WM&R

Waste Management & Research
1–3

DOI: 10.1177/0734242X17694531
journals.sagepub.com/home/wmr
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Solid waste collection technology trends in North America

The application of technology is precipitating substantial changes in solid waste collection programmes in North America; these changes likely will lead to increased levels of service, improved worker safety and reduced costs for waste generators – the traditional 'holy grail' of waste management engineers and administrators. Layered on these trends are citizen and government stresses to 'do more with less' by both public and private service providers. An overview of recent solid waste collection technology trends in North America is summarised here.

Routing technology

Managers of both private and municipal solid waste collection operations in the United States have been using increasingly sophisticated routing software over the past 20 years to optimise solid waste collection routing and fleet and personnel performance monitoring. However, the decision to use any particular computerised routing application must be carefully considered. Since equipment costs, labour and fuel are significant operating expenses for waste collection operations, reducing the number of routes, labour hours and/or mileage through route optimisation is a critical and straight forward approach to increasing efficiency and reducing costs. Waste routing software is not always easy to implement, and too many municipalities have experienced failed implementations. Typical complaints we have heard include that the software is too complicated to be adopted into daily operations; it is too expensive to purchase outright or procure through a monthly service fee; and/or the system maintenance requirements are too extensive. Waste collection routing generally is complex and requires multiple types of routing algorithms to accomplish the optimal routing solutions for different conditions, including:

- high density for residential curb-side collection (particularly in areas with multi-family units); and
- point-to-point routing for commercial collection or residential bulky items collection.

Experience shows that no one application on the market handles all types of waste routing situation effectively. Some of the more widely used routing software applications for typical residential solid waste collection fleets include Fleet Smart™, Route Smart™, WM Design™ and WM Logistics™. Several software vendors have developed point-to-point routing software applications. Point-to-point routing is used when the daily delivery locations (e.g. as might be used by FedEx), or in the case of solid waste, daily collection (the reverse of delivery) of bulky waste, might vary. However, when the routes have more than 50 stops per route, the number of applications that can solve the problem properly is decreased to less than 10 worldwide. Two examples of point-to-point routing software include Roadnet™ and Route Solutions™.

Each program uses various routing techniques and algorithms, graphical information system applications, automatic vehicle location technologies and on-route mapping and monitoring. Multiple applications sometimes need to be implemented to service all types of waste collection routing situations. To assess whether a solid waste agency is a good candidate for implementing waste route optimisation software, the following questions should be asked and answered.

- Do the crews have assigned route boundaries?
- Do the crews have ready access to accurate maps?
- Was the last re-route more than 5 years ago?
- Do you know how many stops and containers are included in each individual route?
- Are the current routes developed based on the key factors of time, weight, number of dump trips and the number of stops?
- Do you have current route statistics (e.g. time on route, time to first dump, time to second dump, travel time to dump site (landfill or transfer station), break time, check in and check-out time, and an allowance for breakdown time?
- Are total route times within an hour of the normal work-day schedule?

If the answer is 'no' to any of these questions, it is highly likely that the agency's operation is not efficient and would benefit from route optimisation.

Deployment of radio frequency identification technology

Municipal solid waste management organisations are increasingly buying radio frequency identification (RFID) tags and embedding them in solid waste and recycling bins. An RFID tag is like a barcode that can transmit its identifying numbers as a radio signal to a receiver up to 100 m away. This means that it is not necessary to see an RFID tag or even be close to it to scan it, as opposed to a barcode, which must be scanned with a handheld reader.

Instead, small readers placed on waste and recycling trucks can automatically detect and read RFID tags. The readers are

small radios with antennas that constantly emit a signal. When an RFID tag comes within range, the reader's signal supplies the tag with the tiny bit of power required to activate it. The active tag transmits its data and the reader records it.

The data on an RFID tag is a series of numbers that identify the object to which it is attached. A tag may also store the name and address of a trash bin's owner as well as other information. The reader conveys the information on the RFID tag to a computer database where software applications put the data to use. Further, with the RFID system, a waste collection manager can view on the server when a truck is falling behind schedule, based on the number of carts that have been emptied (contrasted with the number of carts on that vehicle's route), or based on the address at which the cart is expected to be, thereby indicating the truck's current location.

Including this RFID technology in the overall residential collection system would require an investment for both the RFID tags on the agency's existing refuse carts and readers, preferably included with automated collection trucks if such are not already in use. The advantages to the agency's customers would be substantial, including:

- asset management – ability to track the location of the waste storage bins;
- data tracking and enhanced real-time productivity measurements;
- route visualisation and intelligence;
- ability to target needed education and outreach for individual homeowners or neighbourhoods (e.g. in areas where recycling rates are below average).

An emerging technology involves the remote monitoring of trash volume in each collection bin. In this approach, Internet-connected small mobile closed-circuit televisions are placed inside trash bins, feeding real-time information about the extent to which each bin is full. Using such equipment, a waste collection agency can monitor its bins and schedule collection of only those bins that are full or near full. This technology could thus schedule truck stops only at bins that need service, eliminating stops at empty or near-empty bins, thereby optimising the collection of waste, and perhaps reducing the number of trucks and/or staff needed to provide a city's collection service.

Transition to compressed natural gas fuel

Two other significant trends in solid waste management are the transition by waste haulers of their collection fleets from diesel to compressed natural gas (CNG) or liquefied natural gas fuels, and expanding investment in natural gas fuelling stations. Waste collection manufacturers report that within the last 3 years, more than half of their new vehicle sales include those designed to burn natural gas.

A variety of economic, environmental and political considerations are driving this fuel transition. Foremost among these is that natural gas produced in the United States, which appears to be the lowest cost alternative fuel source. Traditionally, the price of a barrel of oil has been about six times that of a thousand cubic feet of natural gas. With the widespread use of fracking technology in the USA to recover significant quantities of natural gas, this ratio has jumped to as high as 12:1. Depending on geographic location and proximity to gas lines, the average price of natural gas today can cost US$1.50 to US$2.00 less per diesel gallon equivalent. Projections from government, corporate and non-profit prognosticators suggest that natural gas will continue to be plentiful and relatively cheap in the near-term compared with diesel fuel.

Typical refuse truck fuel-use averages between 32,000 to 37,800 L per year at an average fuel efficiency of 1.06 to 1.28 km L^{-1}. Thus, the growing differential between natural gas and diesel fuel, municipal or hauler-operated trucks can shave as much as 30% to 50% on fuel costs. What was once prompted by environmentalism owing to the promulgation by United States Environmental Protection Agency (USEPA) of new restrictive federal heavy-vehicle emission regulations has now been largely driven by the promise of significant long-term fuel savings.

Several of the major waste hauling firms in the United States, such as Waste Management, Inc., Republic Services, Inc. and Progressive Waste Solutions, have already made capital plans to replace their existing diesel-fuel refuse collection vehicles with natural gas vehicles as the existing trucks are retired. A few municipalities as well are entering the arena as 'early adopters' on this wave to natural gas.

What do CNG vehicles cost?

The capital cost of a typical natural gas refuse collection truck ranges from US$275,000 to US$325,000, some 15% to 25% more expensive than comparably sized diesel-fuel vehicles. The primary reasons for the increased cost is their more expensive engine and complex fuel system.

Hybrid vehicles

With fuel costs rapidly escalating over the last several years, car manufacturers like Toyota have been successful in launching products like the Prius with gasoline–electric hybrid engines to boost fuel economy to levels approaching 60 miles to the gallon. Over the past few years, engine manufacturers for waste collection equipment have developed diesel engine designs with extensive post-combustion control and advanced-combustion control to meet the stringent diesel standards mandated by the USA's Clean Air Act. Even more advanced systems are planned in the upcoming years as the Federal diesel standards become even more stringent. All of these design changes have resulted in increasing capital, operating and maintenance costs for diesel solid waste collection trucks.

Typically, the normal solid waste collection vehicle can service upwards of a thousand stops per day on a route, and oftentimes stopping and going hundreds of times. Approximately 75% of an average duty cycle of a garbage truck is spent collecting

refuse, with the balance used to transport the waste to a transfer station or ultimate disposal point. Each time the vehicle is started, a large amount of fuel is consumed to get the vehicle back up to operating speed. Further, when the brakes are applied to slow down or stop, energy is lost as heat. Typically, 40% to 50% of the fuel used to collect refuse is used to generate all of the truck's hydraulic needs. All of the energy needs for a typical diesel solid waste collection truck commonly equates to an average fuel consumption of roughly 2 to 3 miles per gallon.

Current regenerative braking systems employed on passenger hybrid cars store the kinetic energy from braking as electric energy in specially designed battery packs, which are then used to power an electric engine that is installed in the vehicle. Can these hybrid technologies find their way into the municipal waste collection systems? We are happy to report that this day is not long off.

In 2010, a prototype of this new type of vehicle manufactured by a consortium of Parker Hannifin and Autocar, using the hydraulic hybrid technology known as RunWise, was provided to Miami-Dade County, FL. The goal was to help the hybrid system manufacturer, Parker Hannifin, fine-tune its product before launching it into mass production. The test location was Dade County, FL, home to one of the largest municipal solid waste fleets in the United States (a 193-truck fleet servicing 340,000 homes per day). The single test truck was enough to convince the County's Fleet Manager to purchase additional hybrid vehicles over the next 4 years for a total of 64 (as of this writing). Based on this experience, dozens of other cities around the United States have also purchased these hybrid refuse vehicles in recent years.

So far, these solid waste agencies report savings of about 33% over a traditional diesel-powered solid waste collection vehicle. This amounts to average annual fuel savings of about US$8000 to US$10,000 per year per vehicle. The hybrid vehicles are reported to cost in the range of US$350,000 to US$400,000, which is between 40% to 60% more expensive than traditional solid waste collection models. Fleet managers report that the hybrid vehicles require less maintenance. For example, brake pads seem to last longer because the brakes typically do not come in contact with the brake drums until the truck slows to about 2 miles per hour. Normally, brakes for diesel refuse trucks are replaced by most fleet operations every 4 to 5 months, but the brakes on hybrid vehicles may need to be changed every 6 years. Further, vehicle truck tyres appear to last longer as well owing to reduced friction heat on the wheels. Lastly, an added benefit in fuel reduction and reduced maintenance is that it improves air quality and supports many community climate action plans goals to reduce greenhouse gas emissions.

Enhanced vehicle electronics

The use of enhanced electronics is another emerging trend for solid waste collection. In recent years, many agencies have installed cameras on the outside of the residential collection vehicles to help improve safety. DVD recorders have also been installed to track backup and potential safety events. This equipment provides a second, third or fourth pair of eyes for drivers and has proven beneficial in improving safety. The use of advanced on-board electronics is also another trend in solid waste collection.

Closing thoughts

The foregoing pertains mainly to current waste collection situations in urban metropolitan areas of North America. It should be noted that these technologies have evolved over many decades; for example, horse-drawn carts were used to collect waste in many cities, and open dumps were common in the USA, as recently as the early 20th century. So, while waste storage and collection practices are more basic in most developing countries today, advanced technological solutions most likely will become practical and affordable much sooner in developing countries than they were in North America.

WM&R encourages its readers to continue research into the application of information and other technologies in the waste management industry, and to publish results of such research. For those attending WASTECON/ISWA in Baltimore in 2017, there will be a curated technical session addressing these and other trends on solid waste collection technologies.

Marc J Rogoff
SCS Engineers, FL, USA.
Email: mrogoff@scsengineers.com

David E Ross
Associate Editor