CAPTURING EMISSIONS AND TURNING WASTE INTO ENERGY WITH ANAEROBIC DIGESTION

Organic waste to energy (OWE) is exactly what it sounds like: transforming organic waste—from banana peels to sewage—into energy. Canadian municipalities dispose of millions of tonnes of solid waste per year. Nearly a quarter (23 percent) of this is food waste. When organic waste rots in a landfill it releases methane, a greenhouse gas that heats up the planet 85 times more than carbon dioxide can over a 20-year timeframe.

OWE solutions offer governments a clear pathway to reduce greenhouse gas emissions, divert waste from landfills, return nourishing organic material to the soil, and create renewable energy sources.

Anaerobic digestion, the subject of this fact sheet, is an OWE solution that is currently underutilized in Canada.

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What is anaerobic digestion?

Anaerobic digestion (AD) is a natural process where micro-organisms break down organic material in environments lacking oxygen, such as deep within landfills. This process produces two valuable by-products:

1. **Digestate:** an earthy liquid carrying leftover nutrients from organic waste
2. **Biogas:** a mixture of mostly methane (CH_4) and carbon dioxide (CO_2)

Preventing food waste in the first place is the best way to reduce the environmental impact of organic waste. For food waste that can't be fed to animals or otherwise avoided, controlled anaerobic digestion offers a much better alternative. Instead of letting AD happen in landfills, we can funnel organic waste into engineered AD systems, converting the resulting digestate into fertilizer and biogas into renewable energy.

How can OWE solutions like anaerobic digestion help governments achieve their sustainability targets?

Organic waste to energy solutions (in this case anaerobic digestion) can help governments meet sustainability targets in the following important ways.

Capturing GHG emissions

When organic waste goes through an AD facility instead of the landfill, more of the methane emissions from the waste can be captured for energy use. Only about a third of methane emissions from a landfill can be similarly captured and used.

Increasing energy security

Instead of emitting methane into the atmosphere, methane from AD facilities and landfills can be used to generate thermal energy, electricity and transportation fuel and to displace natural gas.

Diverting waste from landfill

Millions of tonnes of food waste go into Canadian landfills every year. Each tonne of food waste diverted into AD facilities can extend the lifespan of existing landfill sites. Ultimately, this diversion means less environmental liability and fewer legacy costs for municipalities.

Supporting sustainable agriculture

Nutrients from organic waste can be recovered and returned to the soil. The digestate produced through AD can reduce our reliance on mined fertilizers or fertilizers made from fossil fuels, supporting sustainable agriculture and food security.

What types of organic waste are suitable for anaerobic digestion?

Organic wastes that are candidates for AD are called **feedstocks**. Some feedstocks are easy to process, while others are more complex. Two key factors that influence the complexity of organic waste processing are **biochemistry** and **contamination**.

Simple feedstocks

AD was initially designed to treat simple feedstocks such as:

- **Raw sewage sludge:** municipal wastewater sludge can be treated in anaerobic digesters, sometimes called *biosolids* digesters
- **Agricultural waste:** crop residues, unsaleable products, and manure

Moderately complex feedstocks

These feedstocks have a more complicated biochemistry, but also a much higher fuel value:

- **Industrial food waste:** organic waste produced by the food and beverage industry (e.g., products that failed quality assurance, by-products that are inedible or can't be upcycled, wastewater, etc.)
- **Retail food waste:** unpackaged food waste from the retail sector (e.g., unsold produce from grocery stores, food scraps and grease trap by-products from restaurants, etc.)

Complex feedstocks

More complex feedstocks are often incinerated or sent to landfill. Capturing these feedstocks with AD instead will offer the greatest environmental benefits:

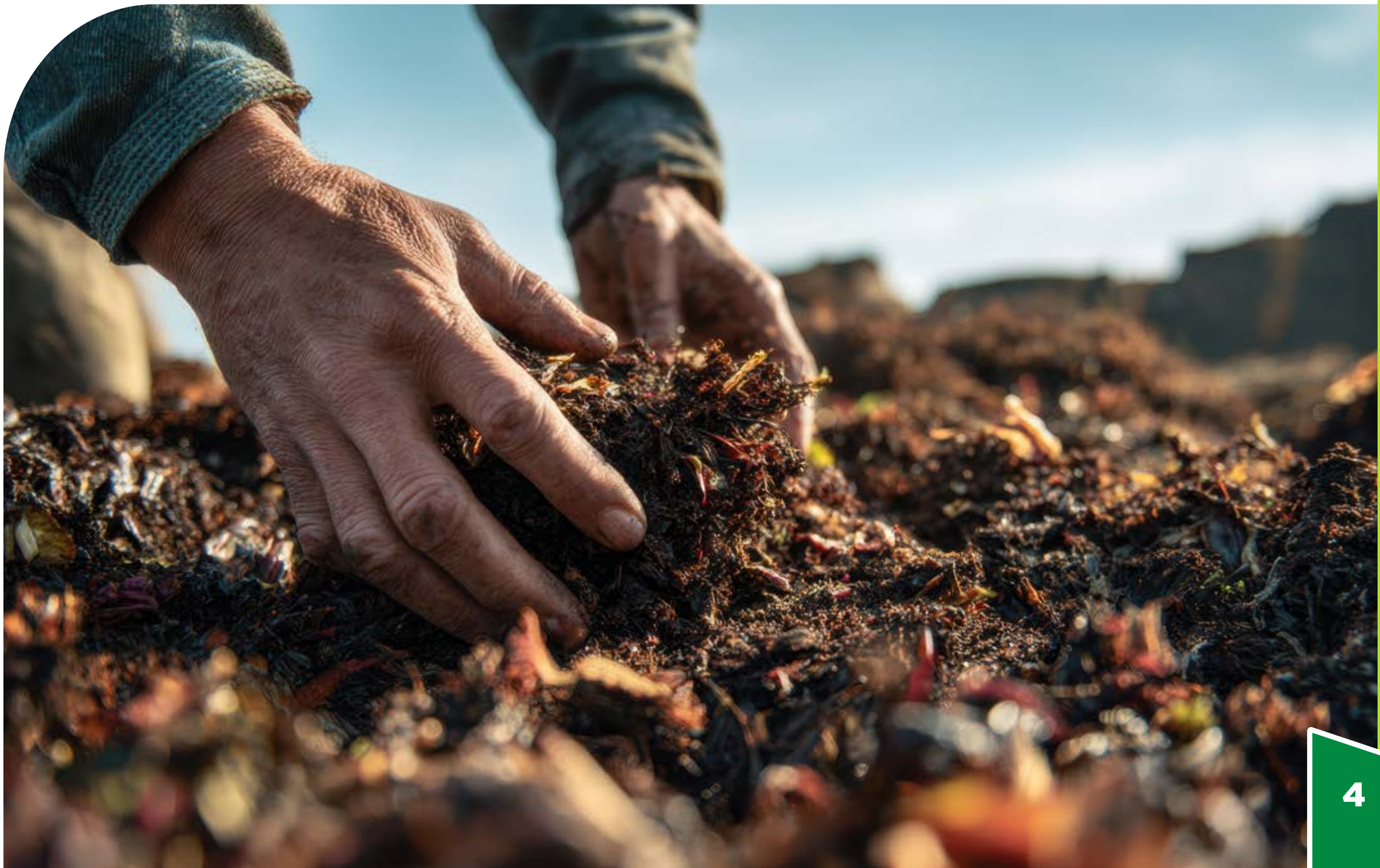
- **Source-separated organics:** residential and commercial food waste (e.g., kitchen scraps from "green bins" and food court waste)
- **Other industrial waste:** waste produced outside of the food and beverage industry (e.g., biodegradable wastes from chemical and pharmaceutical manufacturing)
- **Organic fraction of municipal solid waste:** mixed municipal solid waste (also called "black bag" waste) that has been sorted to recover organics from the mixture

What are the most sustainable options for digestate management?

The nutrients in the digestate produced by AD systems can be returned to the soil to help grow more food. Crops absorb the nutrients from digestate more easily (compared to manure) because these nutrients are more bioavailable.

Recycling nutrients back into soil always delivers the greatest benefit. The following are pathways for managing digestate, listed from most to least beneficial:

1. **Farmland:** Applied directly as fertilizer
2. **Compost:** Especially for biosolids-based digestate, to make it safe for land application
3. **Community use:** Offered similar to compost (this is less common)
4. **Sewer discharge:** After on-site wastewater treatment
5. **Landfill alternate daily cover:** Used to reduce odours, pests, and fire risks at landfills
6. **Landfill disposal**



What are the renewable energy pathways for biogas?

Biogas is a blend of mostly methane and carbon dioxide. The methane concentration can be between 50 to 80 percent, depending on the feedstock. After biogas is purified it can be used for many different applications.

The biogas utilization strategies in the following table all transform the waste we already have into energy. These products can be carbon neutral, and they are the only fuels with the potential to be carbon negative. They are listed here from least to greatest processing requirements.

Product	Processing	Applications
Raw biogas	• Minimal treatment • Contains hydrogen sulfide (H_2S), which is corrosive and shortens equipment's lifespan	Fuel for heat and electricity generation: • Combined heat and power • Heat recovery for digester heating • Boilers
Biomethane	• Removal of H_2S and CO_2 protects equipment and improves performance	• Same applications as above
Renewable natural gas (RNG)	• An "RNG upgrader" purifies biomethane (≥95% CH_4) so it can be injected into the natural gas distribution grid • Some jurisdictions treat biomethane and RNG as synonyms	Same applications as above, plus fuel for pipeline-grade heat generation: • Industrial kilns/furnaces • Natural gas pipelines • Industrial process heating
Renewable compressed natural gas (RCNG)	RNG that is compressed and stored in high-pressure cylinders	Same applications as above, plus fuel for regional trucking or buses
Renewable liquefied natural gas (RLNG)	RNG that is cooled and compressed to a liquid state for easier transport and storage	Fuel for long-haul trucking and marine shipping

Are there any risks associated with anaerobic digestion projects?

When designed and managed properly, anaerobic digestion facilities pose minimal risk to the environment and the community. Carefully considering and managing the following factors can help to avoid risks.

Feedstock–technology fit

The best AD facilities are designed for the feedstocks they process. The design matches the feedstock's biochemistry, amount of contamination, and the variations in quantity and quality over the year. Risks exist when systems don't match real feedstocks conditions. This mismatch can cause operating costs to rise sharply and some systems to fail altogether.

For example, systems built for agricultural waste often cannot handle streams with packaging like source-separated organics, which can clog equipment and fill up the digester. As feedstock complexity increases, the need for more robust pre-processing systems increases. Feedstock characterization and laboratory testing are good ways to inform pre-processing system needs and operational cost projections, avoiding risks.

Unexpected biogas characteristics

Biogas yield and composition depend on the feedstock, and feedstock laboratory testing is the only way to know for certain. For simple feedstocks, simply knowing literature values may be enough for design and financial modelling. But complex feedstocks are best tested as they can contain unexpected contaminants like volatile organic compounds (VOCs) and siloxanes that can damage equipment or block grid injection of renewable natural gas if left untreated. Skipping testing also risks overestimating gas volumes, leading to flawed energy and financial projections.

These risks can be managed well with the right information, equipment, and processes in place.

Not having a digestate management pathway

Without a reliable outlet for digestate, AD projects may not be feasible. As a ballpark estimate, digestate typically equates to 95 percent of the wet feedstock mass. In regions with limited farmland or many animal feeding operations, an AD facility's capacity may be restricted by the amount of water and nutrients that local farm fields can absorb.

Community, policy, and stakeholders

Technically, AD is proven and feasible with good engineering. Difficulties are more likely to arise in managing people and aligning interests. A project's success depends on sharing risks fairly and keeping key stakeholders (local community, regulators, owners, private partners, and energy utilities) engaged while considering their interests.

Conclusion

Cutting methane emissions is one of the fastest, most effective strategies for addressing climate change. Anaerobic digestion not only captures methane, it also diverts waste from landfills, recycles nutrients back into soils, and takes advantage of renewable energy sources.

Governments have a unique opportunity to reduce climate impact by adopting organic waste-to-energy solutions like anaerobic digestion. OWE solutions are proven. They range from simple to highly complex, but all contribute to caring for the environment and the people within it.