Improving the Livability of Our Cities

Automated vacuum collection of trash comes of age.

BY BRUCE CLARK AND AMY LONG

Most of us have pulled into our local bank teller drive-through window and placed our checks for deposit into a plastic tube sitting in a clear pipe. We push a button, hear a whoosh, and the tube magically disappears. In about 15 seconds, the teller is holding our checks. We do not give the technology that allows this a second thought. Now, if I told you that our trash could be collected and managed using a very similar system, would you believe me? Well, such systems exist and, in fact, have for more than 40 years the world over. They are often referred to as automated vacuum assisted collection (AVAC) systems.

AVAC systems meet all of the criteria for a sustainable system, including no greenhouse gas (GHG) emissions; efficient energy use; low maintenance; and repairable, minimal energy needs between operating cycles, reduced space needs, and very low human impact issues such as odor, noise, safety, and aesthetics. They already have made many dozen international cities, both urban and suburban areas, more livable. This article will provide an overview of the technology and how it works, its advantages and potential drawbacks, economic aspects, and several high-profile recent projects where it has been installed.

History of AVAC Systems

Invented in 1961 by Olof H. Hallström, a Swedish entrepreneur and head of Centralsug AB (which would later become ENVAC), the system was originally for use in hospitals where it was used to vacuum dust, and then later to separately convey soiled linens and trash to reduce potential for spread of infections. Then came applications to the food production industry where they were used to convey leftover food scraps from the production process. The first residential system was installed by ENVAC in 1965 in the town of Ör-Hallonbergen, Sweden, and is still in use today.

AVAC technology for urban waste collection has been in use in the US and internationally for more than 40 years, providing an effective solution to cities with large, dense populations, generation of a large volume of solid waste, crowded streets, and air-quality issues, among other urban issues where conventional waste collection by trucks is impractical, or prohibited. Popular in Europe and Asia, for decades the technology was limited for urban area waste collection in the US to three locations where ENVAC provided systems that are still in service: Roosevelt Island in New York City (installed in 1967); Disney World in Orlando, FL (installed in 1970); and Summit Plaza, a residential tower in New Jersey (installed in 1972).

ENVAC

Figure 1. Schematic of an AVAC system

System Description and Applications

An AVAC system uses a standard bank of centrifugal fans to create a vacuum within a tube to suction refuse from its source through

MariMatic

Figure 2. Typical AVAC waste collection inlets (one each for mixed plastic, paper, cardboard, and garbage)

the tube to a location where the refuse is automatically separated from the airstream and then compacted (Figure 1). The system is completely sealed; no waste is exposed in this process. A system is composed of only a few major pieces of equipment, including:

- Waste intake chutes (Figure 2—Typical unit serving a residential subdivision)
- A network of collection tubes (i.e., pipes). Diameters vary from

8 inches (200 mm) to 20 inches (500 mm); some companies use steel, and others use PVC or polyethylene.

- Automatic air-flow control valves
- A terminal station where the waste is compacted and automatically placed into steel containers that are transported to a transfer station or final disposal facility. The station can be underground or at-grade (Figures 3 and 4). Major equipment in the terminal includes: electric-powered centrifugal fans; a cyclone separator; an exhaust air filter system; an operator control room; sealed, transportable waste containers; and fully computerized remote monitoring and visual security surveillance of every waste inlet.

Compatible With Recycling

Most systems in use today serve congested urban areas, where the tubes are located below ground. However, tubes can be exposed and attached to structures where it is impractical to bury the tubes. This design is often used in sports facilities. Tubes can be vertical, horizontal, and sloped upward if necessary to adapt to the facility being served. Depending on the system provider, an AVAC collection system can extend up to approximately 2 miles (3.2 km) from the terminal station.

And importantly, AVAC systems are designed to be integrated into and fully complementary with urban waste recycling programs. AVAC systems can easily be installed in high-rise buildings to provide automated waste and recyclables collection at every floor. For ground-level areas, collection inlets can be placed almost anywhere it is convenient (Figure 5). For areas where a group of inlets may serve a block of homes and more security is desired, the inlets can have an automatic locking access door. Residents are provided with a keyless transponder to operate the door to deposit their trash.

Typical Operation

The operation of an AVAC system is straightforward. Starting at the collection inlet, bags of waste or recyclables are tossed in by consumers. Each inlet has a control valve below ground at the base of the tube where it connects to the main header pipe. As bags start to stack up in the vertical tube, a sensor in the tube sends a signal to the terminal station where a vacuum fan is started. In a few seconds, a sufficient vacuum has been established in the header, and the control valve is automatically opened. Waste bags are whisked through the header pipe at about 50 miles per hour (15 meters per second) to the terminal, where they will be separated from the vacuum in a cyclone unit. A residential system may pull a vacuum of 500 millibars (about 200 inches water)—this is considered a relatively low vacuum. (But, there's no need to worry that small children could get sucked into the system.)

The bags drop into a compactor, and the air from the pipe is sent through an odor removal filter and exhausted out the roof of the terminal. The compactor pushes the waste into a steel shipping container, similar to a standard mobile compactor box. No waste materials are exposed in the terminal station, and thus, the station stays clean and odor-free. The vacuum fans automatically shut off until the next signal is received. Inlet valves can be programmed to open on a set time if usage is low, to prevent odor buildup from bags sitting in the tube for too long.

MariMatic

Figure 3. AVAC terminal station, Finland

MariMatic

Figure 4. Cyclone separator inside AVAC terminal station

System Evolution

Many systems produced and operated today are far superior to the ones that were initially introduced 50 years ago. Improvements to today's systems include:

- quieter operation;
- lower energy consumption;
- reduced air emissions;
- operating in a fully automatic mode, and from a remote location where controls and monitors can be aggregated in a building's main control room;
- improved life expectancy on the tubes; and
- the capability to be designed and programmed to collect, independently, up to four different waste materials.

Another company that serves the growing international market is MariMatic. Owned and operated by Göran Sundholm, the Finland-based company has developed an energy-efficient design for their AVAC system. Primarily through the use of smaller-diameter pipes (200 mm, as opposed to 500 mm in competitors), and the use of high-density polyethylene pipe with a highly durable interior surface, the company documents an average energy use of 45 kWh per ton of waste. Other designs employing large-diameter steel pipes have to move upwards of three times more air and, with steel's higher coefficient of friction, can require energy use of 100 kWh per ton or higher. To eliminate the clogging problem that a smaller pipe might have, Paul Marttila, president of the company's US operation based in Newtown, PA, explains that MariMatic developed a rugged device, called a "Formator," for the inlet to quickly compress and shape a bag of waste so that it moves easily through the smaller-diameter pipes.

The use of light, but strong, polyethylene pipe may be one breakthrough that helps moves the acceptance of urban AVACs forward more rapidly. Pipe installation is simplified with light lifting equipment. Pipe joints are made with standard electrofusion couplings, the same ones used in the landfill gas industry. Compared to a fusion butt weld in steel, the new joint reduces joining time from about 2 hours, to 10 minutes per joint. Piping is flexible, and can be easily curved in the field, reducing cost and time to install bend fittings.

Example Facilities

Although there are more than 100 urban AVAC systems operating in more than 15 foreign countries serving large city centers, residential areas, airports, and theme parks, and dozens more serving hospitals and food plants for decades in the US and internationally, they were slow to be introduced for the urban waste sector in the US. However, things are starting to change as the real benefits of this technology become better appreciated. It should be noted that Canada has been a faster adopter of this technology, having more large-scale AVAC systems in operation than the US does.

An ENVAC system started operation in July of last year at Cite Verte, a new "green" residential community in the Saint-Sacrament District of Quebec City, Canada. The city's system serves 800 residential units and a shopping center—about 4 tons per day (TPD) of waste total—employing 49 waste inlets for the residential side, and 9 inlets for the stores. The main collector tube runs approximately 0.7 miles (1.2 km, Figure 6). Recently ENVAC announced that an AVAC system with an initial capacity of 25 TPD is being designed to serve a portion of the Hudson Yards, a mixed use multi-billion-dollar mega-project being developed by The Related Companies in New York City. Several other developers on both US coasts are considering AVAC systems for new developments.

In 2014, one of the authors, Bruce Clark, had the opportunity to see, first-hand, operating AVAC systems provided by MariMatic, in Finland. The visit included the subdivision of Vuores in the city of Tampere, a "green" mixed residential and commercial community of approximately 14,000 people and its 25-TPD terminal compacting station (Figure 3). The Vuores system has been operating for over two years. The owner/operator indicated that he is very pleased with the smaller-diameter HDPE pipe work, and there have been no clogs. Clark also visited a food production plant in Kotka, Finland, that uses a variation of the AVAC system for conveying up to 1,300 pounds per day of food scraps left over from the preparation processes. The terminal system for that plant provides a dewatered food scrap byproduct that is taken offsite for composting.

You say you have "big city" trash removal needs? No problem. MariMatic recently started up the largest AVAC system in the world, a 900-TPD system for Mecca, Saudi Arabia, that can accommodate the waste generated by several million people daily.

Clark also visited the MariMatic 81,000-square-foot research and development facility in Helsinki, where complete, full-scale operational AVAC systems are on

Figure 5. AVAC waste collection inlets at a medium-density residential complex

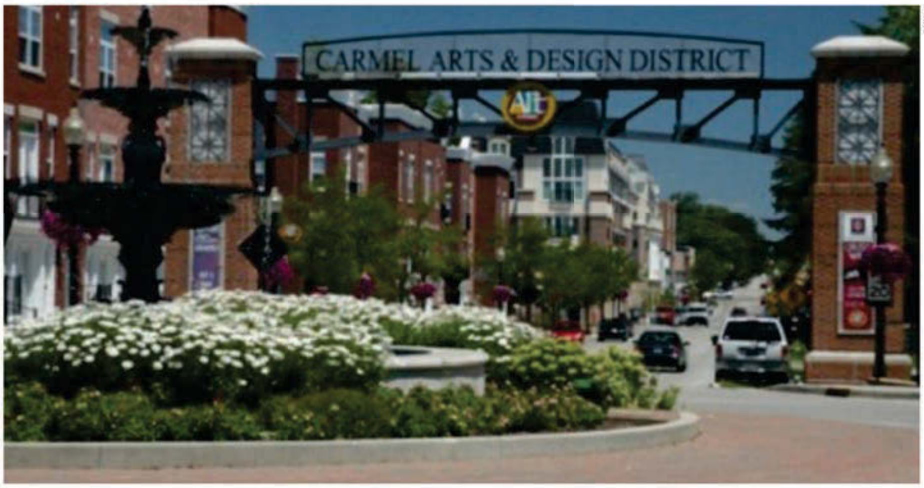


Figure 6. The AVAC waste terminal station in Quebec City, Canada

display to provide guests a close-up look of every component in the system, from collection inlets, to piping, the compacting station, and computerized data management and monitoring systems (Figure 7). At this facility, the company fabricates and tests new components, measures and validates system energy use, and develops and perfects new designs and technologies. Clarke came away impressed with the heavy-duty design and build quality of the system components at these facilities.

System Advantages

An AVAC system offers many advantages over a typical truck-based collection system. Among these are:

- *Quiet:* Collection trucks in the collection areas are eliminated. There is virtually no noise above normal conversation level standing outside a collection inlet or the terminal station. A collection inlet may operate a total of 10 minutes per day.
- *No odors:* The collection system and terminal are sealed; inlets are emptied automatically as soon as they are full or are emptied on a scheduled time if the inlet has not been used within 1 hour. Waste cannot putrefy and result in odors in the system. And because collection trucks are eliminated, the odor of diesel truck emissions is eliminated.
- *Elimination of rats/vermin:* The closed waste receptacle and leak tight system virtually eliminates the attraction of rats and vermin.
- *Air quality:* Fewer heavy trucks result in less GHG emissions.
- *Long life:* systems have performed on a continual basis more than 50 years before a major overhaul. Uptime is very high.
- *Better "curb appeal" and out of sight:* Except for the terminal buildings and the stylish inlet receptacles, the system is underground. The terminal building can have a pleasing architectural style (Figures 3 and 6).
- *Less street wear and tear:* No collection trucks mean less wear and tear on the street right of way. Street repair costs due to less heavy traffic can be reduced over time.
- *Safer:* Waste collection is one of the most dangerous professions in the US with workers continuing to be killed working in traffic. Removing the collection trucks from neighborhoods can result in less accidents and injuries to workers and the public.
- *Reduced workers compensation:* The AVAC system requires significantly less labor to run and are far safer. Collection trucks pose a safety hazard to pedestrians and the public in general on their routes, and workers have been injured or killed as well. For areas without automated collection trucks, worker compensation claims are high, and workers are often plagued with repetitive stress injuries for life.
- *Operation in natural disasters and climate resiliency:* Rosina Abramson, Esq., the US representative in New York City for ENVAC, pointed out that the Roosevelt Island AVAC system continued to operate and collect trash during Superstorm Sandy, even as the storm lashed the northeast leaving smelly and unsanitary piles of garbage in areas that were flooded for days since waste trucks could not gain access. AVAC systems, because they are fully sealed, can operate under water.
- *Reduces need for transfer station:* In many cases, the terminal station eliminates the need for another transfer station.
- *International appeal:* It is no secret that

people from all over the world are investing, moving to, or spending significant vacation time in the US. An AVAC system can be part of the draw for these people, because many prefer its "sustainability" and better quality of life attributes.

System Economics

In the US, waste collection system major costs are primarily for collection trucks, fuel, maintenance, carts, and personnel labor. AVAC system major costs are in the terminal station, inlets, piping, and electricity. Capital costs for an AVAC are usually higher because of the waste terminal station, however, because the AVAC systems can easily last 40 years before major renovation, the long-term, life-cycle benefit begins to shift in their favor as a typical municipal waste collection truck lasts only about seven years, and replacements are upwards of $225,000 average per vehicle as labor costs continue to rise every year. A typical AVAC system can be operated remotely by one technician at the terminal station (Figure 8).

The economic analysis of an AVAC system versus a truck-based collection system is a complex analysis that must account not only for the capital costs and typical operation and maintenance costs (O&M) costs, but also for the economic benefits resulting from the advantages of the AVAC system, including no odor, less street wear and tear, building space freed up from storage of numerous waste and recycling containers that can be repurposed for revenue generating purposes, increased safety, reduced injuries to workers, and virtually no noise. Some of these are not easily quantified, but are real nonetheless, and should be accounted for to "level the playing field" and produce a realistic and complete financial analysis. And because AVAC systems run on electric motors, they do not produce GHGs, as would the typical diesel or natural gas–powered truck.

MariMatic

Figure 7. AVAC research and development center, Finland

The Future

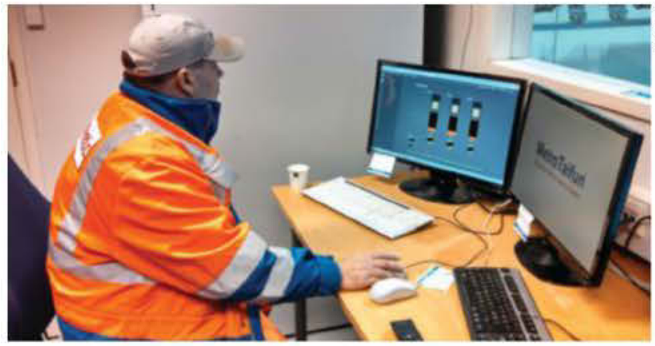
How rapidly will the US market for urban AVACs develop? Likely not as fast as the European and Asian markets, according to Harry Pliskin, president of TransVac—a 40-year old AVAC system provider based in Denver, CO. He indicated that there are many factors that are different overseas than in the US that account for this difference. Those differences between Asia and Europe, and the US include:

1. Systems are partially subsidized (directly or indirectly) by governments.
2. There is more uniformity within certain countries because the environmental benefits of these systems are codified by governments, which have drawn the conclusion on behalf of society that there is a quantifiable environmental benefit from the system. Comparatively, in the US, governments are less inclined to mandate this expenditure as part of a development, and—as a result—individual developers are left to develop their own quantifiable

justification on a case-by-case basis for the use of the system. These analyses inevitably will vary greatly from developer to developer.

3. In the US, there is often a land developer and a separate vertical developer/operator who builds and operates the building. The interests of the land developer and the owner/operator of the building often diverge. In other countries, developments are either state owned or have the same developer/operator whose interests are one and the same.
4. There are higher-density developments in European and Asian countries because there is less available and developable land in these countries.

Granted, there are some situations where an AVAC may not make sense in the US. They are better suited to new development, where the collection pipeline can be installed at the same time and in the same trench as the normal utility lines. And then there is the location and number of waste inlets, which relates to the convenience and cost of the system. Most Americans have gotten used to "door-to-door" waste collection services. Thus, the typical AVAC system that provides the waste inlet in a "common area" where it requires carrying a bag of waste up to perhaps 175 feet is perhaps normal in apartment complexes or some European countries where, shall we say, the people are a bit more "hardy." So, asking the average American single-family homeowner to tote their garbage down the street to the common area could be a hard sell in some communities. Although providing a dedicated waste inlet at every home could be done, it would likely be cost prohibitive.



MariMatic

Figure 8. AVAC terminal station operator

Many "new" technologies have come and gone over the decades in the waste industry. The authors would argue that the AVAC system is a "new" old technology. The technology is proven; what it will take as much as anything when adopting a different system is a change in mindset of how we can integrate other technologies with significant benefits into established systems. Although the bank teller tube system may eventually give way to cell phone banking, AVACs seem to have a bright future ahead of them. It will be interesting to see who will invest in these systems here in the US. MSW

Bruce Clark, P.E., is a Project Director, and Amy Long is a Project Professional, both with SCS Engineers.

For related articles:
www.mswmanagement.com