation enterprises among the chief beneficiaries. Railways, which are advantaged by being well versed in bulk materials transport, have within their reach the potential to tap numerous existing and rapidly developing waste handling markets for hauls to distant landfills and waste-to-energy (mass burn) plants. If acted upon adroitly, these opportunities will position railways to realize large and rapidly growing volumes of business. For example, Conrail is extremely well positioned to take advantage of the waste market, since its network serves nearly all major metropolitan areas in the U.S. Northeast and Midwest, with half that country's population. That railway expects its waste hauling market to catapult from a 1987 revenue of virtually zero, and only $.13 million (U.S.) in 1988 to approximately $4 million (U.S.) in 1989. It forecasts revenues of $10 million (U.S.) in 1990 and $100 million (U.S.) in 1995.[13]

An important factor in realizing such revenue growth is the capability to handle numerous types of waste. The generic term waste brings to mind household waste and other more common forms, each of which has different natural properties.

Although the great mass of household-originated solid waste would seem to be particularly suitable to rail transport especially if compacted, many smaller volume wastes, for example construction debris or yard waste, which increasingly are separated from other wastes, also may be markets for rail transport. Since the specialized facilities at which such wastes are disposed may be limited in number, lengthy movements are required which tend to increase the competitiveness of the rail mode. For example, "Waste Management, Inc. is building a construction and demolition debris landfill in Ohio that will be accessed primarily via rail. Railcars (open-topped hoppers and gondolas) will come right onto the site via Norfolk Southern's line."[14]

MODAL CHOICE DECISION FACTORS

The principal factors which determine the ability of rail carriers to compete with trucks in the hauling of municipal solid waste are length of haul, rail accessibility, experience and image, equipment selection, backhaul philosophy, and reliability.

Length of Haul - As local landfills close, solid waste is forced to travel further. Since rail transport incurs significantly higher terminal costs and lower line-haul costs than motor carriers, the longer the haul, the more competitive rail is. The shorter the rail haul, the more critical the impact of terminal handling costs on the rail mode's ability to compete and the more demanding the fit between equipment selection and loading/unloading/transfer system requirements.

Rail Accessibility - Assuming a moderate or longer haul, the most important determinant of favorable rail economics is that the origin, destination or both be on or near a rail line. It is fortunate, therefore, that most large solid waste movements originate in large metropolitan areas where rail access, even intramodal competition, often is available. Furthermore, our research indicates that many transfer station sites are adjacent to rail lines, either by design or because the land use zoning which permits such operations is likely to be in the older, industrial parts of metropolitan areas dotted with enterprises that historically relied heavily on rail service.

Today, proximity to a rail line is considered good rail access; because existing technology favours truck movement of solid-waste containers which are loaded and unloaded at nearby rail yards. So lack of direct rail access is of little consequence. However, to maximize transportation options and ensure low rates, future landfills and mass burn facilities will feature direct (not nearby or adjacent) rail access. New transfer station technology may take one or both of the following approaches: 1) mechanized loading of containers from compactors onto rail cars or 2) direct loading of solid waste into rail cars. In particular, direct rail access offers the opportunity to eliminate large staffs now engaged in jockeying trucks/chassis and loading individual containers at waste facilities, to free up the capital costs associated with trucks and chassis themselves, and to realize lower rates through improved railway equipment utilization associated with faster turnaround times at loading sites.

Unfortunately, many facilities with apparently good rail access are on hills adjacent to, but above (or below) nearby railway lines. The steep grades and sharp curves characteristic of rail access to hillside facilities may be impractical for future unit train formation in light of their implied increase in capital and operating costs. These hillside locations will be forever wedded to container technology with a host of trucks and drivers. Even current facilities with "good" rail access designed to accommodate the transfer of recycled materials to/from rail cars may be too limited in land or track configuration to accommodate the movement of solid waste in unit trains.

Experience and Image - Assuming access and length of haul issues are resolved favourably, perhaps the biggest challenge facing the rail mode today as it competes in solid waste transport market is that it is a latecomer. First, it is handicapped in the competition for movements to/from landfills, incinerators or waste-to-energy facilities whose original designs and engineering never even considered the rail transport option. Therefore, railways often face the threshold dilemma of competing for significant capital expenditures from often constrained corporate treasuries, or persuading potential customers to fund such investments before rail service can be initiated. Second, the rail mode must compete with decades of solid waste movement experience and innovation enjoyed by truck haulers.

As real and significant as these disadvantages are to rail carriers competing to haul waste materials to and from existing facilities, railways should not be discouraged given the radically improved efficiency which may be achieved through rail car innovations, improved rail technology and the promise of new facilities constructed to load and unload both modes with equal efficiency.

Equipment Selection - The railway equipment selection decision should be driven by the nature of the waste material to be handled as well as the load/unload/transfer system technology. While the essence of waste and the vehicle in which it is transported make the mundane chore of loading and/or unloading a transportation focal point, all three should be considered simultaneously to maximize a systems solution. Critical waste material factors including composition, density, weight, compactibility, smell, noise, leakage, dust, and toxicity are determinants of the choice among loading and unloading methods. As an example, smell and dust must be kept to a minimum while containers are in unloading or loading stages. Public ordinances governing both noise and smell regulate when and how shipments can be unloaded. These ordinances largely determine operational characteristics of any rail transfer facility located near a residential section. Given the wide variation in each waste stream component's physical properties, it is obvious that each waste type demands specialized transportation attention. As Charles N. Marshall, Conrail's Senior Vice President-Development stated, the problem is "[W]e need a really good garbage carrying vehicle. This traffic now moves in boxcars and containers. A specialized car is needed."[16]

While there is not yet a standard equipment type employed in rail movements of solid waste or ash, containers appear to be the most commonly selected option. Container movements are most favoured because they represent the simplest adaptation to rail movement of existing waste technology, which is geared toward truck movement. Available equipment can compact more refuse into a forty foot truck than over the road weight limits will allow. Since four containers moving over a railway can move the same refuse as five trucks, rail movement offers an opportunity to reduce truckloads. Further, as garbage movements usually are closed systems with dedicated equipment, chassis control is not an issue as it is in conventional freight container movements. Thus the lower tare weight advantage of containers versus trailers on rail cars can be exploited. If terminal space is tight, containers can be double-stacked in yards and on rail cars. However, as double-stack movements mandate 125 ton capacity cars, the choice of rail routes is severely constrained by railway bridge restrictions.

Special situations require specialized equipment. A system which employed rail bogies with a well for trailer wheels to move waste by rail from Long Island across New York Harbor to northern New Jersey received praise because of its pioneering nature, but it is really a special system to move truck trailers by rail through low clearances. As yet untried for solid waste in North America, but with substantial promise, is the RoadRailer system where special trailers can be mounted and joined on rail wheels (a single truck bogie) to form trains of trailers. That system's strongest advantage is the minimal terminal facility investment required, making it ideal for small daily shipment volumes and constrained loading and unloading sites. However, the difficulty in mixing such equipment with conventional rail cars implies terminal-to-terminal dedicated service.

Modification of conventional rail car designs also may be promising for long hauls or movements with direct rail access at each end, provided technology dedicated to rail car compacting is developed. Because uncompacted garbage is relatively lightweight, conventional bathtub hopper cars exhaust their cubic capacity at less than 50 tons, thereby underutilizing potential shipment weight by at least 40 tons per unit. However, one railway added removable roofs to rebuilt surplus boxcars to facilitate loading and unloading (by rotary dumper), an inexpensive innovation in which the extra cars required by the absence of a compacted load apparently are justified by low car modification costs.

The principal obstacle to overcome in respect of employing conventional railway equipment is that as a result of truck loading tradition, compacting equipment works through end doors to fill a long box. By contrast, rail cars cannot be end loaded or unloaded without extensive individual switching of each rail car at both origin and destination. A compacting system to bale waste for top (or side) loading rail cars is the necessary next step.

Backhaul Philosophy - One of the major reasons motor carriers have been able to strip long and medium haul traffic from rail carriers is that they have found backhauls to minimize their uncompensated mileage, while rail systems often do not. This difference is at least as great in the movement of solid waste as in other commodities. Solid waste truck shipments often are the backhaul leg of another truck movement. The railway industry position is the exact opposite. Specifically, North American rail carriers are typically unwilling or unable to solicit front hauls to match up with the generally low rated trash movements. However, a recent public furor following disclosure that many trucks hauling food stuffs to the New York City area were backhauling refuse suggests that both modes soon may compete on a more level economic playing field.

In deference to the rail carrier position, we recognize that finding a backhaul for a single container which is part of waste-by-rail system is difficult enough but pales in comparison to the logistics challenge of selling trainloads of container space from rural landfill, incinerator or mass burn facility locations. Possibly a more fruitful approach would be to try to match waste movements in rail cars with bulk coal or aggregate movements; commodities that tend to move toward metropolitan locations. The opportunities to realize such balanced moves seem particularly attractive in the U.S. context of moving waste from East Coast cities in the direction of Appalachian Mountain coal fields. We suspect that the rail movement of aggregates used in highway construction in the vicinity of Canada's major cities may provide comparable opportunities.

Reliability - A key concern of most waste management systems is reliability; trash arrives daily at transfer stations whether or not the waste transportation system is operating on schedule and according to plan. Such systems simply cannot tolerate late or inoperable trains.

Unfortunately, railways bear the burden of perceived general unreliability. In addition, as all North American waste-by-rail systems are new and, therefore, generally perceived as risky, reliability is being maximized through conservative design, often supported by a backup truck system -- just in case. The overdesign and backup flexibility impose costs on the rail system which offset inherent competitive advantages.

EXISTING AND PLANNED WASTE-BY-RAIL MOVEMENTS

In Canada, negotiations are underway for a refuse movement by rail from Toronto to a distant landfill. No doubt other opportunities will arise as increasing demand and decreasing landfill supply conflict. In the meantime, it is useful to look south of the border to examine existing and planned waste-by-rail ventures.

Eastern Massachusetts

The first railway in the United States to haul solid waste by rail on a large-scale was the Bay Colony Railroad. On June 26, 1989 this 122 mile long shortline began carrying solid waste from the Upper Cape Regional Transfer station at Otis, to SEMASS, a trash-to-energy plant in Rochester, both in eastern Massachusetts. "Recently Bay Colony's solid waste handling system has been hauling six to eight carloads per day, six days per week, with each car carrying 40 to 45 tons"16 or more than 50,000 tons of trash annually.

The waste moves in 50-foot boxcars, modified by NRUC Corporation to incorporate a removable roof made from the original boxcar roof. "Interior dividers and lining provide strength and create the smooth free fall area necessary for handling solid waste. In transit the cars are totally sealed."[17]

"The $208 million (U.S.) SEMASS plant is a 1,800 tons per day facility that employs a 'shred and burn' process," designed to generate 52 megawatts of electricity, enough to power about 18,000 households. A second phase should increase capacity to 2,700 tons daily. Fuel is provided by means of rail-delivered refuse collected at two principal locations. The towns of Mashpee, Falmouth and Sandwich built a $1.8 million (U.S.), 150 tons per day transfer station adjacent to Bay Colony trackage in Falmouth, at which a front end loader pushes the waste into the Bay Colony rail cars. A second refuse-providing facility at Yarmouth, MA accepts inbound trucks which dump waste on a tipping floor. Waste is then dumped into the rail car below by a front end loader."[18]

New York

All three of the rail carriers that serve the largest U.S. city are either already moving or actively soliciting waste-by-rail shipments. Present rail efforts are hampered by low truck rates caused by the heavy terminating imbalance in the region. This prompts teamsters to move garbage at backhaul rates towards the U.S. Midwest from which westbound loads can be solicited more easily. Such backhaul truck rates so far have been a major factor in hampering the efforts of rail carriers seeking the headhaul rates commensurate with their pricing philosophy. On the other hand, the avoidance through rail shipments of congested river crossings is a big plus for the railways.

Los Angeles

The Los Angeles County Sanitation Districts is evaluating a short list of waste-by-rail proposals from among the 10 responses it received to an RFP it recently issued. The most ambitious of those proposals is designed to move as much as one-third of the 48,000 tons per day of trash generated daily in the County, nearly all of which presently is trucked to 10 rapidly filling public and private dumps.

Seattle

In 1989, the Seattle City Council selected Waste Management Inc., to move that city's garbage via truck and rail in a twenty year contract which has been estimated to be worth $230 million (U.S.). Garbage is gathered from four transfer stations compacted into 'slugs' of approximately 7.5 x 7.5 x 37 feet, weighing approximately 25 tons each, loaded into containers and on to rail cars hauled in trains operated by Burlington Northern Railroad to Portland. At that point, the freight cars and their loads are interchanged to Union Pacific Railroad, for movement to WMI's landfill in Arlington, Oregon where the containers are taken off the rail car, placed on a Columbia Trailer tipper, unloaded, and placed back on the rail car. The reported initial charge of $38 (U.S.) per ton includes the 37 hour, 320 mile roundtrip by rail.[19] The two million tons annually and $15 to $20 million (U.S.) in initial freight revenue associated with this one move suggests the tremendous potential represented by the waste-by-rail market.

Montgomery County, Maryland

The Northeast Maryland Waste Disposal Authority is constructing a two-way waste-by-rail system through the northern suburbs of Washington D.C., in which an ash residue movement to a landfill resulting from and originating at an MSW mass burn facility will return by rail to the transfer station from which backhaul solid waste rail movements originated. Rail movement totaling only 36 round-trip miles was chosen to ameliorate various adverse impacts on the County and its residents including the avoidance of constructing a mass burn facility in the neighborhood adjacent to the transfer station.

The crucial reliability of this new rail movement is being addressed by designing a container system with spares and sufficient truck chassis for direct movement to the landfill in event of rail service interruption. In addition, to maximize regular movement, reliability was designed into all system components under Montgomery County's control. Train length had to be minimized not only because of constraints on yard track length on the loading area, but also because of the need for on-site runaround tracks at both facilities, so a double-stack container system was selected. The system will be capable of moving over 2500 tons of refuse per day.

Research Potential

The opportunities for market, economic and technical research related to the movement of solid waste by rail are patent. Railway managements may not like passengers per se, but the solid waste which they generate is another commodity altogether.

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