Advancing On-Site Organics Recycling Across Canada

Taking Action for our Soils, Waste-Resource Diversion, Community, Water, Biodiversity, Climate, Health & FUTURE

Conseil canadien du COMPOST Council of Canada

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I. INTRODUCTION

Vision:

Recycling unavoidable organic residuals is amongst the most powerful action statement available to express our commitment to environmental stewardship, community action and a calmer climate. What has already been achieved in organics recycling in Canada has been through the dogged determination of organizations and individuals, spanning public and private sectors with advocates across all fronts. And yet, in Canada, while organics are the #1 material now being recycled, we are still sending two-thirds of the organic residuals which are annually created at work, home and play to be buried in landfills, whether in Canada or in other countries. A blatant statement of wasted potential.

While centralized organics recycling infrastructure – be it composting or anaerobic digestion – has become an established option in many cities and for proactive businesses, much still needs to be established. Often this involves years of debate, financial assessment and regulatory procedures.

Backyard composting has become a more limited option now for many Canadians, particularly in urban settings where many live in apartments and condominiums or when a curbside organics recycling program becomes established.

On-site organics recycling offers many exciting opportunities for community empowerment; sustainable local jobs; reduced contamination in end products; possibly less expensive organics recycling solutions; better climate change solutions to hauling the waste away. And yet, on-site recycling of organic residuals stands out as an option which has yet to have full traction across Canada.

Encompassing both composting and anaerobic digestion, a wide range of systems are now operational in the North American context. These systems are empowering action across many different fronts, involving programs for an individual organization, tenants of a common location and community.

The Compost Council of Canada, with the support of Environment and Climate Change Canada, has created this report with the aim to help advance on-site organics recycling in Canada. In addition to information-sharing and encouragement, the Council's work ahead will focus on further awareness-building, funding, training, certification and product markets as supported by the CQA: Compost Quality Alliance and DQA: Digestate Quality Alliance. This document serves as a baseline for ongoing additions, targeted on an annual basis, as on-site organics recycling develops more fully across Canada.

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Organics Recycling .....

<u>... is inclusive of composting and anaerobic digestion (AD)</u>

On-site organics recycling encompasses composting and anaerobic digestion. Scaled-down on-site systems for AD are emerging, whereas on-site composting systems are common — from 3-bin, hand-turned designs to in-vessel rotary drums. Opportunities for each — from low tech to high tech — will be discussed.

<u>... provides options for residential, commercial and institutional food scraps and other organics</u>

On-site organics recycling services the commercial and institutional sectors, as well as residential. The several on-site anaerobic digesters in operation service small food and beverage manufacturers. The majority of programs incorporate a food scraps stream from one or more of those sectors. All on-site composting operations include yard trimmings and/or wood chips as amendment. Inclusion of other organics, such as soiled paper and certified compostable products, varies.

<u>... fosters community engagement and enterprise opportunities</u>

A unique characteristic of more recent on-site organics recycling programs is engagement with the community, whether the installation is at a community garden or urban farm, food bank, school, park, or on a vacant lot. Some tap volunteers to help manage operations; others are integrated into the operation of the site's host, e.g., students or urban farm employees. Increasingly, employment of youth, recently incarcerated community members and other socially and economically disadvantaged individuals are intrinsic to the operation, especially if the on-site program includes food scrap collection.

Organizations with on-site composting projects, including schools, clubs and youth organizations, can market the finished compost. Some are very innovative with the packaging, e.g., reusing paper coffee bags or sacks.

II. TERMS AND DEFINITIONS

<u>What is on-site in this vision?</u>

On-site composting and anaerobic digestion are designed to service more than one individual or household. Organics are managed at the place they are generated (on-site), although some receive materials from other generators, e.g., households, and small businesses in the same neighborhood. The end product, e.g., compost or biogas, is primarily used on the same site. In some cases, compost is given to generators providing organics to the on-site operation, e.g., households whose food scraps are composted at the site, or other community gardens.

<u>Is on-site composting the same as community composting?</u>

The short answer is sometimes. Over the past 10 years, community composting has emerged as a tier of composting. These operations typically use the same types of systems employed in on-site composting; the main distinction is community composting, by design, receives organics from off-site, versus some on-site composting operations that only service the generator where the system is located. In both cases, the motivation is to keep the collected organics local, and use of the finished product local, i.e., cycling the resources in the community or at the establishment where they are generated. Another similarity is that on-site and community composters utilize “hot” composting methods, i.e., they meet PFRP (process to further reduce pathogens) when processing food scraps (pathogen destruction, e.g., maintaining temperatures of 55°C or higher for minimum 3 days for aerated static piles).

Do on-site anaerobic digesters achieve pathogen destruction if processing food waste?

These digesters typically operate at mesophilic temperatures (30° to38°C or 85°F to 100°F). Therefore pathogen destruction is not achieved. Some systems pasteurize the digestate before it is used as a fertilizer.

<u>Is scale a defining parameter of on-site?</u>

Scale of the operation does not explicitly define what is deemed “on-site.” For example, some on-site composting operations that service correctional facilities or universities may be scaled to process several tonnes/day of feedstocks. The systems designed to accommodate higher volumes have higher capital costs (examples in the case studies section). The beauty of on-site composting is that it can be low-cost and low-tech to get started. The investment is in the knowledge and skills to manage the operation to produce high quality compost without nuisances or vectors.

By its nature, on-site anaerobic digestion can be more capital-intensive due to the technologies and system components. There is very low-tech systems to accommodate individual households or small groups of households, but these would be difficult to scale for on-site anaerobic digestion. Several on-site systems are highlighted in the Technologies section.

<u>What compatible systems and processes may be used?</u>

On-site organics recycling of food scraps can also include the categories of dehydrators, liquefiers and fermentation (e.g., bokashi). To utilize the outputs of these systems, further treatment, e.g., composting and/or curing, is necessary.

III. Historical Context

On-site organics recycling — in particular, composting — emerged in the 1990s as an option for managing food scraps at institutions, e.g., correctional facilities, college campuses, summer camps. In locations where space and amendments were available, composting was done in windrows or aerated static piles, or in tandem with an in-vessel unit used for the initial stage of composting. The finished compost was utilized on-site for gardens and small farms and landscaping.

Interest grew in on-site composting at locations with limited space, e.g., office buildings, restaurants, hotels and corporate campuses. This led to development of small-scale in-vessel composting units such as aerated rotary drums and "tubs" with a rotating auger. Compost produced in these in-vessel units typically needs to be cured, which was a challenge in confined spaces, especially office buildings. They also required maintenance, as well as a power source to operate. As a result, widespread adoption where space is limited did not occur.

Adoption of on-site composting accelerated with the increased interest in food scrap diversion, e.g., due to climate change and/or closing the loop with on-site food production. In many cases, organizations starting on-site programs opted for low- to medium-technology systems, depending on budget and available labour — and the amount of source-separated organics allowed on-site (which varies by jurisdictional regulations).

On-site anaerobic digestion has little historical context in North America., although it is widely used in developing countries as a source of cooking fuel for households. Unlike on-site composting, on-site anaerobic digestion requires more design and engineering in order to get started. There are definitely applications for on-site anaerobic digestion; at this point, cost of technology can be a hurdle to implementation.

IV. Regulations

In Canada, there generally is the regulatory differentiation for on-site composting composting and anaerobic digestion is very limited from the requirements for large-scale initiatives. This is a definite area of next-step focus requiring attention to support expanded implementation of this system-type within the range of organics recycling options.

In the United States, many state organics recycling regulations have a tier in their solid waste rules that exempts on-site composting and on-site anaerobic digestion from permitting requirements. State wastewater agencies are typically not involved due to the scale of these operations. However, some types of AD projects may trigger involvement of the wastewater and water regulators.

The on-site exemptions for composting were adopted many years ago as interest grew in processing food scraps at businesses and institutions. The on-site exemptions for AD are more recent, prompted in part by increasing interest in diverting source separated municipal organics — residential, commercial and institutional — to digesters.

Typically, projects that fall under exemptions are limited to a specific amount of organics on-site at any one time. As the quantity of organics increases, so do the requirements, typically under a tiered regulatory scheme. For example, New York State has 3 categories — exempted, registered, and permitted.

A handful of states have established regulations for community composting, e.g., at community gardens and urban farms. These operations are exempt if they fall under a certain quantity of material on site at any one time. Historically, on-site exemptions required that the operation only process organics from that operation, and use the compost on their site as well. In some cases, this has been modified with the advent of community composting where compost may be distributed to program participants.

A summary of some states on-site composting and on-site anaerobic digestion rules are below. Links to the full rules are provided.

On-Site Composting Regulations

California:

State permitting overview: https://www.calrecycle.ca.gov/swfacilities/permitting/facilitytype/compost
Exemption language:
https://govt.westlaw.com/calregs/Document/I3A8C5D5F906D496AB5610EA03179C184?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)
Community composting: https://www.calrecycle.ca.gov/swfacilities/permitting/facilitytype/compost
Tiers: (https://www.calrecycle.ca.gov/LEA/Regs/Tiered/TierChart/)
Community Composting Grant Program:

Composting green, agricultural, food, and vegetative food materials, alone or in combination, is an excluded activity if the total amount of feedstock and compost on-site at any one time does not exceed 100 cubic yards (cy) and 750 square feet (sq. ft.). This covers both on-site composting and community composting operations. If a project has more than 100 cy of compostable material on the site at any one time, and/or the pile(s) of material take up more than 750 sq. ft. of area, the operation may need permission from its local environmental health department, which enforces California state laws and CalRecycle regulations (known as the Local Enforcement Agents or LEAs). This tier is called the "Enforcement Agency Notification Tier" and covers yard trimmings composting facilities processing ≤12,500 cy. Vegetative food material composting facilities receiving ≤12,500 cy fall into the Registration Permit Tier.

Any on-site operation that also includes a food scrap collection component may have to comply with the local waste franchise agreement. CalRecycle notes that many counties license solid waste haulers, and picking up food waste from residents — even on a bicycle — may require obtaining such a license. Another option might be to organize the composting group as a cooperative, charging participants a membership fee where pick-up of feedstocks and delivery of finished compost are included.

Community Composting Grant Program [https://calrecycle.ca.gov/climate/grantsloans/communitycomposting]: CalRecycle initiated the Community Composting for Green Spaces Grant Program several years ago to increase the number of community groups operating small-scale composting programs in green spaces within disadvantaged and low-income communities, and to increase the capacity of those composting programs. Green spaces include, but are not limited to, community gardens, urban farms, and other public spaces where small-scale composting is appropriate.

Maryland:

https://mde.maryland.gov/programs/Land/RecyclingandOperationsprogram/Pages/composting.aspx
Maryland Department of Environment's (MDE) composting rules, revised in 2015, are divided into three general feedstocks types. Type 1 is yard trimmings; Type 2 includes food waste, nonrecyclable paper, MDE-approved animal manure and bedding, MDE-approved

industrial food processing materials, animal mortalities, and compostable products; and Type 3 covers biosolids, soiled diapers, and mixed MSW. MDE created two new tiers, with Tier 2 divided into smaller and larger facilities. Tier 1 regulations are for facilities composting only Type 1 materials, i.e., yard trimmings. Tier 2 is for facilities composting Type 1 and 2 materials. Tier 2-Small applies to operations producing ≤10,000 cy/year of compost. Tier 2-Large covers facilities producing >10,000 cy/year of compost.

The MDE rules exempt a Tier 1 or 2 composting facility from having a permit when the site has no more than 5,000 sq. ft. "in support of composting" and meets maximum pile height restrictions. Feedstock piles may not be higher than 9 feet and all other piles are limited to a height of 12 feet. When determining the area used in support of composting, areas used for feedstock receiving and preparation (such as mixing, shredding, and water addition), active composting, curing, and storage (including compost, equipment, and waste) must be included. The areas do not need to be contiguous, and spaces not used for any of these activities listed above may be omitted, including empty fields and roads.

New York State: https://www.dec.ny.gov/chemical/55420.html
The New York State Department of Conservation (NYDEC) revised its Part 360 Solid Waste regulations and expanded the limits to which a composting facility is considered exempt, registered, or permitted in 2017. One goal of the revisions was to address the expansion of community composting in the state. The following revisions apply to Source Separated Organics (SSO) Composting that includes food waste:
•*Exempt*: A composting facility that accepts, measured on a monthly average, no more than 1,000 pounds (lbs) or 1 cy, whichever is greater, of SSO per week is exempt, provided no more than 2,000 lbs are accepted in any one week.
•*Registration Required*: A composting facility that accepts no more than 5,000 cy or 2,500 wet tons, whichever is less, of SSO per year, provided that no more than 800 cy are accepted in any month, has to register.
•*Permit Required*: A permit is required to compost any amount of SSO above the registered amount.

Ohio: https://epa.ohio.gov/portals/34/document/fact_sheets/food_scrap_factsheet.pdf
The Ohio Environmental Protection Agency's (Ohio EPA) revised composting rules became effective in October 2018. There were some improvements to the exemptions, which are based on square footage that can be used without needing any composting permitting — not on amounts of material. States the rule, "Any person composting yard waste, agricultural plant materials, animal waste, food scraps, bulking agents, and additives within an aggregate area not greater than 500 sq. ft. on any premises in a manner that noise, dust, and odors do not constitute a nuisance or health hazard and does not cause or contribute to surface or ground water pollution [is exempt]." This exemption is intended to cover on-site composting anywhere and by anyone, including smaller scale community composting of food scraps.

How much material is accepted is not a concern to Ohio EPA as long as the amount does not exceed 500 sq. ft, and is not causing a nuisance or water pollution. These operations are encouraged to process as much as they can, stated an Ohio EPA official. The exemption doesn't restrict the source of the waste material or specify where the compost must be used, nor makes testing mandatory.

For a community food scraps composting scenario larger than 500 sq. ft., Ohio EPA requires a registration (free) as a Class II facility. A license to operate is needed from the local health department or Ohio EPA, along with financial assurance. The financial assurance (closure cost) is calculated based on $2.50/cy of material, not including compost that was tested and met the quality standards. If the estimated cost is $5,500 or less, registered operations are not required to set the financial assurance. This means that a community composting facility can have up to 2,400 cy of materials on-site before it needs to come up with these funds or buy an insurance policy with the agency as beneficiary. The license to operate has an annual fee based on maximum tonnage of *all* materials that can be accepted in a day. For 0-12 tons, the fee is $300, 13-24 tons, it is $600 — increasing as the quantity of material to be composted increases. A community composting facility is more likely to be in one of the lowest two brackets.

Why 500 Square Feet?

Prior to its 2018 composting rule revisions, Ohio EPA had set the maximum limit for an exemption at 300 sq. ft. The agency prefers to regulate by area and not volume; it assumed that a person using just a shovel (which happens at community gardens) might build piles about 4 feet tall. It calculated that a pile of 250 cy at 4 feet tall would require 275 sq. ft. and then rounded it up to 300 sq. ft. (because it was an easier number to remember and to give them a little more space).

The limit was increased to 500 sq. ft. in the last rule revisions for 2 reasons:

1. Ohio EPA inspectors, when responding to inquiries from operators to see if their composting piles/system were exempt, often encountered set ups that were well maintained and appeared to be just about right size. But when they measured the area, it was about 500 sq. ft. The inspectors reported that there was hardly a noticeable visible difference between 300 sq. ft. and 500 sq. ft. unless the space was measured. The larger area, in terms of compliance, did not present anything different than the 300 sq. ft. A community composter in the state, who provided testimony on the rule revisions, noted that from the business side, the increase to 500 sq. ft. would help small businesses have a better start, and serve as a small business incubator in urban areas, etc.
2. The county and city planning departments in Ohio's largest urban areas are starting to plan for food access in urban areas as a way to achieve food justice and sustainability. Composting of food waste is a big component of that. Several larger community gardens maxed out their 300 sq. ft. area and that still wasn't enough space. Typically a group would be in charge of several gardens, but would do the composting only on one because it is easier to monitor and manage one.

In many places, city and county zoning and planning departments, health departments, metro parks and soil and water conservation districts collaborate to help establish the gardens and provide tools and assistance. Several of these entities asked Ohio EPA to increase the size because more compost was needed. When 500 sq. ft. was suggested, the zoning officials agreed, stating that 500 sq. ft was indistinguishable visibly and wouldn't trigger more siting requirements or additional zoning permits.

Washington State: https://apps.leg.wa.gov/WAC/default.aspx?cite=173-350-220
The Washington State Department of Ecology (WADOE) exempts a variety of composting facilities from permitting based on feedstock types and amount of material received. Smaller scale on-site composting of all pre- and post-consumer organics that include food, animal or vegetative-based sources is exempt when no more than 5,000 gallons or 25 cy of material are on-site at any one time. These operations are not subject to notification, reporting or testing requirements. The WADOE notes that "material on-site at any one time" includes feedstocks, active composting, curing piles, and composted materials.
The next tier covers the same types of organic feedstocks but at a scale of >25 cy but <250 cy of material on-site at any one time, not to exceed 1,000 cy in a calendar year. This tier requires that 30 days prior to operation, facilities must submit a notification of intent to operate as a conditionally exempt facility to the jurisdictional health department and WADOE. If these facilities distribute composted material off-site they must manage the operation to reduce pathogens, conduct compost analysis (testing frequency is based on volume of compost produced annually), and submit annual reports and results of composted materials analysis to WADOE and the jurisdictional health department.

Those are the only two exempt categories that include food scraps. The next tier is for facilities composting yard trimmings, crop residues, manure and bedding, and bulking agents that compost >5 cy but <500 cy of material on-site at any one time, not to exceed 2,500 cy processed in a calendar year. This tier is subject to the same requirements as facilities allowed to receive all organic feedstocks that are in the >25 cy to <250 cy of material.

On-Site Anaerobic Digestion Regulations

States vary on how they regulate on-site digesters that process food waste streams. A brief review of several states' requirements includes:

California: https://www.calrecycle.ca.gov/swfacilities/permitting/facilitytype/invessel
CalRecycle's "Excluded" Tier covers in-vessel digestion activities with less than a total of 100 cy of solid waste, feedstock, and digestate on-site. The state also has an "Enforcement Agency Notification Tier that covers "Research" in-vessel digestion operations and distribution center in-vessel digestion operations, e.g., processing spoiled or expired food products in a digester located at a food distribution center. An Odor Minimization Plan is required for all in-vessel digestion operations and facilities.

Maryland:
https://mde.maryland.gov/programs/LAND/AnalyticsReports/permitting%20guidance%20for%20md%20anaerobic%20digestion%20facilities.pdf
Anaerobic digestion facilities may be subject to several Maryland Department of the Environment (MDE), Maryland Department of Agriculture (MDA), and Maryland Public Service Commission (PSC) permits and approvals. A guidance document was created [https://www.biocycle.net/anaerobic-digest-96/] to assist prospective anaerobic digestion facilities in identifying applicable Maryland state government laws and regulations. MDE does not have stand-alone anaerobic digestion facility regulations or a permit. However, Chapter 376 of 2017 directed MDE to convene a study group with recycling stakeholders to evaluate and assist in the development of regulations that: specify when a recycling facility is exempt from a refuse disposal permit; establish design, construction, and operational conditions for recycling facilities; and a separate system of permits or approvals applicable to recycling facilities. Any new recycling facility regulations that are proposed by the study group may amend current MDE regulations applicable to anaerobic digestion facilities.

New York State: https://www.dec.ny.gov/chemical/97488.html#Anaerobic_Digestion
On-site anaerobic digesters are exempt as long as they do not take any sanitary waste (i.e., septage and sewage). The digester can be sited at another location as long as the generator owns it. The facilities must be operated in a manner that does not produce vectors, dust or odors that unreasonably impact neighbors of the facility, as determined by the NYSDEC. The digestate must be stored and used in a manner that is protective of the environment. Included in the exempt tier is an anaerobic digestion facility that accepts no more than 1,000 lbs or 1 cy, whichever is greater, of source separate organics per week on a monthly average. No more than 2,000 lbs can be accepted in any week.

Ohio: https://epa.ohio.gov/Portals/34/document/currentrule/w2efinal.pdf
Ohio EPA's solid waste division did not create its own regulations for "thermal and biological solid waste-to-fuel conversion facilities." Those are currently subject to Ohio EPA's air pollution control requirements and may require a permit for emission sources and material handling operations. In addition, if these facilities have wastewater discharges, they are required to obtain appropriate permits or authorizations for these discharges. Ohio EPA's storm water permitting program may also help ensure that adequate controls are in place to prevent contaminated run-off from outdoor material handling or storage. Ohio EPA will not require a solid waste permit or license for these facilities. If necessary, Ohio EPA and local authorities can still use solid waste and public nuisance laws to address public nuisances and open dumping issues at waste-to-fuel conversion facilities.

Washington State: https://apps.leg.wa.gov/WAC/default.aspx?cite=173-350-250
WAC 173-350-250
Digester exemptions apply to all facilities that treat solid waste by anaerobic digestion. The exemptions are similar in design to WADOE's exemptions for composting. Small-scale digesters taking all organic feedstocks — with no more than 5,000 gallons or 25 cy of material on-site at any one time — are not subject to notification, reporting or testing requirements. Small-scale digesters taking >5,000 but <50,000 gallons of liquid or semi-solid material on-site at any one time, or >25 but <250 cy of nonliquid material on-site at any one time, and if organic materials are received from or distributed off-site, the owner or operator must, 30 days prior to operation, submit a notification of intent to operate as a conditionally exempt facility to the jurisdictional health department and WADOE. Facilities that distribute digestate (solids, semi-solids or liquids) off-site must meet one of the following conditions:
(i) Sample and test digestate solids every 5,000 cy or once per year, whichever is more frequent, to demonstrate it meets compost quality standards of WAC 173-350-220(4) (Table 220-B) before it is distributed for off-site use
(ii) Ensure digestate liquids or nonseparated digestate meets the conditions for a commercial fertilizer as applicable in chapter 15.54 RCW, Fertilizers, minerals, and limes
(iii) Send digestate to a compliant permitted or conditionally exempt composting facility for further treatment to meet compost quality standards
iv) Land apply digestate in accordance with WAC 173-350-230, Land application; or
(v) Use digestate in accordance with WAC 173-350-200, Beneficial use permit exemptions
(vi) Process or manage digestate in an alternate manner approved by the department or the jurisdictional health department

V. Feedstocks, Technologies And Markets

V.1 Feedstocks

On-site organics recycling programs almost always include a food waste stream, be it from food service operations (e.g., restaurants, cafeterias, coffee shops, juice bars), households, and/or small-scale food and beverage manufacturers. On-site composting requires a carbon source, which can vary based on the location of the project, e.g., if it's at a community garden or urban farm, on a university campus, or at a commercial operation. Common sources include leaves and other yard trimmings, wood chips, sawdust, and soiled paper (e.g., napkins, paper towels). Again, depending on location, some include animal bedding, e.g., horse manure.

Projects that include a postconsumer food waste stream and/or meat, fish and dairy, and animal bedding, should be sure the material achieves and maintains thermophilic temperatures to destroy pathogens. This is less critical if only preconsumer vegetative food scraps are being processed. In general, however, achieving higher thermophilic temperatures for a minimum of 3 days is a best management practice for on-site composting, even if only to ensure weed seed destruction.

V.2 On-Site Organics Recycling Technologies

On-site organics recycling technologies are similar in categories to full-scale organics recycling technologies, i.e., composting and anaerobic digestion (AD). Within the composting category, some projects utilize vermicomposting as a second step; others use bokashi (a fermentation process) as a first step.

While on-site composting methods are the same as their larger scale counterparts, e.g., windrow, aerated static pile and in-vessel, the on-site AD methods found for this report are wet systems that incorporate the very basic digestion process of microbes breaking down organic waste and creating biogas. There are many examples of on-site composting operations utilizing the various methods; however our research only identified a handful of on-site AD systems in operation.

No matter the level or type of technology, projects located in colder climates that want to recycle organics on-site year-round need to take steps to insulate their piles, bins, and vessels. Some operations use insulation wraps; others consolidate volumes to better retain heat, e.g., build bigger piles and cover them with ground yard trimmings or finished compost. Vessels may also be insulated, whereas on-site anaerobic digesters can utilize biogas to keep the units heated.

On-Site Composting Systems

On-site composting systems come in 3 basic "forms" — static piles, aerated static piles and in-vessel. The case studies include details on how these systems are utilized.

Static Piles: Typically, the static piles are contained within bins that are often built with recycled pallets or rot-resistant boards, and then lined with hardware cloth to create rodent barriers. The piles need to be turned in order to aerate the materials, and prevent small animals from building homes there. Smaller volumes can be managed by turning from the top of the bin. With larger volumes, it may be easier to have one of the sides be removable to facilitate turning the contents.

Static piles at on-site composting operations are typically built in a 3-bin configuration. Contents are moved from one bin to the next as the material ages, and then the third bin is unloaded for curing. Having larger size particles in the mix facilitates air flow within the piles. An open-source design for building rodent-proof bins (named "Compost Knox") are available through urbanfarmplans.com (http://www.urbanfarmplans.com/portfolio/compost-knox/)

Aerated Static Piles: Adding forced aeration to the static piles provides more process control, especially when composting proteins like meat, fish and dairy — which necessitates the piles be managed to achieve thermophilic temperatures needed for pathogen destruction. Aerated static piles are often contained in bins or small bays, although some operations lay aeration pipe directly on the ground and build the piles over the pipe.

In-Vessel: In-vessel systems used at on-site composting operations come in 3 general styles — drums, aerated containers, and aerated containers with an auger. Reasons for going in-vessel over an open-air system often are related to the site constraints and/or "neighbours", which in many cases are other facilities or operations close by, e.g, at an institution or college campus. Others opt for in-vessel systems to maximize process control and facilitate the active composting process, especially if food waste is in the mix. The majority of these systems require further processing to complete the composting/curing processes. While static pile and aerated static pile systems can be built at a fairly low cost, in-vessel units typically are more expensive.

A 2011 *BioCycle* article (https://www.biocycle.net/in-vessel-composting-options-for-medium-scale-food-waste-generators/) assessed mid-size on-site in-vessel composting systems with capacity ranging from approximately 5,000 to 10,000 lbs/day of food scraps that are appropriate for small institutions including schools, hospitals and nursing homes and commercial establishments. While slightly dated, it is a good starting point when assessing on-site composting systems.

A more recent BioCycle article highlighted North Country School in New York State, which built a rotary drum on-site composter using a 4-foot diameter, 20-foot long double walled polyethylene road culvert, an electric motor with gear reduction, and a series of 8 wheels durable enough to hold up under the weight of the food waste (up to 3,300 pounds when at capacity). Materials were about $15,000. Design plans, an operating manual, and other supporting materials are free to anyone and can be accessed on the North Country School website. [https://www.northcountryschool.org/signature-programs/farm-garden/sustainability/composting}

Process "Enhancements"

Vermicomposting: As noted earlier, some on-site composting systems are paired with vermicomposting — essentially introducing worms into precomposted material to further break down and ultimately enrich the finished compost. (Worms can be used from the get-go, but temperatures will need to stay in the mesophillic range, which can be a challenge if all food waste types are being composted.)

Bokashi: Bokashi is a fermentation process that takes place in a container. Food scraps are sprinkled with bokashi-inoculated bran and then covered. Bokashi does not decompose the material, however the change in cellular structure does make the food waste decompose more rapidly than fresh food waste. The rapid microbial proliferation of fermenting bacteria as they consume the simple sugars in the bucket is a benefit to the composting process. One facility (see Solana Center in case studies) introduced bokashi as a way to include postconsumer food scraps, including meat and dairy, in its residential food waste service.

On-Site Anaerobic Digestion Systems

Two types of on-site anaerobic digestion systems were identified for this document one fairly low tech and the other fairly high tech. On-site digesters have been used for a very long time in developing countries as a source of home cooking fuel. These are the most basic type of digester — organics are put in a rudimentary "tank" and digested to produce biogas; the digested contents flow out and can be used as a fertilizer.

A more "modern" version was introduced by HomeBiogas in North America for households. A hand-operated waste inlet/grinder is attached to a flexible digester tank. Biogas flows from the tank into a line that can be used to operate a cooking plate. A tap on the opposite end removes the liquid fertilizer. A larger unit is being designed for on-site anaerobic digestion. It is sized to handle up to 1 ton/day of food waste. (https://www.homebiogas.com/) System components include the biogas system (digester and biogas storage), a grinder that feeds the digester and water heating unit fueled with the biogas.

Two vendors were identified — Impact Bioenergy and SEaB Energy — that manufacture modular systems, with the biogas utilized to generate electricity. Each sells prefabricated smaller units — SEaB's Flexibuster™ (500kg-3000 kg per day) and Impact Bioenergy's Horse™ (960–6,700 lbs. per week (440 – 3,050 kg per week)). Similar to the HomeBiogas commercial unit, they can be hooked up and operating after delivery.
https://impactbioenergy.com/horse-ad25/
https://seabenergy.com/products/mb400/

V.3 Considerations When Selecting A System/Composting Process

There is no "one size fits all" system or technology for on-site organics recycling. It depends on multiple factors that include location, climate, types of feedstocks, available labour, carbon source(s) needed and storage for those, access to water for the composting process and cleaning containers, space for curing, working space for mixing incoming materials and screening finished compost — and more.

Sites with space constraints may opt for an in-vessel unit, but care must be taken to have some space for curing and/or a location off-site where the compost can be cured. On-site digesters have to manage the liquid digestate, either on-site or having it transported off-site.

The 2011 *BioCycle* article cited earlier (https://www.biocycle.net/in-vessel-composting-options-for-medium-scale-food-waste-generators/) has a useful list of questions that will help determine the best route to take. It also provides tips on how to determine if a given composting system is appropriately sized: "It is important to know the volume of compostable materials generated on a daily basis — including the bulking material. The amount and type of bulking material required depends primarily upon the moisture and porosity of the materials to be added. For example, food scraps tend to be relatively moist and nonporous and will require significant bulking material in order to obtain the proper moisture and air spaces needed for composting.

"However, the type of food scraps greatly affects its moisture content and porosity. The target moisture for any type of composting is 60% and in-vessel units, by design, tend to keep moisture in the unit. A correctional facility that serves precooked meals from a centralized food preparation kitchen will generate primarily leftover prepared foods including soup, chili and mashed potatoes. This material is quite moist, has a low porosity and will require a considerable amount of bulking material. A cafeteria that offers a salad bar and is collecting preconsumer food scraps will produce lettuce, carrot trimmings and other items with moderate moisture and porosity. Finally, a school that collects pre and postconsumer food scraps including napkins, compostable plates, bowls, cups and flatware, will have relatively low moisture and more porous food scraps, and will therefore require less bulking material."

V.4 Costs, Operational And Maintenance Considerations

System costs vary from about $500 to $1,000 (materials and labour) to many thousands of dollars for some in-vessel designs and on-site AD. Operational and maintenance costs also vary, depending on the degree of mechanization and whether the project uses volunteers and/or paid staff for labor. But even low-tech systems using bins built out of wood have to replace boards and reinforce the hardware cloth.

On-site organics recycling projects located at universities, correctional facilities and similar campuses typically have access to free or lower cost labour, as well as adequate space to utilize system outputs. This is also often the case for projects at community gardens and farms and K-12 schools. Conversely, projects at food service establishments, grocery stores, offices and institutions such as hospitals often have to either use facilities' staff or pay a third party to help manage the system. Paying for labour and/or management services can raise operational costs significantly.

Drums and vessels with hydraulics and moving parts like augers and chains will spend more time and money on maintenance. Similarly, on-site AD systems, like the prefabricated ones discussed earlier, require maintenance, spare parts, etc. Daily maintenance — washing down floors, scraping up loose remnants of food waste, leveling out ruts in the tipping and composting areas, cleaning tools and containers — is critical to good housekeeping and odour and vector management.

Ultimately, what really makes or breaks any composting and AD project, whether on-site or full-scale, are trained operators who understand all facets of what it takes to recycle organics successfully. This is an A to Z necessity from feedstock receiving and contamination vigilance, and proper recipes and mixes, to process optimization to manage temperatures, odors and mixing/aerating, to ending with high quality compost or digestate. Create and follow best management practices (BMPs); use those BMPs when training volunteers and paid staff.

Speaking of contamination vigilance, one advantage of smaller scale on-site projects is a better ability to control incoming contamination. In many cases, the on-site projects also have a collection service or drop-off program, and work closely with the businesses and households that are sorting the food waste. But that is in no way sure-fire, so continual training and communications, instituting fees for chronic contamination, and examining incoming loads are all critical. This is especially true when receiving front-of-house postconsumer organics, as well as any program that accepts certified compostable paper and bioplastic foodservice ware.

V.5 Markets and End Uses

Examples of end markets for composted and digested organics recycled on-site are in the case studies. This section briefly discusses end market fundamentals and considerations.

While some on-site operations are primarily handling organics on-site to save money on trash hauling, the vast majority want both the cost savings and the finished product to use for landscaping, in on-site gardens and farms, and to give back to customers who sent them the food waste to begin with.

Critical fundamentals include having a stable and mature product that is free of pathogens, weed seeds, and contamination. The degree of maturity can vary depending on the application, e.g. topdressing landscapes and lawns versus growing vegetables (the latter requires a mature product). Pathogens and weed seeds are taken care of via higher pile temperature, and contamination must be removed.

For many end uses, the compost should be screened, with overs like wood chips recycled back into the beginning of the process. Many projects are very innovative when it comes to screening, e.g, turning an old washer drum with a bicycle. Lower costs screens for larger on-site operations are available.

The majority of on-site composting projects either utilize the compost on-site or give it back to customers as part of a collection service. Some package and sell it at farmers markets and community events. On-site composting operations at zoos brand their compost and sell it at their stores.

VII. Best Management Practices, Training

All organics recycling operations, no matter the scale, need to institute Best Management Practices (BMPs) right out of the gate. Organics recycling is a biological process, and can go askew if best practices are not followed. Step One in adopting and utilizing BMPs is to get training and education about all facets of managing a site — from materials receiving to end product management.

For projects accepting food waste, it is critical to understand that unlike leaves, brush, and tree trimmings, food waste is highly putrescible — in short, it does not degrade gracefully. When processing food waste, BioCycle and The Compost Council of Canada emphasize these 4 ground rules. They apply primarily to composting, but can be adapted for anaerobic digestion projects:

1. **AVAILABILITY OF CARBON**
   Always have carbonaceous material (e.g., wood chips, ground brush, sawdust, mulch, screened overs) available to mix with incoming food waste.
2. **PROCESS FOOD WASTE IMMEDIATELY**
   Never let a fresh load of food waste sit on the ground once unloaded. Immediately mix in carbon amendment (roughly 3 parts carbon to 1-part food waste). If you cannot mix the food waste with the amendment within the first hour after receipt, cover the food waste with a 3- to 4-inch layer of compost or a 6- to 8-inch layer of wood chips to deter birds and other vectors. If going into a digester, process the materials as soon as possible and add to the digester or hold them in a storage tank.
3. **INCORPORATE MIXED FEEDSTOCKS AS SOON AS POSSIBLE**
   For windrow-based operations, once all incoming loads are processed and in the windrow, consider putting a layer of wood chips or finished compost on the surface to suppress odours. Anaerobic digesters that receive the same general types of food waste on a regular basis can feed the material into the digester per the operating guidance. However if the feedstocks vary, e.g., highly acidic or high in fats and oils, it may be necessary to premix that material with digestate to buffer the load to the system.
4. **HOUSEKEEPING IS A DAILY AND ONGOING PRIORITY**
   At the end of the day — or even twice a day — scrape down the surface of the food waste receiving area to eliminate any fresh food waste remnants. Ensure any run-off is cleaned up, avoiding any pooling of water or leachate.

Most of the BMPs for on-site organics recycling are focused on composting, as there are so few actual on-site digesters in the U.S. and Canada. The following BMPs have been been culled from the Institute for Local Self-Reliance's (ILSR) *Community Composting Done Right: A Guide to Best Management Practices,* which includes a summary guidance document along with illustrations.

Checking Out The Site:

•Choose your location and develop a site plan.
•Get to know your potential neighbours.
•Observe the site. Avoid standing water on the site, even after a rain event.
•Map out the entire composting process and where everything will be stored. Focus on the flow of the site, avoid bottlenecks and clutter. People "smell with their eyes." Rats like places to hide.
•Secure a water source for adding to composting piles (as needed) and cleaning up.
•To avoid rodent issues, maintain a buffer of at least 2 feet between the composting system and exterior walls, fences, shrubs, or any other potential hiding spaces for rodents and other animals. A minimum 3-foot buffer is needed around sidewalks, building foundations, concrete slabs, and footings to prevent burrowing. Keep this buffer area clear at all times.

Operating BMPs:

•Create a recipe. Two to three parts browns (leaves, wood chips, sawdust) to one part food scraps and other "greens."
•Secure a reliable source of browns.
•Start small and simple. Get a handle on the process, then slowly expand.
•Record pile temperatures and weights of food scraps added; monitor for odours and vector disturbances.
•Keep material moist (in range of 50 to 60% moisture content).
•Aerate piles via turning and/or forced aeration.
•Cap active piles with a semi-permeable cover, or a biocover: at least 2 inches of finished (screened) compost, 6 inches of unscreened compost, or 12-inches of overs to prevent pest problems and avoid any nuisance smells.
•To achieve PFRP (process to further reduce pathogens) when composting food waste and/or manures, build a pile of sufficient size (at least 27 cu. ft., notes ILSR) to achieve necessary temperatures (55°C).
•Use compost thermometers, the hand-squeeze test, and your nose to gauge and record temperatures, moisture content, and odor levels throughout the composting process. Allow these measurements to guide your management.
•Record these measurements to help re-create successful compost mixes, avoid problematic ones, and have the data in case regulators or members of the public inquire.

Compost Curing, Testing:

•Cure the compost, or allow the composting process to gradually come to a complete finish, in order to produce a chemically stable finished product.
•Allow a minimum of 4 weeks for curing; 2 to 4 months are preferable.
•Protect or monitor curing and finished compost piles from weather and pests.
•Regularly test compost quality, especially if the compost is being produced for sale, to be used in food production, or if the site accepts materials that have the potential for pathogens (such as manures, meat, and large amounts of food scraps from off-site).
•Screen out overs such as tough woody materials and contaminants.

VIII. Economic Considerations, Community And Environmental Benefits

A general rule of thumb with on-site organics recycling is that as the automation and process control capabilities of the systems increase, so do the capital costs. In some instances, especially where paid labour is used, the tradeoff may be that fewer employees are necessary as the degree of automation increases. For example, with an in-vessel drum or aerated composting unit, less labour is involved in the active composting phase, and less may be necessary during the curing phase.

Another cost factor is if the composting site needs to purchase carbon amendments to mix with food waste. This may include sawdust and dry wood chips (vs. ground yard trimmings). In many cases, carbon amendments are available from the site's landscape maintenance (trimmings, leaves), a parks department or tree chipping operation, or neighbourhood leaves.

Calculating Revenues And Costs

BioCycle Senior Editor Craig Coker has written an article series on Compost Business Management. While written for larger scale systems, many of the theories and cost-benefit analyses can be applied. Examples include:

Revenue Forecasts: https://www.biocycle.net/composting-business-management-revenue-forecasts-composters/
•Forecasts should be made on a 3- to 5-year basis.
•The composting industry is unique in the business landscape as facilities can earn revenues from both incoming feedstock processing fees and outgoing product sales. Plus there are ways to bring in revenues from collecting feedstocks and delivering products along with vertical integration into related areas like food waste collection.
•Processing (tip) fee should be calculated on the basis of what it costs you to make a cubic yard of compost.
•Compost and soils sales estimates are more difficult to project, as factors such as your distribution model (retail, wholesale or both), presence (or absence) of competition, "eco-friendliness" of the demographic in your 50- to 75-mile market zone, and diversity of markets can all affect pricing and sales.

Capital Costs: https://www.biocycle.net/composting-business-management-capital-cost-composting-facility-construction/
•The main categories of capital costs to be estimated include site development, processing equipment, and process monitoring equipment.
•In early facility planning, site development estimates will have an accuracy of +50%/-30%; following detailed design, accuracy will improve to +25%/-15%; after bid receipts, accuracy improves to +10%/-5%. To accommodate that varying accuracy, you should budget for contingency funds to cover any unforeseen items.

•Site development costs are dependent on the chosen composting approach, as some methods take up more space than others.

Operating Costs: https://www.biocycle.net/composting-business-management-composting-facility-operating-cost-estimates/
•Operating costs are all the costs you will incur to make a cubic yard of finished compost/soils product. For this analysis, operating costs are defined as non-capital related costs, e.g. fuel, labour, electricity, and maintenance.
•As composting is essentially a materials handling exercise, it takes a certain amount of time at a certain cost, to perform each task in the compost manufacturing process. The time to perform each task is estimated (or measured in existing facilities), and the cost of each task is defined by the loaded labor rate and the machine rate.
•Loaded labour rates include the pay actually paid to the worker, plus amounts needed for employer Federal taxes and Provincial/Territorial requirements, plus any fringe benefits the workers are paid.
•The machine rate is a compilation of fixed costs, operating costs and labour costs that are expressed over a particular unit factor, usually dollars per hour. The machine rate multiplied by the actual or estimated hours of use in a budget year gives the annual projected cost for that piece of equipment.

Community Benefits

Increasingly, on-site composting with food production is viewed as a significant community benefit, and one with environmental attributes. These operations are truly closed loop — incoming organics are processed, the compost is used in the gardens or on the farm (and sometimes also sold), the produce goes to the community (and sometimes also sold) and the garden waste and the food scraps are fed back into the composting process.

Equally important is that this model provides job training skills, addresses food insecurity and fresh food access, and spawns social enterprises. It often uses vacant lots or larger properties to create these operations, getting rid of neighborhood eyesores. A number of these on-site organics recycling projects incorporate food scraps collection from commercial establishments (restaurants, markets, coffee shops, juice bars) and households. Revenue from collection is often used to employ youth to do the collection and assist with composting and compost screening.

In other cases, on-site composting takes place at food banks, where food waste is processed on-site and the compost is used in the food bank's gardens. Some food banks have commercial kitchens where perishable food can be prepared and packaged into ready-to-eat meals. Cooking classes are offered using the produce from the gardens.

While not happening yet in practice with on-site anaerobic digestion (to our knowledge), the outputs of on-site AD — biogas and digestate — can be utilized for on-site food production. The heat recovered from utilizing biogas to create electricity is a source of heat for greenhouse production; the digestate can be utilized as a fertilizer source. While not an on-site digester, a dairy farm digester in Vermont is capturing the heat from its combined heat and power engine, and heating water, which is piped into the ground underneath a greenhouse. Raised beds are built over the pipes to enable year-round production.

Environmental Benefits

On-site organics recycling provides substantial environmental benefits. First is the reduction is having the organics hauled off-site, reducing greenhouse gas emissions. The finished compost reduces use of chemical (fossil fuel) inputs and improves the soils — which in turn helps to infiltrate storm water and reduce erosion. Finally, adding compost to soils improves soil health and sequesters carbon.

On-site anaerobic digestion also reduces hauling waste off-site. Substituting biogas generated power or renewable natural gas for fossil fuel and natural gas can greatly reduce carbon emissions. Utilizing digestate as liquid fertilizer offsets use of chemical inputs.