# Making Organics Diversion & Recycling Policy in California Work:

# Experience from a Leading Investor/Operator

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## Executive Summary

*Organic Waste Diversion and Recycling Infrastructure is Essential to Rapidly Reducing California's Methane Emissions*

In the last five years alone, drought, flooding, severe forest fires, and record temperatures have all catastrophically impacted California's people, landscapes, and economy. While the Golden State has responded to this climate crisis by developing and implementing unprecedented greenhouse gas (GHG) reduction policies, efforts to address one of the major sources of methane – the waste sector – have failed to match the statutory ambition or success achieved in other sectors. This is despite the fact that methane, which is often called a "climate super pollutant," has an environmental impact that is 84-87 times greater than carbon dioxide over a 20-year period.[1] Therefore, according to CalRecycle, methane mitigation is one of the fastest, most efficient ways to address the climate crisis.[2] Methane generated from just the organic waste decomposing in landfills represents 20% of California's methane-related climate impact.[3] **Simply put, California cannot meet its climate goals without changing its approach to organic waste management.**

The idea of mitigating the waste sector's methane emissions is not new. For over a decade, California's leaders have recognized the need to tackle short-lived climate pollutants (SLCPs), with a particular emphasis on methane from organic waste sources. Diverting organics from landfills was included as a strategy in the state's groundbreaking 2008 Greenhouse Gas Scoping Plan; it was the subject of a series of legislative actions in 2014-2018; it was highlighted in a 2017 targeted SLCP Reduction Strategy; and has been noted as part of extensive regulatory work at multiple state agencies since then.

Despite these efforts, the policies currently in place have not led to sufficient methane reductions. While progress has been made in reducing methane emissions from some organic wastes, like cow manure, there has been very little investment in the infrastructure needed to address the food waste portion of the organic waste stream. California's organic waste diversion goals will only be met through substantial private sector investment[4] in organics recycling

[1] IEA (2021), Methane Tracker 2021, IEA, Paris https://www.iea.org/reports/methane-tracker-2021, License: CC BY 4.0

[2] "Reducing Short-Lived Climate Super Pollutants like [methane generated by] organic waste will have the fastest impact on the climate crisis." CalRecycle website: https://calrecycle.ca.gov/organics/slcp/

[3] CalRecycle Website. California's Short-Lived Climate Pollutant Reduction Strategy. https://calrecycle.ca.gov/organics/slcp/.

[4] By "private sector" we are referring to climate investors and renewable energy and waste recycling solutions providers. Electric vehicle deployment took a combination of public sector (federal and state) investments and private sector (new all EV-companies initially) investment and innovation to get the EV industry off the ground and prove that it is viable. Currently, a combination of federal and state EV incentives are helping accelerate the scale-up of the EV industry, while the majority of the capital is coming from the private sector.

infrastructure, particularly anaerobic digestion (AD) facilities that have specialized equipment to process the highly varied, complex food waste components of the organic waste stream.

Authored by subject matter experts at Generate Upcycle—one of the largest owners and operators of food waste recycling facilities in North America (both composting and AD) — this report provides a comprehensive review of food waste diversion challenges and policy solutions designed to catalyze California's efforts to reduce methane, shift to a circular economy, and tackle the climate crisis.

### *What is Anaerobic Digestion and What Role Should It Play?*

Anaerobic digestion (AD) is the process by which organic materials, such as food waste or manure, are broken down inside an enclosed, oxygen-free vessel. Microbes break down the material and, through a biological process, create biogas and a nutrient-rich, pathogen-free digestate which can be used as fertilizer. Depending on the system design, biogas can be: combusted to run a generator producing electricity and heat (a co-generation system); burned as a fuel in a boiler or furnace; or upgraded and used as a natural gas replacement.

A critical technology for the upcycling of food waste, AD has several key advantages over composting for food waste recycling. Food waste is heavy and therefore both expensive and GHG intensive to transport long distances since it is made up primarily of water (anywhere from ~45-95%). It also tends to be concentrated near food manufacturing facilities and in highly populated areas where access to appropriate real estate can be limited and expensive. This makes land use efficiency critical. First, anaerobic digestion requires far less real estate than composting because the process breaks down organic matter faster. Second, and possibly even more important, is that anaerobic digestion also produces valuable energy in addition to low carbon fertilizers.

### *What is the Status of Anaerobic Digestion Infrastructure Development in California?*

California is behind on its organic waste diversion goals, particularly with respect to infrastructure that can upcycle food waste. State law 1383 mandates the reduction of organic material deposited into landfills by 50% by 2020, and by 75% by 2025. Not only did the state fail to achieve its 2020 target, but it also sent 1 million tons of organic waste *above* the 2014 baseline to landfills.

The private sector has not built out organic waste processing infrastructure in California in any meaningful way – nor do we believe this is likely to happen over the next 5-10 years – unless key policy changes are implemented. Compare this to other similar/related climate solutions, such as dairy manure AD, which has seen rapid infrastructure buildout leading to significant methane abatement.

In an effort to help unlock the needed investment in organic waste recycling infrastructure, this report explains the operational complexities and the business model intricacies involved in food waste AD. It explores societal, regulatory, and economic barriers unique to California, and it draws on lessons learned from successful global case studies.

### *What Has Worked in Other Geographies?*

Europe, Scandinavia, the U.K., and Canada have demonstrated how, with robust and stable public policy frameworks, rapid buildout of AD is possible. Germany alone has well over 10,000 AD facilities. In Denmark, over 39% of the gas in the national grid is renewable natural gas (RNG) derived from AD. The clear driver of success in these countries has been long-term high-priced renewable energy offtake contracts.

Comparatively, the U.S. lacks the necessary multi-decade public policy framework for these large-scale, complex infrastructure investments. As such, very few food waste digesters are being successfully operated in the U.S. (including in California). Much of this can be attributed to the piecemeal, start-stop policy support focused on grant funding for

ADs, most of which were poorly developed projects that did not have proper business models able to cover operating expenses. Moreover, it is common in the U.S. for lower cost disposal methods, like direct land application of food waste, to be un- or under-regulated. Proper valuation of the renewable energy generated by ADs has often also been lacking. Therefore, rarely, if ever, have these U.S. food waste AD projects been able to succeed based on long-term sustainable business models.

In every jurisdiction where AD has been successfully deployed at scale, supportive policy and regulatory frameworks have been integral to catalyze AD infrastructure development. While the details may vary, all the successful frameworks include establishing long-term, fixed-price incentive structures, enforcing waste separation requirements to create high-quality feedstock, mandating recycling, and streamlining permitting processes to reduce administrative delays and development risk.

Ultimately, the most common thread across successful jurisdictions is a long-term commitment to addressing the challenge of how to sustainably process organic waste. It is clear that the State has the political will to address the challenge and the foundations of a stable policy framework, such as SB1440, already exist in California. However, further work is essential to improve these policies so that they attract and accelerate the necessary investment in food waste AD and related infrastructure to meet the state’s climate and waste reduction goals.

### *Summary of Key Findings*

Anaerobic digestion is an optimal solution for landfill diversion and upcycling of food waste, and it needs to be deployed rapidly to get California on track to meet the requirements of its waste reduction and climate laws. To enable the large-scale buildout of this solution, a suite of waste diversion and renewable energy valuation policies and programs need to be implemented simultaneously.

While there is no single perfect example for California and other U.S. States to copy, the experiences in other countries provide clear guidance on the essential elements required to spur the buildout of the entire infrastructure “ecosystem” needed to collect, process, and recycle food waste specifically. For instance, the long-term clean energy price support – via Feed In Tariff (FIT) – was essential for the successful buildout of food waste-style digesters in the U.K. and Germany.

In each case, the presence of a long-term offtake contract, at appropriate prices, spurred significant investment in high quality food waste AD infrastructure by development companies with significant financial backing. We also recognize that, from the policymaker perspective, long-term contracts can be costly; therefore, if our goal is to balance the costs and benefits among various stakeholders, a coordinated suite of policies and programs would be most advantageous to Californians.

### *Challenges to Building Food Waste ADs*

Ultimately, the stop-start pattern of providing grants and other incentives in the U.S. has led to an overall low quality of AD infrastructure being built. Generate’s experience with the four food waste digesters it owns in the U.S. illustrates this point. Each of them needed significant retrofitting, expansion, or complete rebuilding to be functional. Why? Because there has never been sustained policy support for the buildout of a robust AD sector. Many of these digesters were built by amateurs who were able to secure grant funding but did not have the knowledge or financial backing to otherwise design, build or operate high quality infrastructure. Whereas consistent policy support has allowed the solar industry to experience substantial investor interest and the establishment of repeatable, bankable, and scalable industry practices, the food waste management sector has seen none of that, resulting in low quality and un-bankable projects.

The key challenges to building food waste AD infrastructure, and proposed recommendations are shown below:

| Challenges | Proposals |
| --- | --- |
| **Siting**<br>Availability of large enough sites in properly zoned (industrial) areas with access to needed utilities (e.g., water, pipelines, etc.) | • **Facilitate the use of publicly owned land to expedite infrastructure buildout**<br>• **Incentivize private landowners to sell property for food waste AD facilities** |
| **Permits**<br>Ability to obtain and layer relevant zoning/conditional use permits (CUPs) and California Environmental Quality Act (CEQA) requirements with solid waste, air, water quality board, and other permits | • **Establish a department within CalRecycle to oversee and expedite food waste recycling project permitting**<br>• **Create a development cost risk reduction program** |
| **Feedstock**<br>Availability and pricing and term longevity | • **Strengthen SB 1383 to create stronger incentives for food waste diversion**<br>• **Incentivize long-term commitments/pass throughs from waste generators to haulers to food waste AD facilities** |
| **Digestate Management**<br>Availability to land apply or blend with compost operation in close proximity to facility | • **Direct the California Department of Food and Agriculture (CDFA) to make a state designation for digestate to be treated as an organic fertilizer** |
| **Workforce**<br>Availability of skilled workforce | • **Provide tax incentives for on-the-job retraining of fossil fuel industry workers in food waste AD jobs**<br>• **Provide scholarships for AD training schools** |
| **Profitability**<br>Ability to provide an acceptable return on investment to incentivize taking on the risk of funding new projects | • **Create access to reliable, high-value and long-term power purchase agreements (PPA) or RNG offtake contracts in the range of $200-300/MWH or $30-40/MMBTU with inflators** |



Section 5, Challenges to Building Food Waste AD describes the challenges in detail and our full recommendations are listed in Section 8, Conclusion and Proposals from the Investor/Operator Perspective.

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## 1. Who We Are

Generate Upcycle is an independent platform of Generate Capital, PBC (a leading sustainable infrastructure investor) that develops, owns, and operates waste-to-value infrastructure across three core segments: food waste, compost, and wastewater. Focused on reducing the costs and environmental impact of organic waste, Generate Upcycle provides solutions to municipal, industrial, and agricultural customers in Canada, the United States, and the U.K.. Generate Upcycle is one of the largest owners and operators of food waste recycling facilities in North America.

The team's experience as finance providers, owners, and operators of organic waste and wastewater recycling infrastructure offers a 360-degree view of what it takes to make these assets economically viable, as well as technologically and logistically feasible. From permits to specialized equipment to the necessary labor pool, we know what it takes to get these projects up and running successfully.

Figure 1.1 - Map of Generate Upcycle's North American Facilities.

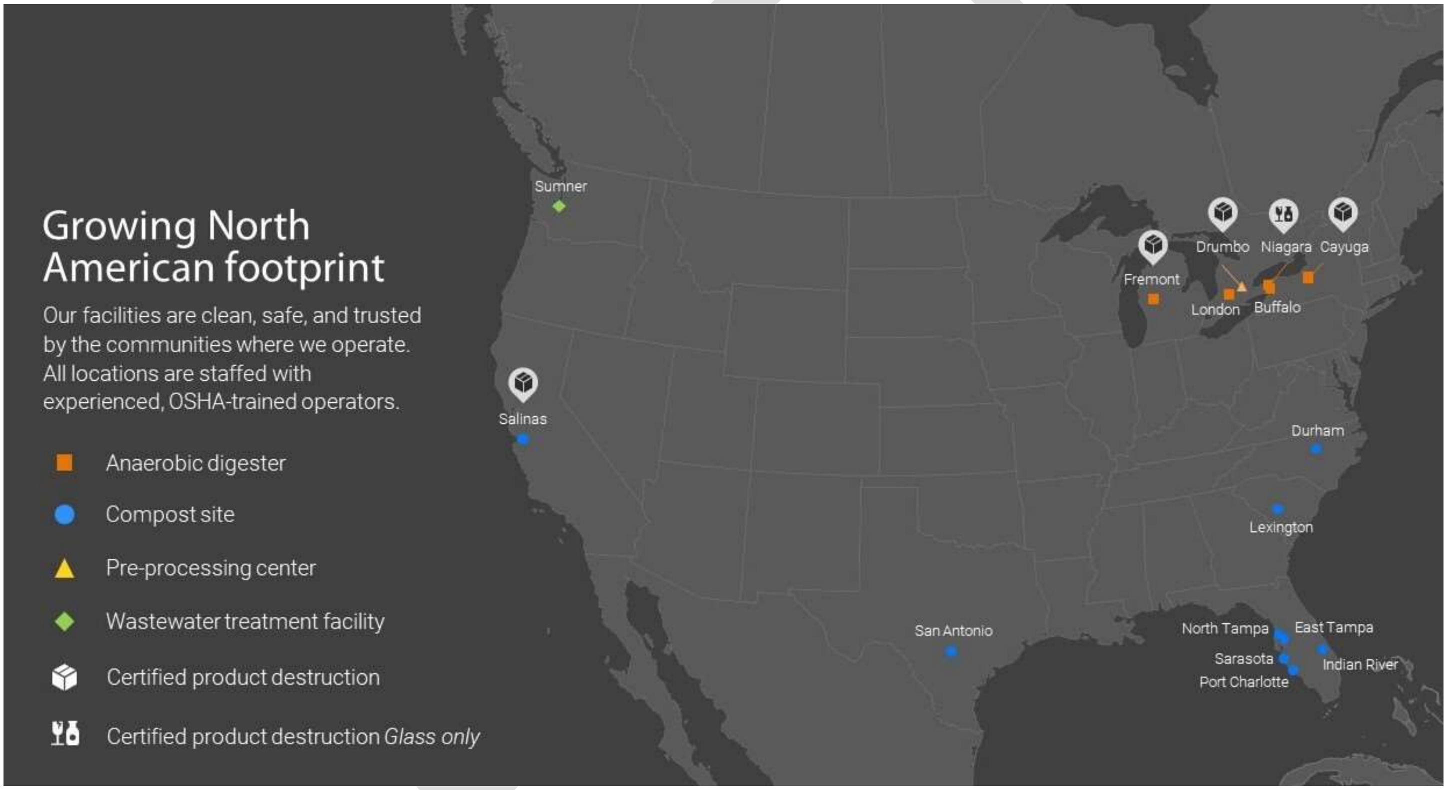
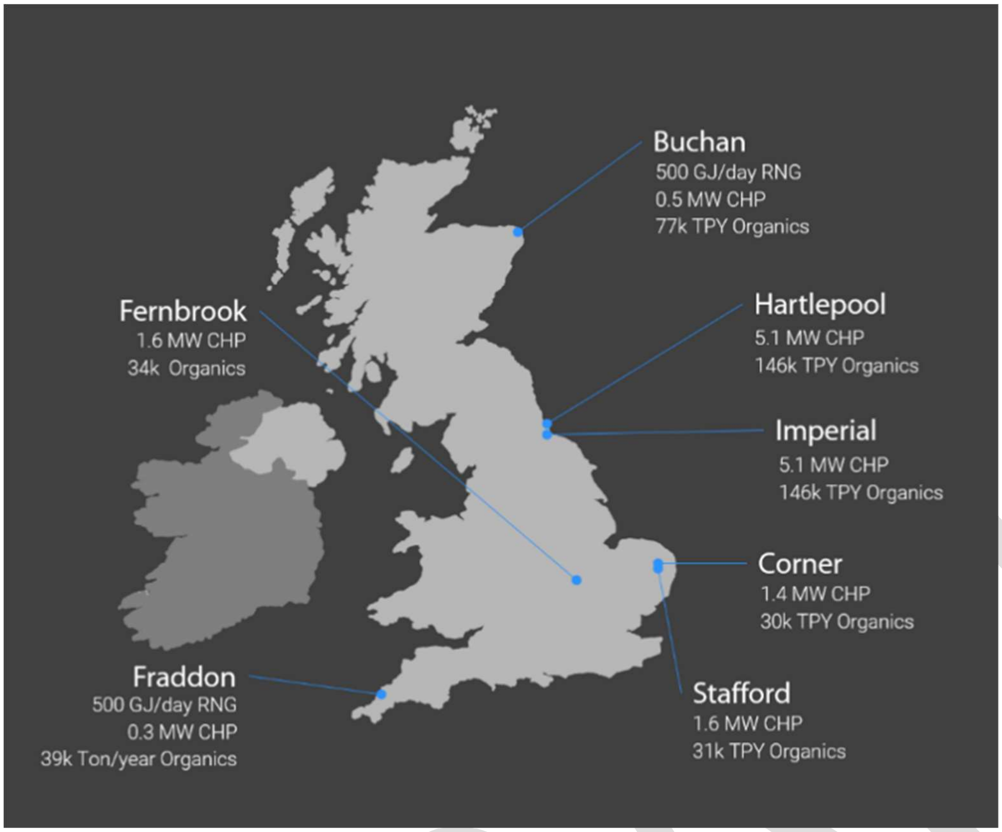


Figure 1.2 - Map of Generate Upcycle's U.K. Facilities.




## 2. Introduction to Anaerobic Digestion

Anaerobic digestion is a biological process used to recycle or "upcycle" organic waste and convert it into energy and fertilizer. Organic materials, such as food waste or manure, are broken down by microbes inside an enclosed, oxygen-free vessel. This produces biogas and a nutrient-rich, pathogen-free digestate which can be used as fertilizer. Biogas is composed primarily of methane ($CH_4$, 55-65%) and carbon dioxide ($CO_2$, 35%), with a small amount of water vapor and other gases. Depending on the system design, biogas can be:

- Combusted to run a generator producing electricity and heat (a co-generation system),
- Burned as a fuel in a boiler or furnace, or
- Upgraded to nearly pure biomethane/RNG and used as a natural gas replacement.

Figure 2.1. Food Waste AD Simplified Process Flow Chart.

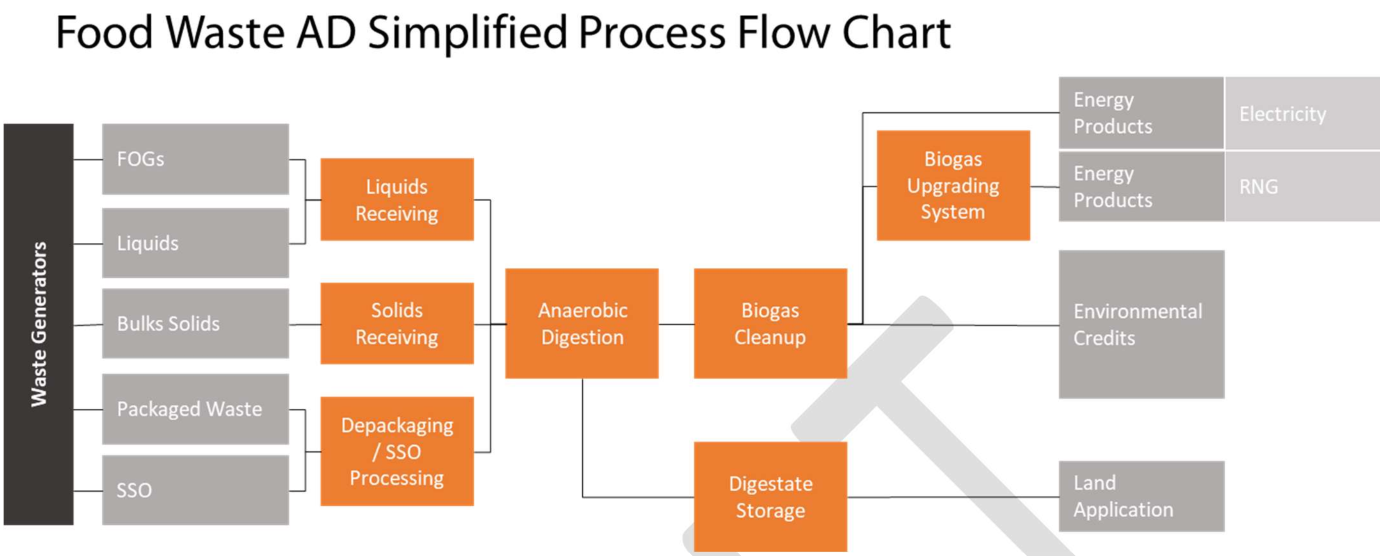



Figure 2.1 provides a basic process flow diagram. It shows that digesters are capable of recycling a variety of different food wastes that are sourced from different waste generators. As shown in the diagram, different types of waste require different processing equipment and infrastructure. This is discussed in detail in *Section 3: What is Food Waste?* Once processed into a liquid slurry, the food waste is pumped into the digester where it takes approximately 20 to 30 days to break down. Food waste digesters typically operate at about 98-100 degrees F (similar to the human body temperature).[5]

In addition to the two physical products (biogas and digestate), environmental attributes are also typically created from the sale of the energy products (either electricity or RNG). Requirements for grid injection of RNG are very stringent, typically involving 98%+ methane content and other specifications and thus requires the biogas to go through a biogas upgrading system (BUS). Biogas used for creating electricity via an engine goes through less intensive cleaning. Ideally, the digestate (i.e., the nutrients and water that are left after the digestion process) is delivered to farms where it can be used to grow more food – helping close the nutrient loop.

[5] There are some types of ADs that operate at higher temperatures.

Figure 2.2 – Generate Upcycle's London, Ontario Food Waste AD Facility.

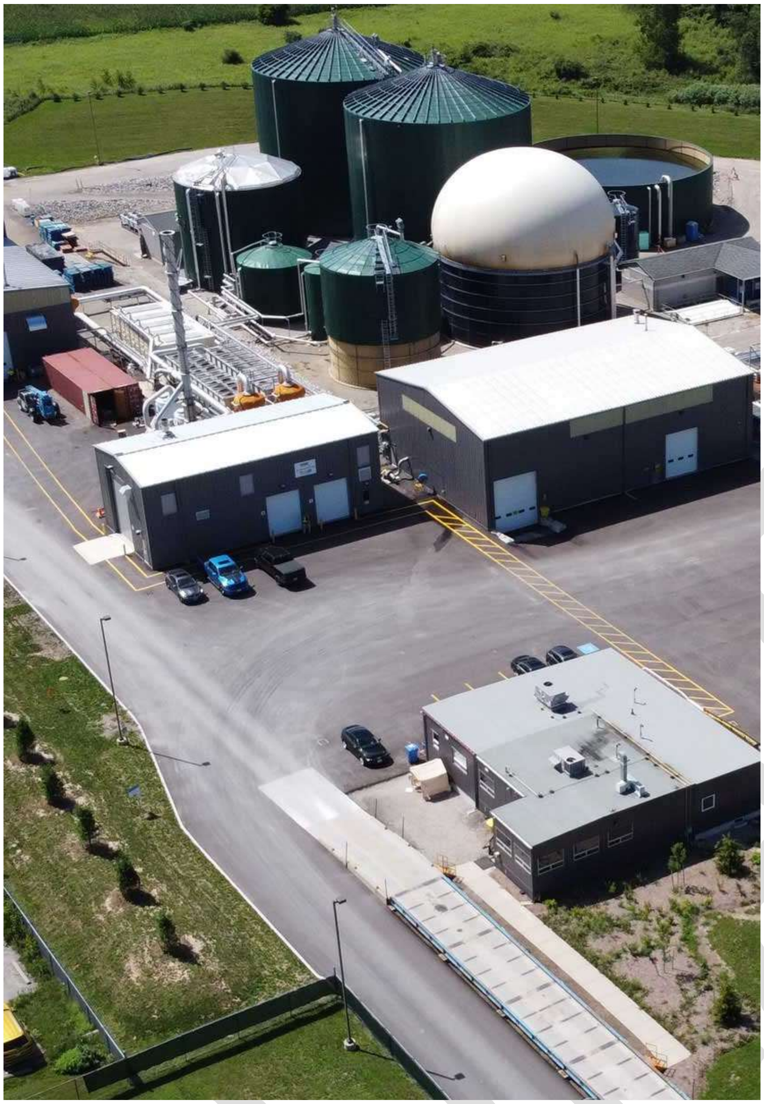


Figure 2.3 - Generate Upcycle's Buffalo, NY Food Waste AD Facility.

*<u>Anaerobic Digestion is an Optimal Solution for Landfill Diversion and Upcycling of Food Waste and Works Well in Conjunction with Composting</u>*

Approximately 23 million tons of organic waste are produced in California every year, including 5 to 6 million tons of food waste.[6] Currently, the vast majority of that waste ends up in landfills where it rots and breaks down into methane, a powerful greenhouse gas.[7] A full 18% of material going to landfill in CA is food scraps or food waste.[8] Methane

[6] https://civileats.com/2022/03/02/california-compost-law-food-waste-produce-farmers-brown-gold-soil-health-climate-agriculture/. Accessed 6/21/2023.

[7] Nationwide, food waste is the largest component of MSW going to landfills, representing about 24%. Source: US EPA. National Overview: Facts and Figures on Materials, Waste, and Recycling. 2023. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials

[8] https://calrecycle.ca.gov/organics/food/. Accessed 5/11/2023.

generated from organic waste represents 20% of California's methane-related climate impact.[9] Therefore, to achieve its climate commitments, California must dramatically increase its organic waste recycling.

The two main strategies for recycling organic waste are: 1) composting (biological decomposition with oxygen), and 2) anaerobic digestion (biological decomposition without oxygen). There are advantages and limitations to both strategies, primarily related to:

- Types of material that can be recycled;
- Speed of processing;
- Amount of space needed;
- Capital requirements; and
- Value and types of products produced.

**Organic waste comes in many different forms, so both composting and AD facilities are needed, and sometimes in combination.** The production and use of compost results in multiple important benefits, including replacing petroleum-based chemical fertilizers, restoring soil health, and improving water retention and plant nutrition.[10] It can be done at very small, medium, and large scale. Composting must be actively managed to maintain the even mixing and aeration needed for the microbes to break down the organic wastes. Proper management is critical to ensure that temperatures get high enough, and for long enough, to destroy pathogens that may be present in organic waste. The aeration and mixing equipment deployed in large-scale composting systems use energy.

AD has several additional key advantages over composting for food waste recycling. Food waste is concentrated where people are concentrated, and where food manufacturing is concentrated. It is made up of a lot of water (anywhere from ~45-95%) and so is heavy and expensive/fuel intensive to transport. Therefore, much of the commercial and residential food waste recycling should be done in or near urban populations to be most cost and greenhouse gas (GHG) efficient. This makes land use efficiency critical. Generally speaking, anaerobic digestion breaks down organic material faster and can therefore process more food waste in less time than composting and requires considerably less space (i.e., expensive real estate), which allows for developing and locating AD infrastructure closer to the major sources of food waste. Furthermore, anaerobic digestion generates much of its own heat and power, making it more energy efficient than composting solutions.



*California's Organic Waste Diversion Policy and Results*

California's SB 1383 and related policy actions (SB 1440, SB 45, AB 1826) were created to help achieve the State's ambitious organic waste diversion and methane reduction goals. These goals are critical to meeting California's climate commitments, particularly those focused on short-lived climate pollutants such as methane. Unfortunately, these policies have not had the desired results.

SB 1383 requires the state to reduce the amount of organic material deposited into landfills 50% by 2020 and 75% by 2025.[11] Not only did the state fail to achieve its 2020 target, but it also sent 1 million tons of organic waste *above* the 2014 baseline to landfills.[12] There are numerous factors and challenges – detailed herein – that have attributed to the overall lack of success in advancing the mandated goals set forth under SB 1383 and related policies.

[9] https://calrecycle.ca.gov/organics/slcp/. Accessed 5/16/2023.
[10] UN Environment Program. https://www.unep.org/news-and-stories/story/how-composting-can-reduce-our-impact-planet
[11] Using 2014 as a baseline.
[12] Little Hoover Commission. Draft Report on SB 1383 Implementation. May 2023.

The private sector has not built out organic waste processing infrastructure in California in any meaningful way. Our research and experience suggest that this trend will continue unless key policy changes are implemented. Compare this to other climate solutions, such as the anaerobic digestion of dairy manure, which has seen rapid infrastructure buildout that directly contributes to significant methane abatement.

It is worth noting that with additional investment, many existing wastewater treatment plants (WWTPs) in the state could also provide a useful outlet for commercial source separated organics (SSO) through co-digestion.

*Energy Outputs of AD*

Anaerobic digesters produce biogas, heat, and liquid fertilizer as by-products of the organic waste recycling process. Biogas (which, as mentioned above, is made up of methane, $CO_2$ and small amounts of water vapor and other gases) can be used to generate electricity or upgraded to nearly 100% methane (called renewable natural gas (RNG) or biomethane). RNG can be used to displace fossil gas in all of its uses, including in industrial processes, heat and electricity generation, and as a transportation fuel in compressed natural gas (CNG) vehicles. ADs can produce renewable energy 24 hours per day year-round with a reliability rate of about 95%. Comparatively, weather variable renewables currently have average capacity factors[13] in the 25-35% range (without associated storage assets).[14] This makes ADs a helpful addition to the distributed clean energy generation mix. AD systems with gas storage can provide renewable electricity on demand in minutes, reducing the need to turn on expensive "peaker plants" – a type of fossil-fuel power supply that is exclusively used to meet spikes in electricity demand.

*High Solids Anaerobic Digestor (HSAD) is the Optimal Food Waste AD System for California*

Some types of ADs are designed to handle drier (higher total solids) wastes, while others are better suited to process wet (lower total solids) waste.

In California, residential waste must be addressed distinctly from industrial, commercial, and institutional (ICI) waste, as they are different in terms of collection methodology and waste stream composition. Residential organic waste is a variety of materials that are clearly defined under SB 1383, which can be collected in either a two-bin system or a three-bin system. In the case of a two-bin system, the black bin material would need to be processed to create an organic fraction of municipal solid waste (MSW) that would be highly abrasive and required to be handled in a high-solid anaerobic digester (HSAD) followed by composting. A three-bin system, which would create a co-mingled leaf/yard waste with food waste, could be handled in a different style of HSAD and composting facility.

The ICI tonnage is typically comprised of food/organic waste with some physical contamination. These materials are often collected and aggregated at a waste transfer station to allow for pre-processing, which can produce a clean

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[13] The U.S. Energy Information Agency defines "capacity factor" as "the ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period." So that means that a facility that generates power 24 hours per day, 365 days per year, would have a capacity factor of 100%. In practice, capacity factors are generally lower due to limited energy sources (e.g., wind that doesn't blow all the time) and because energy generation assets have to shut down periodically for maintenance).

[14] S&P Global, "Usual sun states shine bright at top of US solar capacity factor leaderboard," 2021. https://www.spglobal.com/marketintelligence/en/news-insights/research/usual-sun-states-shine-bright-at-top-of-us-solar-capacity-factor-leaderboard

feedstock that can be sent to food waste digesters or, depending on the extent of the pre-processing, to WWTPs for co-digestion.

## 3. What is "Food Waste"?

*Food Waste is Highly Diverse*

Food waste is not homogenous. It comes in diverse forms and from diverse sources. For example, unsalable milk can arrive at a food waste recycling facility as a finished product in various sizes of glass bottles, plastic bottles, or paper containers; as a commercial ingredient in a 240-gallon intermediate bulk container; or straight from a bottling plant in a 9,000-gallon tanker truck. All of these forms require specialized machines to remove packaging and/or inorganic contaminants before the milk can be recycled.

We characterize food waste into five major functional categories based on procurement and operational requirements of the materials as follows:

- Fats, Oils, and Grease (FOGs): There are two types of FOGs generated by food manufacturers, restaurants, and other food service establishments: 1) yellow grease, such as used cooking oil; and 2) grease trap waste, which is accumulated in an interceptor onsite and prevented from entering the municipal wastewater system. FOGs often have high energy potential and often require heated feedstock storage tanks at ADs to prevent solidification – resulting in clogging of pipes – before digestion.
- Liquids: Liquid feedstocks arrive via tanker truck and include bulk substrate from wineries, breweries, and soft drink manufacturers; industrial organic material such as wastewater from onsite treatment, e.g., dissolved air flotation (DAF)[15] and byproducts from glycerin manufacturing; and other food processing byproducts from the manufacture of consumer food products such as pickles, yogurt, ice cream, and infant formula.
- Bulk Solids: Solid feedstocks are often generated by the same producers of liquid feedstock, and their composition is similar. However, bulk solid feedstocks typically contain a lower moisture content and are not pumpable (as they are solids) nor are they able to be transported by a tanker truck. Bulk solids are usually delivered in roll-off trailers and end-dump trucks and require a tip floor for unloading. Bulk solid feedstocks contain minimal contamination and do not require the use of pre-processing equipment, such as a de-packager. Examples include bulk fruit and vegetables from food processors; sludges and dissolved air flotation cakes; soiled agricultural products ingredients and seasonings; meat scraps; and pet food.
- Packaged: Packaged waste is primarily pre-consumer food in ready-to-sell packaging that is typically palletized. This can also include food in drums, barrels, intermediate bulk containers, gaylord boxes, supersacks, buckets, bins, or crates. Packaged materials require a mechanical or labor-intensive separation process to remove packaging and transportation dunnage from organic substrate. Examples of packaged waste include kegs, cans, and bottles of beer; polyethylene terephthalate (PET) plastic jars of peanut butter; single serve bags of chips; palletized boxes of pasta; aluminum cans of olives, and milk in Tetra Paks.
- Source Separated Organics (SSO): SSO is received in bulk, but collected in small quantities, and contains contaminants (including garbage bags, plastic utensils, and clamshells[16]) that require additional processing with a de-packager. SSO is primarily collected via municipal residential curbside food waste collection programs. Some also comes from community food scrap drop-off locations, grocery stores, and restaurants.



[15] DAF – dissolved air flotation; a common wastewater treatment process.
[16] Clamshells are a type of food packaging that come in a variety of sizes and materials (e.g., plastic, biodegradable, etc.).

Each of these categories can be further subdivided based on the characteristics of individual waste streams (solids content, percent volatile solids, chemical oxygen demand (COD)[17], biomethane potential, packaging, packaging recyclability, delivery method (loose, tote, gaylord, etc.), and contamination rate, to make up what we call their "materials handling" and "contribution margin" profiles, as shown in Table 3.1 below. As indicated, there is a wide breadth of food waste available from a wide range of sources or "food waste generators." Different food waste streams require different facilities and equipment. Therefore, the availability of food waste streams in proximity to a food waste AD facility ("the waste shed") will determine the design and equipment selection for the facility itself. That is to say, the design of food waste AD infrastructure needs to be optimized for the feedstock available to it.



[17] Chemical Oxygen Demand (COD) is one common analysis for predicting the gas yield per ton of inbound feedstock, which helps with energy revenue estimates as well as overall contribution margin determinations.

# Packaged products requiring depackaging services


Bulk single
serving packages

Palletized
boxed materials

Buckets
and pails

Tetra Pak

Aluminum cans

PET jars

# Bulk containers

Metal, cardboard, or plastic drums and barrels

Reusable plastic containers

Bulk bags and supersacks

Caged tanks

Insulated containers

Corrugated containers

# Bulk solids

Municipal curbside collection programs

Sludges and DAF cake

Spoiled agricultural products

Restaurant waste

Ingredients and seasonings

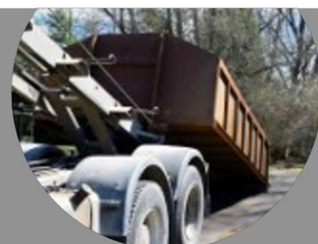
Distressed organic products

# Delivery methods

Dry vans and
reefer trailers

Liquid tanker
truck trailers

Organics collection
trucks



Roll-off
trailers

Open-top tipping
end dump trailers

Live-bottom
trailers

Table 3.1 – Examples of Food Waste Characteristics and Illustrative Contribution Margin.

| Food Waste Type | Source | Relative Tip Fee | Pre/Post Consumer | Equipment Required | Materials Handling Complexity | Energy Content | Chemical Oxygen Demand (COD) | Illustrative Contribution Margin |
|---|---|---|---|---|---|---|---|---|
| Canned Pie Filling | Bad batch disposal, grocery store | High | Pre-Consumer | De-packaging Center | High; de-packager and materials recycling | 3,000,000 BTU/ton<br><br>High | COD = 300,000 | $71.00/ton |
| Canned Tomatoes | Bad batch disposal, grocery store | High | Pre-Consumer | De-packaging Center | High; de-packager and materials recycling | 450,000 BTU/ton<br><br>Low | COD = 50,000 | $30.00/ton |
| Milk Manufacturer's DAF Sludge | Solids removed from a manufacturer's onsite wastewater treatment | Low | Pre-Consumer | Liquids Receiving Hall | Low | 1,135,000 BTU/ton<br><br>Medium | COD = 125,000 | $25.00/ton |
| Pickle Manufacturer's DAF Sludge | Solids removed from a manufacturer's onsite wastewater treatment | Low | Pre-consumer | Liquids Receiving Hall | Low | 200,000 BTU/ton<br><br>Low | COD = 20,000 | $8.00/ton |
| Source Separated Organics | Municipal curbside collected food waste | High | Post-Consumer | De-packaging Center | High; significant processing equipment required | 1,500,000 BTU/ton<br><br>Medium | COD = 160,000 | $47.50/ton |
| Bulk Apple Waste | Pressed apple waste and off-spec apples from apple juice manufacturing | Medium | Pre-Consumer | Solids Receiving Hall and/or Tip Floor | Low | 1,031,500 BTU/ton<br><br>Medium | COD = 100,000 | $40.00/ton |

*Industry and Regulatory Definitions of Food Waste Lack Standardization*

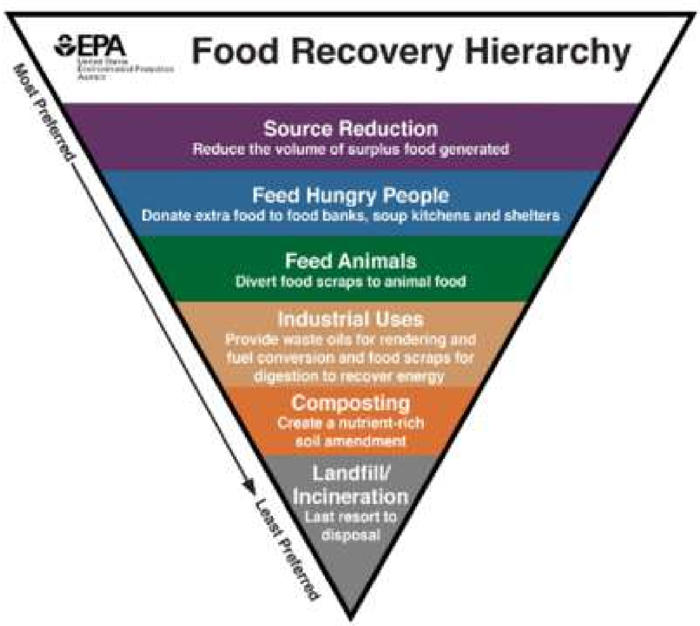
Based on the many types of food waste that exist, and the many different ways of categorizing those waste streams, it is not surprising that **there is not a uniform definition of food waste among states and regulatory agencies in the U.S.**

Developing and adopting a uniform definition(s) will take time. And while it is a goal worth striving for, a simpler fix could help facilitate the diversion of food waste from landfills in the near term: offering permits that explicitly allow for all the types of food waste mentioned above, in whatever way those waste streams are defined in any given jurisdiction.

*What is the Hierarchy of Food Waste Treatments?*

Much like the "reduce, reuse, recycle" mantra applied to solid waste, there are three R's for food waste: Reduce, Recover, Recycle. The U.S. Environmental Protection Agency (EPA) lays out the hierarchy of food waste treatments in greater detail in Figure 3.1 below. The top priority is to reduce food waste at the source. The next is to recover food that is still edible and distribute it to people in need. Then, the best use with what remains is to feed livestock and pets with food scraps that they can digest (also recovery). The next priority is to recycle via AD the remaining inedible food waste (included in the "Industrial Uses" section). Anything that can't go to digesters should be composted (another form of recycling). And then, as a last resort, waste can go to landfills or other (disposal) sites.

Figure 3.1 – EPA's Food Recovery Hierarchy




In general, processing via AD provides the most comprehensive upcycling of inedible food waste with the least environmental impact as shown in Table 3.2 below. However, food waste AD infrastructure typically requires the largest CapEx because of the building space, materials handling equipment, tankage, and energy equipment required.

Successfully deploying a robust portfolio of reduction and recycling strategies will be critical to achieving the EPA and the U.S. Department of Agriculture (USDA)'s 2030 Food Loss and Waste Reduction goal of cutting food loss and waste in half by the year 2030, in alignment with the United Nations' Sustainable Development Goal (SDG Target 12.3).[18]

*Aside from Digesters, Where Else Is Food Waste Processed or Disposed?*

Having identified multiple types of food waste, **it is also important to understand that each type of food waste operates in its own individual, and competitive, disposal market.** Examples of processing facilities and disposal methods that compete with AD include:

- Wastewater treatment plants (WWTPs),
- Compost facilities,
- Landfills, and
- Land application.

Liquid waste, for example, can generally be disposed of in all the above facilities. Liquid wastes can (i) go directly to a WWTP (many of which have ADs as part of their infrastructure, but typically the biogas is flared and the energy value is lost), (ii) go directly to a compost facility (depending on the compost site technology and permitting), (iii) be thickened/solidified and sent to landfill, or (iv) be directly land applied (depending on the type of liquid waste; certain liquid wastes cannot).

Some of these options can be less expensive for liquid food waste generators than ADs and thus more appealing as a disposal method. However, **in all cases there are not as many environmental benefits as when the waste is treated via a dedicated food waste AD system.**

It is common for food waste generators to choose the cheapest waste disposal option over a more sustainable option. The land application of raw, undigested food waste creates multiple problems for farms, farmers, and the environment. Undigested food creates odor and attracts vectors and vermin which can spread disease. Alternatively, when food waste is digested before being land applied, it is more stable, more uniform, less odorous and the nutrients are more bioavailable for plant uptake. Regulation of the direct land application of food waste is variable across states.

In comparison, packaged waste and SSO have fewer competing outlets (generally landfill or incineration only) and can attract higher tip fees as a result. However, these waste types require large investments in infrastructure, labor, and specialized equipment to manage SSO in a food waste AD facility.

[18] U.S. EPA. United States 2030 Food Loss and Waste Reduction Goal. https://www.epa.gov/sustainable-management-food/united-states-2030-food-loss-and-waste-reduction-goal

| | Product | | Solutions | |
|---|---|---|---|---|
| **Treatment Type** | **Energy** | **Nutrient / Fertilizer** | **Methane Abatement** | **Nutrient Recovery** |
| **AD** | **Yes:**<br>Electricity<br>RNG<br>Heat | **Yes:**<br>Digestate | **Yes:**<br>Proven method of methane abatement creating carbon-negative fuels.<br>Minimal "methane slip" from process. | **Yes:**<br>Digestate can be applied as a fertilizer.<br>AD owners are better placed to follow Nutrient Management Plans (NMPs) than waste generators. |
| **Compost** | **No** | **Yes:**<br>Compost<br>Soils<br>Mulches | **Limited:**<br>Compost facilities cannot handle large volumes of food waste, and typically do not have the necessary equipment to handle SSO. | **Yes:**<br>Compost facilities typically do not produce digestates but do recover nutrients. |
| **WWTP** | **Maybe**<br>Infrastructure for energy recapture varies by facility | **Yes:**<br>But complicated as it is in the form of "biosolids" as food waste is co-mingled with human waste. | **Maybe**<br>Infrastructure for energy recapture and methane abatement varies by facility.<br><br>Not equipped for SSO. | **Partial**<br>Biosolids can be used as a fertilizer but tend to have more pollutants than digestate from a digester. |
| **Landfill** | **Yes (most):**<br>Electricity<br>RNG<br>Heat | **No:**<br>Often landfills create leachate pollution issues. Leachate is not a fertilizer. | **Yes (partial):**<br>Proven method of methane abatement creating low CI fuels.<br>More "methane slip" from process given scale of operations and gas gathering pipes. | **No:**<br>Often landfills create leachate pollution issues. Nutrients are not recaptured for beneficial use. |
| **Land Application** | **No** | **Yes:**<br>Direct land application of liquid wastes provides nitrogen, phosphorus, and potassium (NPK), but often poorly supervised/without a Nutrient Management Plan. | **No:**<br>Does not solve methane emissions. | **Partial:**<br>Can create nutrient pollution if poorly managed. |

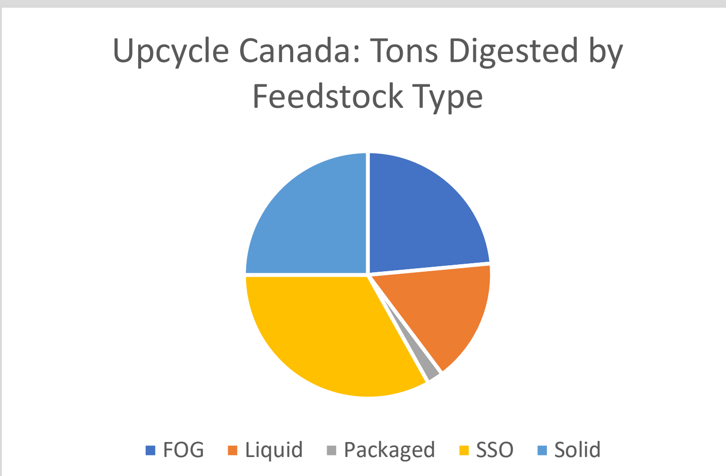
Table 3.2 – Comparison of AD to Alternative Waste Management Practices.

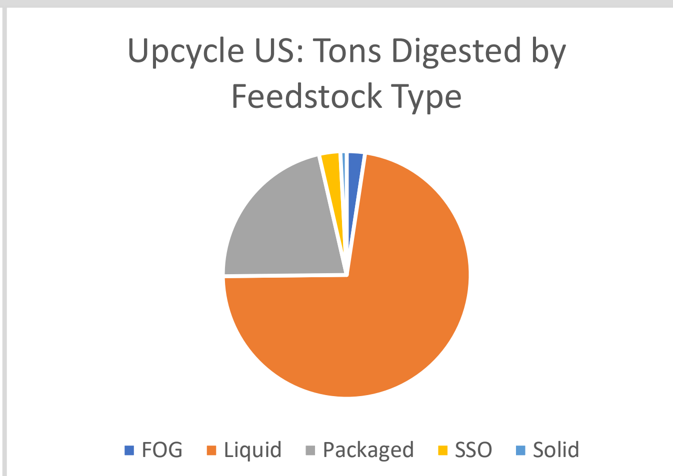
**Investor Perspective:**

*Food waste comes in many shapes and sizes and needs specialized equipment and knowledge to process it into beneficial reuse products. Today, most food waste is disposed of by food waste generators with the lowest common denominator in mind (i.e., lowest cost) as opposed to a purposeful effort to reduce methane emissions and/or nutrient pollution.*

*To help accelerate investment in food waste infrastructure and reduce waste disposal, we believe policies need to recognize all types of food waste – as opposed to the major focus on SSO today – and drive all food waste generators toward not just landfill diversion, but also toward diversion away from other sub-optimal practices, such as direct land application of liquid wastes.*

*Food waste AD facilities need to be able to take all types of food waste to have operational flexibility and succeed economically. This has been our operating experience since there's historically been little incentive to divert food waste from landfills, and limited anchor customers that can be relied upon to fill a digester. The below pie charts show the mix of food waste types handled by our fleet of digesters.*



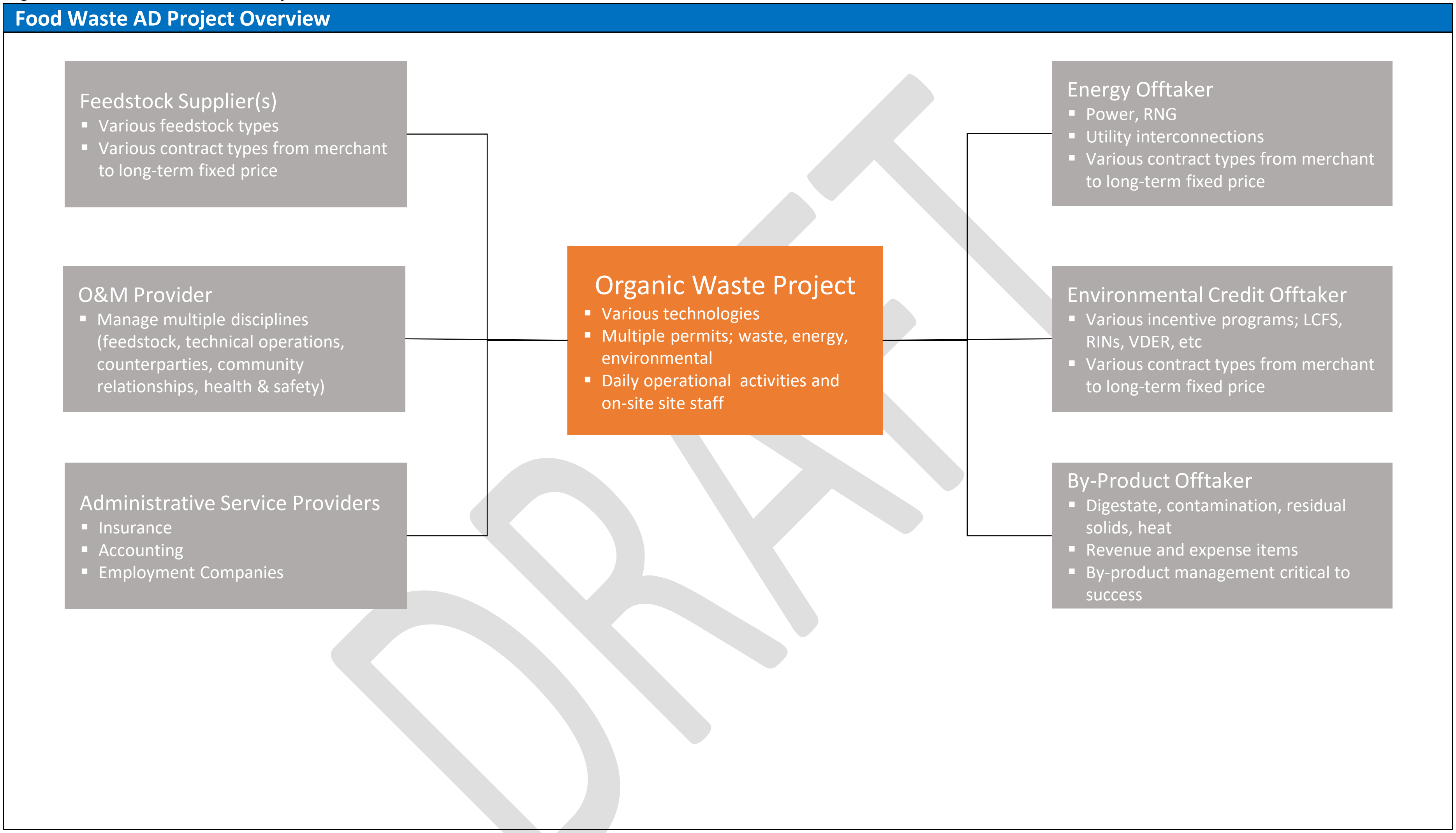




*SSO collection in the Province of Ontario is commonplace and represents a mature market. Yet, despite owning one of the only disposal outlets for SSO in Ontario, SSO only accounts for about one third of the total feedstock at our Ontario facilities. This reinforces the point that policy needs to incentivize the disposal of all food waste types through anaerobic digestion to give projects a chance to succeed commercially and ensure the best environmental outcomes including maximum diversion of food waste from landfill.*

## 4. The Business Model for Food Waste AD Infrastructure

On the surface, the business model for a food waste AD plant is quite simple: (i) receive feedstock, (ii) digest it to produce biogas, and (iii) monetize the energy and nutrient outputs. However, once you begin to peel back the layers of complexity, both commercial and operational, it quickly becomes apparent how much is involved in running a successful food waste AD plant. The "Food Waste AD Project Overview" diagram below highlights the core elements of the food waste AD business model. By reviewing the six boxes in Figure 4.1 below we can begin to show the complexity and costs of operating a food waste digester.

Figure 4.1 Food Waste AD Project/Business Model Overview



1. Feedstock Suppliers

As explained in the "What is Food Waste?" section, the feedstock for these facilities varies in form, availability, accessibility, processability, and productivity, and each has a unique value or contribution margin. Furthermore, each type of feedstock has its own set of disposal options and is generally not available on a contracted basis.

The first part of the food waste AD business model relies on municipalities/haulers and other organic waste generators to pay tipping/processing fees so that organic waste AD operators can build the infrastructure to handle and process these materials. Tip fees should vary based on the processing costs/energy value of the inbound materials and the amount of physical contamination that comes in with the material.

The undeveloped nature of feedstock markets means that revenue from feedstock is often not as high as expected, nor is it contracted and bankable. Therefore, the lack of contractability and working regulations to require food waste to flow to a digester creates availability risk (existential to the operations of a food waste digester) and requires feedstock procurement personnel (plural) to keep the project at full capacity. Entering into long-term contracts for this waste is a meaningful driver of the scalability of solutions for food waste, as infrastructure can be invested in and deployed with greater certainty of return of that capital investment.

Existential performance risk – inextricably linked to feedstock supply risk – requires high return on investment to justify the risk of the investment. Experienced feedstock procurement personnel are highly skilled professional employees that can help mitigate performance risk but add to overall operating costs.

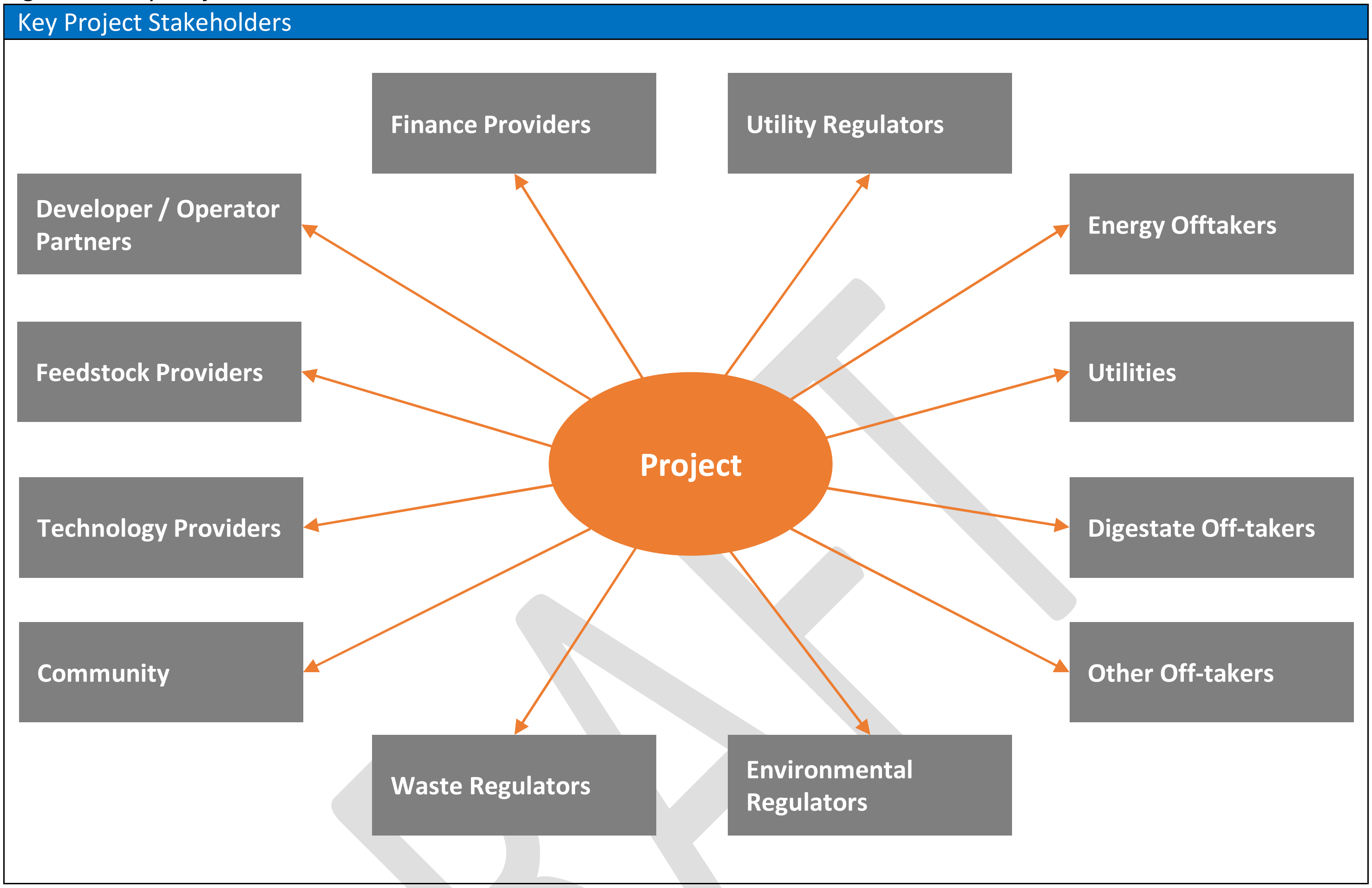
2. Operations and Maintenance (O&M) Providers

There are no third-party O&M providers active in the U.S. today that possess all the operating capabilities listed in Figure 4.3 - Required Capabilities for Successful Development and Operation of Food Waste AD Projects chart below. These required capabilities are driven by the multitude of stakeholders that any food waste project will have, as highlighted in Figure 4.2 - Key Project Stakeholders.

Furthermore, these skillsets are not readily available for hire in North America and there is currently a shallow talent pool to draw from for the food waste AD industry. Therefore, based on our own experience, it is necessary to hire and train an in-house operating staff to succeed in this business.

Creating an organization capable of successfully operating a food waste digester requires a significant headcount of both professional and site-level labor, which also increases operating costs for projects.

Figure 4.2 Key Project Stakeholders.




3. Additional Administrative Considerations

Due to the shortage of skilled labor in the AD industry administrative service providers are often hired on a third-party basis. The level of expertise, and therefore service, varies.  Also, many insurers do not have a classification for biogas projects of any type given there is no NAICS (North American Industry Classification System) code[19] for the industry.

Food waste AD sites require significant systems investment to manage customers (feedstock, energy, digestate/fertilizer), as well as spare parts and inventory purchasing, insurance, vehicle administration, and employee administration, process monitoring, and lab testing, among others. Financial reporting, investor reporting, customer reporting, and regulatory compliance require additional highly trained employees and skillsets.

All of these services are necessary to run a site under best practices and thus represent significant operational complexity associated with any project.

[19] According to the United States Census Bureau, “The North American Industry Classification System (NAICS) is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy.” https://www.census.gov/naics/

Figure 4.3 – Required Capabilities for Successful Development and Operation of Food Waste AD Projects.

**Required Capabilities for Successful Development and Operation of Food Waste AD Projects**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Project Development | Project Design Experience | Technical Knowledge | Operating Experience | Financial Analysis | Legal Contracting Experience | Construction Experience | Permitting Experience |
| Business Development | Developer Network | Technical Network | Regulatory Network | Financial Network | Customer / Feedstock Network | Media Network | Industry Presence |
| Plant Operations | Local Feedstock Market Experience | Materials Handling | Operational Process Experience | Systems and Analytics | Energy Equipment Operations Experience | Utility Experience | Equipment / Inventory Procurement |
| Asset Management | HR | Finance & Accounting | Legal | Compliance & Regulatory | Community | IT | Customer Service |

4. Energy Sales

AD operators also get paid for the renewable energy (i.e., RNG/biomethane or renewable electricity) that is produced from the process. This energy will typically be sold to utilities, natural gas consumers, or municipalities.

Selling electricity or RNG requires skillsets as laid out in Figure 4.3 - Required Capabilities for Successful Development and Operation of Food Waste AD Projects above.

In general, energy product offtake needs to be long-term contracted (10+ years) at high rates to make a project "bankable"; it is a gross misconception that tip fees are enough to fund a food waste AD project; they are typically not even sufficient to make a project break even. This is because there are lower-cost and less regulated alternatives for disposal of almost all types of food waste as described in the sections above, making the energy sales an important revenue stream to cross-subsidize competitive tip fees. Furthermore, tip fees have not historically been governed by long-term contracts, making them less predictable and harder to base a large investment on.

The "Lessons Learned from Other Geographies" section below details some of the policies in other countries that have led to a rapid buildout of food waste AD infrastructure. Note that in most successful cases the electricity and RNG prices on offer exceed those contemplated under SB 1440, as highlighted in Table 8.1.

To operate the energy components of a food waste AD project requires skilled professionals with relationships to execute contracts in the development phase and as well as excellent operational and financial record-keeping staff to maintain high performance and administrative compliance. These are all necessary staffing costs to develop and operate a project successfully.

5. Environmental Credit Sales

To the extent that environmental credits are created by a food waste AD project, then the associated reporting, compliance, and paperwork must be performed. Depending on the credits being created (federal D5 Renewable Identification Numbers (RIN), state-level low carbon fuel standards (LCFSs), or other), a combination of third-party consultants and internal resources are required to manage these administrative processes, further increasing operational expenses.

6. By-Product Distribution for Beneficial Reuse

The third potential revenue stream is the sale of digestate or compost from the facility. These revenue streams typically make up less than 1% of the revenue from a facility and, more often than not, the costs of material handling exceed the (small) revenue from the sale of the product. However, it is necessary to make a quality product that the market will purchase, otherwise the facility will have a significant liability for the management of the digestate.

Digestate, the remains of the digestion process, is a nutrient-rich liquid than can be land applied for fertilizer value, or used with green waste to make compost (additional feedstock and infrastructure is required for this), or upgraded into a higher quality nutrient product (significant extra infrastructure and capital expenditure is required for this). Historically in the U.S., digestate management has been the leading cause of digester failures; the recurring theme is that AD owners didn't have a plan for the digestate disposal and ended up having to truck millions of gallons of liquid to distant destinations at high cost, quickly making projects uneconomical.

Digestate material in the U.S. typically has no designation as a renewable fertilizer or other beneficial reuse product, and as such does not have meaningful commercial value, such that transportation and disposal costs outweigh any payment received for the nutrients. Ideally, projects would get paid a fair price for the nutrient value in digestate, but that is often not the case in practice. U.S. federal Organic Materials Review Institute (OMRI) standards typically do not allow for digestate from food waste AD projects to be certified as organic, and furthermore digestate is not recognized as a nutrient product in most states.

In some countries, including Canada, digestate can be registered as a certified fertilizer and (depending on the inputs) may meet the requirements for organic production certification. For food waste digesters to work economically there either needs to be abundant nearby land for liquid digestate application, or enough economics in the tip fees and energy sales to support building a compost operation or a more expensive digestate upgrading system as part of the food waste project.

Digestate management requires that AD staff work with landowners for land application, including working with specialists to ensure digestate is applied in compliance with landowners' nutrient management plans. **Hauling and land application costs make digestate management the single largest operating expense line item for a food waste digester.**

**Investor Perspective:**

*Given the complexity of operating food waste ADs, the organizational setup and cost required for success is a lot for a single project.*

*So why not build bigger projects?*

*Digesters over a certain size don't make sense because practical physical constraints come into play, such as availability of sufficient feedstock within a viable transportation radius. Even if feedstock supplies are sufficient to support a larger facility, other limiting factors often emerge. For example, the maximum number of trucks that can be unloaded/loaded in a day, the space required for those trucks, and the stress on the local community of that traffic load can each be problematic for the sustained success of a project. As such, we believe 200,000 TPY (tons per year) is a reasonable size limit for a food waste AD facility. Upcycle's largest facility today is approximately 160,000 TPY with another being expanded to 180,000 TPY.*

*Moreover, given the existential risk posed by disruptions to feedstock supply, there is no financial reason to build bigger; it's just risking more capital without any reduction in risk.*

*To spread the organizational setup, engineering, legal, and other costs across a number of assets, it is critical to have a network of facilities as well as corporate-level capabilities. That way, feedstock relationships can be forged with companies across multiples state geographies, operating knowledge can be shared, and best practices implemented across sites. This allows for greater leverage of scarce resources while also developing some resilience to the inevitable challenges that arise. For example, underperformance at a single site can be absorbed by owning and operating a portfolio of sites like Upcycle does.*

## 5. Challenges to Building Food Waste AD Infrastructure

The key challenges to building food waste AD infrastructure can be summarized as:

- Siting – availability of large enough sites in properly zoned (industrial) areas with access to needed utilities (e.g., water, pipelines, etc.),
- Permits – ability to obtain and layer relevant zoning/CUPs and CEQA requirements with solid waste, air, waste, and water quality board permits,
- Feedstock – availability, pricing, and term longevity,
- Digestate management – availability to land apply or blend with compost operation in close proximity to facility,
- Workforce/specialized skills – availability of skilled workforce, and
- Profitability – ability to provide an acceptable return on investment to incentivize taking on the risk of funding new projects.

As described previously, it is common for a food waste digester to have dozens of feedstock customers, a fact which requires a food waste AD plant to have significant organizational infrastructure to succeed, as highlighted in the "What is the business model for Food Waste AD infrastructure?" section. The complexity of each general category of food waste drives the equipment needed to process each type of food waste, and thus drives:

- the design of the project,
- required permits, and
- capital expense.

Packaged waste and SSO require significant tip floor space, high ceiling buildings for internal truck tipping, specialized de-packaging equipment to separate the organics from the packaging, and significant labor and preventative maintenance costs. This is all for materials handling prior to feedstock even entering the digester.

In general, we believe any new facility in California will need to be able to process all the forms of food waste mentioned above to be commercially successful. This means new projects will require a site that:

- can receive 50-100 truckloads per day of waste delivery, and
- has tipping floors capable of receiving packaged waste and SSO, and
- has de-packaging equipment capable of processing packaged waste and SSO, and
- has liquid receiving infrastructure.

Some of the key challenges to building new food waste AD infrastructure are listed below:

*Siting (Location, Location, Location!)*

The feedstock types and procurement potential will drive site selection for any AD facility. Site procurement for a food waste digester is a multi-faceted challenge with a multi-year timeline and often a multimillion-dollar cost. A key difference to note is that food waste projects are not host site projects – meaning they do not get their feedstock from one site on which they are co-located. They are typically standalone facilities that need to attract waste from a waste shed, typically 200 miles or 2-3 hours driving radius for waste haulers or less. As such, their location needs to be in an attractive waste shed, limiting the options for attractive available land, and meaning that the land will be more expensive as it needs to be close to industrial and/or population centers.

*Zoning and Permitting*

All this design and operational complexity translates into the second major roadblock for project design, which is permitting. Permitting for food waste projects requires waste handling permits, for the several types of waste that form "food waste," as well as environmental permits (for performing AD, composting, digestate application), and energy-related permits (for operating an RNG facility), not to mention civil concerns such as truck traffic approvals. The process for obtaining any one of these is lengthy, let alone all of them at once.

For food waste anaerobic digesters, the process starts with zoning. This type of AD is typically zoned industrial and requires a conditional use permit from the relevant municipality. These are binary permits (yes/no) and can sometimes require public hearings/consultations very early in the development process. However, they generally do not include a process to address any concerns the zoning body may have with the applicant before denying a permit.

Second is the CEQA process, which takes two to three years and costs several million dollars. This is also a binary (yes/no) process with no visibility for the developer into decision-making, or ability to adjust, before the yes/no determination.

Next, prospective AD developers go to the Regional Water Quality Boards to ensure that the proposed AD facility will not negatively impact the local watershed. It is unclear how AD fits in with the current regulatory structure of the Regional Water Quality Boards, creating significant uncertainty and risk of additional project costs and delays.

Then developers must get permits from the relevant Air Quality District. Stringency varies depending on location within California. Large metropolitan areas, where most food waste is concentrated, are the strictest. Some Air Quality Districts' current regulatory requirements render any new infrastructure development impossible.

There are additional safety permits and other code-related issues, but the above covers the major code and permitting factors that relate to long lead times, elevated costs, and uncertainty involved in developing food waste ADs.

The above permitting challenges are in dramatic contrast to those of dairy manure AD projects, where permitting is addressed easily through existing Concentrated Animal Feeding Operation (CAFO) permits with minor modifications.

*Feedstock*

At present, feedstocks that flow to food waste digesters are generally uncontracted and often low priced. This is due to the cheap alternatives for food waste disposal and a lack of sufficiently strong waste diversion policies. The outlook is improving thanks to expanding corporate goals related to zero waste to landfill, climate, and related areas, although long-term contracts are limited in number and volume (tonnage) of food waste. Therefore, **long-term municipal contracts for the supply of SSO at an appropriate tip fee are a fundamental necessity to attract more private investment into food waste AD infrastructure.** This is a key area where policymakers can use the tools that they have to make an impact. In addition to SSO, incentives or regulations requiring other food waste types (e.g., industrial food waste) to go to digesters would help provide feedstock certainty and thereby attract investment to build the infrastructure.

*Digestate*

Another key difference relates to digestate management. While all digesters have to find beneficial uses for digestate (the liquid nutrient product remaining after digestion), here again, food waste digesters are different. On a dairy AD site, liquid digestate is land applied on the surrounding farmland. For food waste digesters, digestate can be land applied or sewer disposed, but both options are expensive and sewer disposal wastes the useful nutrients in the digestate. As mentioned previously, digestate management is often the largest line-item expense for a food waste digester. The digestate can be dewatered and made into more refined fertilizer products, but these products do not sell for a high value (because they are not typically certified OMRI organic) and the equipment required is very expensive, both in terms of capex and opex.

*Alternative Disposal Methods Are Currently Cheap*

As mentioned previously, the current regulatory landscape encourages environmentally unfriendly, and often unregulated, disposal of industrial food wastes via direct land application or some other lowest cost local disposal option – as opposed to proactively promoting more sustainable AD or composting solutions.

Landfill diversion laws throughout the U.S. have not had the desired effect of jumpstarting a domestic food waste recycling industry. Instead, they have continued to use alternative (non-landfill) disposal methods. Therefore, vast volumes of food waste continue to be directly land applied or treated at WWTPs that have no energy recapture equipment, both of which are suboptimal scenarios from an environmental perspective.

*Workforce – The Specialized Skillsets Necessary Are in Short Supply*

An additional key limiting factor to the speed at which food waste AD can be expanded is the skilled workforce required. Food waste ADs are complicated to operate, and the specialized skillsets required are not readily available today.

Unlike some other traditional renewables, e.g. wind and solar, food waste AD facilities require significant labor for day-to-day operations, site management, administration, etc. Much of this labor force can migrate from other industries and hit the ground running, while some of the jobs require on-site experience and training. In the dairy manure AD industry, we are already witnessing an influx of engineers and other professionals from the oil and gas industry.

Due to the elevated development risks, and higher capex and operating costs, there are fewer developers focused on food waste AD than dairy AD, and in general there is a smaller professional pool of talent to build out this segment of the industry. This shortage needs to be addressed in order for the food waste AD industry to scale up.

*Who Pays for This Infrastructure?*

A modern 200,000 ton per year (TPY) high solids food waste AD project will cost between $150-200 million. Understandably, no single party wants to pay for this infrastructure whether it be (i) state and local governments, (ii) residents and businesses shouldering elevated waste collection fees to pay for elevated tip fees for the diversion of food waste from the landfill, (iii) residents and businesses paying high energy prices for the procurement of renewable electricity or RNG, or (iv) farmers/landowners paying premium nutrient prices for organic digestate/compost products. The cost inevitably has to be shared.

Ideally, the cost of building food waste AD infrastructure is borne by the private sector, by companies like Upcycle that can arrange the investment and operate the facilities. Such companies make a return on their investment by earning tip fees and selling an energy product, and possibly some revenue from by-product sales, and occasionally with some tax incentives or grants from federal and state government agencies.

In theory, the tip fees needed to support a food waste AD project would be shared by the local residents from where the waste is collected through monthly collection service fees; these would allow the waste hauler to earn their operating margins and pay a tip fee to the food waste AD facility. (Note: The Canada case study in Section 7 describes successful strategies to reduce hauling costs.)

In practice, key stakeholder interests are often misaligned. For example, waste haulers – which typically own landfills – have no incentive (or actually have a disincentive) to divert organics from landfills in California, with the exception being when they eventually run out of space. They can collect SSO waste under franchise contracts, put rate increases through to customers for compliance, state that none of the infrastructure is developed, and ultimately take the SSO to the landfill with no penalty (and often with increased revenues to their landfill). It is an easy workaround where the ratepayers (California residents) pay increased fees for waste collection services but no food waste processing infrastructure is actually built. Waste haulers are not building, nor acquiring, food waste AD facilities, they are aware of the slow pace of private development, and they are not incentivized to support the shift to food waste recycling.

As for energy costs, utilities could be required to purchase food waste-derived RNG or renewable electricity under long-term contracts. This model is being implemented via SB 1440, but the pricing provided under the Tier 1 and Tier 2 pricing schemes thereunder are not yet adequate to make a food waste AD project profitable enough to attract investment in the first place, as further highlighted in Table 8.1. The utilities will have no incentive to agree to prices high enough under the Tier 3 mechanism, largely in the same way the waste haulers have no incentive to change their behavior.

Lastly, the provision of grants to help build infrastructure isn't useful if the facilities are not profitable; the facilities will get built only to go through a public bankruptcy spectacle and be shut down after a year or two of operation, resulting in the loss of taxpayers' hard-earned money.

*<u>Differentiation Among Digester Types – Feedstocks, Locations, Business Models</u>*

Digesters can have radically different designs, operating complexity, and biogas production expectations depending on what type of feedstock they use (e.g., animal manure, WWTP wastewater, food waste). These differences lead to divergent revenue profiles as well as costs to build and operate. These dramatic differences are not currently reflected in the California Air Resources Board (CARB)'s or other agencies' expectations of future project numbers and associated RNG supply(s).

To illustrate these differences concretely, and how these significant differences impact CARB decisions, we compare food waste AD to dairy manure AD projects in Table 5.1 Key Differences Between Food Waste and Dairy Manure AD Projects. We explain the key differences, which highlight why development in California is particularly difficult, even for experienced operators.

***Investor Perspective:***

*There are clearly many considerations to be accounted for before making an investment decision to build a food waste AD facility. The litany of challenges listed above can be distilled into three critical risks for firms such as Upcycle making investment decisions.*

*<u>Development Risk:</u>*
*Do we believe that it is worth spending $2-10 million dollars and up to 5 years to pursue a facility in a given location? This capital is very expensive because of the high risk being taken and the possibility that the project will not get built. Developers need conviction from day one that the project will succeed.* ***It is just as hard for a company like Upcycle to approve $1-2 million of development expense as it is to approve $150-200 million of construction expense.***

*<u>Operating Risk:</u>*
*Do we have access to enough feedstock to run the facility at a minimum acceptable level? Does that feedstock level support the minimum energy production we need to comply with offtake contracts? Is that feedstock contracted or uncontracted?*

*These are basic questions designed to highlight the importance of feedstock and the risk profile of having merchant feedstock versus contracted volumes. Not only is a facility designed to run at a minimum capacity, but often energy* *offtakes will have minimum monthly volumes that need to be met; reductions in feedstock, even temporarily, can be economically catastrophic if they lead to the termination of an energy sales contract.*

*Beyond feedstock, the process flow diagram of a food waste digester (see Figure 2.1), is complex, covering feedstock materials handling, digestion, energy production, and digestate management. Problems with any one of these components can affect the throughput of a facility and result in downtime and lost revenues.*

*The multiple and complex variables associated with operating an anaerobic digester means it is far more difficult to predict a facility's energy output with the same degree of confidence that is possible for other renewable energy infrastructure. For example, when investing in a new solar asset, one can easily obtain solar irradiation data, and this single variable allows one to project the energy output with a P90 (or higher) confidence level; meaning that there is a 90% probability of the actual energy output meeting or exceeding the P90 estimate. Such confidence is not achievable for food waste AD, which increases the uncertainty and risk of these investments.*

*<u>Investment Risk:</u>*
*Return on investment is dependent on feedstock, operations and throughput, digestate management, community relations, counterparty quality, and stability of regulation (waste, environmental, and energy). Even with long-term contracts for feedstock and energy offtake, there are still significant risks for a project and as such the returns required need to reflect that risk. In other words, the higher the risk, the higher the required return.*

## 6. The State of California's Food Waste AD Infrastructure

<u>Food Waste AD Infrastructure Is Scarce; Practical Knowledge Is Even More Scarce</u>

Despite ongoing efforts and ambitious goals, the state of food waste AD infrastructure in California is in its infancy. Existing WWTPs have the capability to handle a significant amount of the commercial food waste that can be generated from the ICI (industrial, commercial, institutional) sector, although many would need to install energy generation infrastructure. Meanwhile, existing composting facilities can only handle a small amount of food waste, as discussed in the "What is Food Waste?" section above.

However, the significant additional organic waste processing infrastructure required to handle the residential SSO that would be collected through the three-bin system, or the organic fraction of municipal solid waste (OFMSW) that would be generated through a two-bin collection system, barely exists today. Furthermore, there is a general lack of understanding among food waste market participants (including many project developers) about what is required to handle these materials properly and successfully.

Examples of the three-bin material are evident in other jurisdictions such as Vancouver and British Columbia in Canada, and Seattle, WA, which provide an indication of what could happen in CA for a three-bin system. However, if various CA cities decide with their haulers to do a two-bin system, then almost no successful examples currently exist in North America. Proper reference projects for that are available only in Europe; the OFMSW is a very difficult material to handle due to the grit/glass that would come with this feedstock.

There are very few industrial-scale food waste digesters in operation in California today (See Figure 6.1), and even fewer that are built to handle SSO effectively. The same is true throughout the U.S. Furthermore, there are even fewer food waste digesters that are commercially and economically successful. And there are only a handful of agricultural (crop) waste digesters (note, agricultural waste is not manure in this context) that could be converted into food waste digesters, whereas there are many in the U.K. and Europe. In other words, there is limited existing infrastructure that could be expanded or repurposed into food waste AD, further necessitating the need for new AD site development.

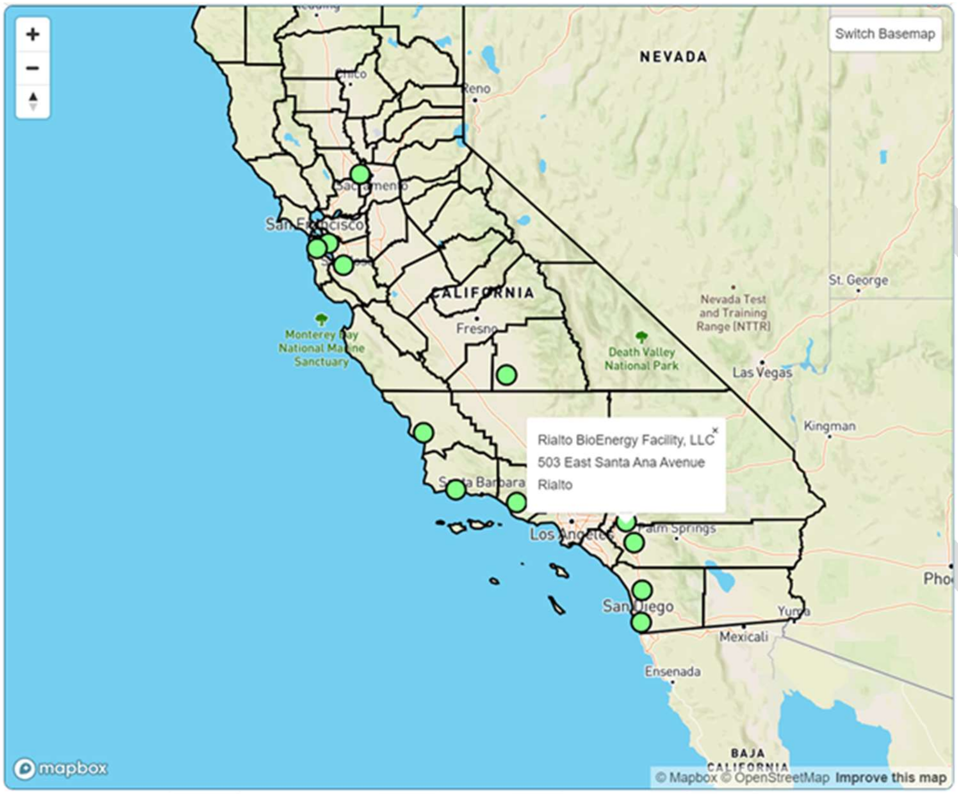



Figure 6.1. - Map of Commercial Food Waste Digesters in California.[20]

As a result, our research and experience indicate that without direct intervention and support from municipalities and regulators for site selection, permitting, and stable supportive tip fee or energy offtake pricing, it is going to take 5-10 years to build any meaningful scale of food waste recycling infrastructure in CA. The reasons for the lengthy build timeline were described in detail in Section 5, “Challenges to Building Food Waste AD Infrastructure.”

*Why Has the Dairy Manure-Based AD Sector Seen Such Rapid Buildout and Food Waste Hasn’t?*

In contrast to food waste recycling infrastructure, the buildout of dairy manure-based AD systems is well underway. This divergence can be explained by several key factors, including:

- While the digestion process is similar for each project type, food waste is significantly more complicated to procure and process than dairy manure;

[20] Source: CalRecycle. https://www2.calrecycle.ca.gov/SolidWaste/Activity.

- Greater financial and development resources are required to build food waste AD infrastructure ($150-200M million per 200,000 TPY project) than dairy manure AD;
- Unlike the food waste AD business model, the dairy model is a "hosted" business model, meaning that the key challenges of siting, permitting, feedstock supply reliability, interconnection, etc. are all easier;
- Municipalities and haulers do not typically have the expertise to build AD infrastructure dedicated to recycling food waste; instead, they are building/supporting compost facilities, which do not produce RNG; and
- Biogas development companies are the only market participants capable of delivering food waste AD infrastructure in CA today (i.e., waste haulers and other waste management companies do not currently have these capabilities).

The table below further details the differences between the development, construction, and operation of food waste AD systems relative to dairy-manure AD systems.

Table 6.1 - Key Differences Between Food Waste and Dairy Manure AD Project Development.

| | Food Waste | Dairy Manure |
|---|---|---|
| **Feedstock Types** | • Food production waste / FOGs / Grocery store food waste / Quick Service Restaurant (QSR) food waste / SSO / Packaged waste<br>• Food production waste and FOGs are generally available | • Manure |
| **Feedstock Availability / Competition** | • Food production waste and FOGs are generally available<br>• Packaged waste tends to be event-driven (i.e., bad batch production)<br>• SSO not available in meaningful volumes in CA yet, contamination levels TBD<br>• POTWs, Compost, Land Application, Renewable Diesel, and others all compete for food waste | • Manure is onsite, homogenous, and readily available<br>• No competition for the resource – it stays onsite at the dairy |
| **Collection** | • Trucked if available, subject to competition | • Pumped onsite direct to AD |
| **Contractability** | • Long-term supply contracts generally not available | • 10-20 years contracts with dairies are market standard |
| **Interconnection** | • 1-3 years location and energy type dependent | • Same |
| **Digestate Management** | • Land application (least expensive but least readily available)<br>• Sewer discharge (requires more equipment to clean up to spec, if available)<br>• Additional treatment requires $30 million+ extra capex; and $2-3 million of annual additional opex | • Land application onsite or on neighboring fields; responsibility of dairy |
| **Site Availability** | • Very limited; sites need specific organic waste permits (does not exist today), environmental permits, logistical permits, and energy permits to operate | • Readily available at dairies |
| **Site Cost** | • Very expensive, particularly for best locations as they have alternate uses | • Rent and commissions |
| **Permitting Timeline** | • Extensive and time consuming; can take as long as 5 years with limited visibility to success | • Limited and quick due to CAFO |
| **Project Cost** | • $150-200 million (200,000 TPY food waste facility) | • $25-35 million (5,000 cow RNG facility) |

| | | |
|---|---|---|
| **Development Cost** | • $5-10 million excluding land purchase/lease cost | • $2-3 million |

*What Is the Role of the Private Sector in the Buildout of Food Waste AD Infrastructure?*

As highlighted in the "What is the Business Model for Food Waste AD Infrastructure?" section, the development, construction, operations, and management of food waste AD infrastructure requires significant resources and skillsets including feedstock procurement, process management and monitoring, energy production, and capital formation.

The private sector, through well-resourced companies like Generate Upcycle, is uniquely equipped to provide these capabilities and the significant amounts of capital required for food waste AD infrastructure in one organization. This capital- and operations-intensive infrastructure does not have to burden taxpayers and tight municipal budgets, nor can it be delivered by small private sector companies that do not have appropriate financial backing. **Local government entities and inexperienced players have demonstrated that they are not capable of delivering and maintaining large-scale food waste AD infrastructure over a decades-long time horizon.**

By crafting effective/elegant incentive programs, California can unlock private sector investment, thereby allowing the State to benefit from the innovation and experience that will help increase efficiencies as well as drive down organic waste and methane mitigation costs.

***Investor Perspective:***

*As a company that has been actively investing in food waste AD infrastructure since 2016, we believe a primary reason for the lack of existing infrastructure is the start-stop nature of support from legislation at both the federal and state levels. We further believe a long-term committed approach to legislative support is required by California's relevant agencies to attract and accelerate investment in food waste AD infrastructure.*

*In general, food waste digesters have been built on a start-stop basis with free taxpayer funding dictating the start and stop of the cycle. For example, Generate Upcycle has acquired one food waste digester in Canada, seven in the U.K., and four in the U.S. as well as pursued investments in dozens of others over the past seven years and has observed the following:*

- *Almost all of the U.S. digesters Upcycle acquired and pursued were built with non-repayable grants (i.e., free money) from the American Recovery and Reinvestment Act of 2009 ("ARRA").*
- *Almost all of the U.S. digesters Upcycle acquired and pursued had neither an ongoing business plan nor a source of long-term revenue. While the ARRA provided capital for projects, the owners had no capital at risk and therefore treated the entire project as a free option. Furthermore, inexperienced project developers that otherwise could not raise capital in the private sector suddenly became owners/operators of facilities and did not have the requisite capabilities to fulfill that role.*
- *Almost all of the U.S. digesters Upcycle acquired and pursued had failed within two years of commencing operation because they had no way to dispose of digestate effectively.*
- *Upcycle acquired all four of its current U.S. facilities from an idle, failed state and rejuvenated them; only one of them had a long-term PPA (power purchase agreement) for the power it produced, on a variable rate. Since owning these facilities, the various landfill diversion laws in the states where we are active have failed to provide an increase in volume or tip fee (i.e., state-level regulation has hitherto been ineffective).*
- *This stop-start dynamic is typified by the recent bankruptcy filing of Rialto Bioenergy Facility, LLC in California in May 2023.*

*Looking ahead, more sustained and targeted support will be needed in California to attract investment and take advantage of the benefits provided by the U.S. Inflation Reduction Act (IRA). We would stress that:*

- *The IRA, while offering excellent incentives, includes time limitations on the key benefits for biogas and RNG, so could end up being another "start-stop" incentive for food waste AD.*

- *If coupled with a stable and supportive local offtake regime in CA, it should incentivize significant investment. Importantly, we must state that the contract prices proposed under SB 1440 are relatively short of the prices required to incentivize investment.*
- *Without the ability to fast-track site location and permitting, very few facilities will be built within the timeframe of the IRA.*

## 7. Lessons Learned from Other Geographies

*Instructive Food Waste Diversion and AD Infrastructure Policy Case Studies*

We can benefit from the lessons learned in countries where food waste diversion, biogas and/or biomethane/RNG already play a significant role in their climate and energy strategies (and in some cases waste management, rural development, transportation, and others). Germany alone has well over 10,000 ADs, and more than 39%[21] of the supply in Denmark's national gas grid is RNG.

Among the countries that have developed AD infrastructure, there is quite a bit of variation in how biogas is produced and used. Some countries have focused primarily on biogas for the purposes of heat and power, while others have prioritized the production of biomethane/RNG. Some have focused on agricultural crops and residues as feedstocks in rural areas, while others have focused primarily on utilizing urban and industrial organic wastes.

One commonality across these countries is that it took a series of policies working in concert to unlock investment in ADs. Various financial instruments have been used including feed-in-premiums (FIP), feed-in-tariffs (FIT) and tax exemptions, as well as organic waste diversion laws, manure storage mandates, and other sector specific requirements that influenced feedstock availability. In the EU for example, biogas production grew by 100% between 2008 and 2016. And then, in stark contrast, production grew by only 3% in the subsequent three years. That dramatic change can be attributed to changes in the policy environment.

Consistent with our experience as food waste AD investors and operators, a number of studies have emphasized "**policy coherence, stability and continuity as central factors for policies to be effective in areas [such as AD infrastructure] that require large investments over a long time period**."[22]

An analysis of policies and production development in Europe found that, "Different forms of support for biogas production and use have proven successful for increasing biogas production in the studied [European] countries." Their modeling and analysis found that, "**The outcome of an economic instrument seems to depend more on its size and its longevity than on its form and which part of the value chain it targets.** In the end, all economic instruments that make biogas solutions more competitive can effectively stimulate growth of production and use, whether they are directed to the producer or are used to reduce the price for the customer."[23]

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[21] EnergiNet. https://en.energinet.dk/gas/biomethane/

[22] Marcus Gustafsson & Stefan Anderberg (2022): Biogas policies and production development in Europe: a comparative analysis of eight countries, Biofuels, DOI: 10.1080/17597269.2022.2034380

[23] Marcus Gustafsson & Stefan Anderberg (2022): Biogas policies and production development in Europe: a comparative analysis of eight countries, Biofuels, DOI: 10.1080/17597269.2022.2034380

In the following sections we do not attempt to capture the enormous policy and regulatory complexity shaping the AD landscape in these countries; rather, we highlight some of the relevant context and lessons learned that may be applicable in California.

***Germany***

Germany is the leading biogas producer in Europe, and in the world when expressed per capita, producing the equivalent of more than 10% of the natural gas consumption in this large, industrialized nation.[24] ADs in Germany are predominantly farm-based currently, but there is increasing focus on urban organic and other waste feedstocks. According to the World Biogas Association, “after years of tremendous growth, the industry [in Germany] has significantly slowed down and is in a state of transition. This is partly due to changes in regulations supporting the biogas industry, such as the Renewable Energy Sources Act (EEG) amendment to energy auctions, sustainability criteria limiting the use of energy crops, and partly due to saturation of certain segments of the industry.”[25]

Germany’s global leadership in AD can be largely attributed to the long-term Feed In Tariffs (FITs) that it provided to biogas (and other renewable energy) producers via the Renewable Energy Source Act (EEG). The EEG guaranteed 20-year FITs above those paid for electricity from fossil fuels, differentiated by plant size and feedstock mix, in order to compensate for the “higher production costs involved in producing low carbon energy.”[26,27]

***Denmark***

Denmark also used generous, long-term FITs to enable the successful buildout of a domestic AD industry. As mentioned previously, it has already achieved 39% displacement of fossil gas with biomethane/RNG in the grid, with the goal of reaching 50% by 2025 and 100% by 2040.[28] ADs started out in Denmark as a solution for the municipal wastewater sector and then to aid in manure management in the farm sector. FITs were focused on electricity generation until 2012 when a Feed In Premium was added to encourage upgrading to biomethane/RNG and injection in the national gas grid. Targeted tax breaks also helped spur investment in ADs.[29]

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[24] Implementation of BioEnergy in Germany – 2021 Update. IEA Bioenergy. Country Reports. October, 2021.

[25] Dr Sarika Jain (Lead Author). World Biogas Association. Market Report. Germany. 2019

[26] Based on the European Renewable Energy Road Map (European Commission, 2007) and the Renewable Energy Directive (European Commission, 2009) Member States of the European Union (EU) were obliged to establish national mandatory targets which aimed to increase the share of renewable energies for primary energy consumption to 20% by 2020, and to 10% in case of transport. As part of its response, Germany created the Renewable Energy Source Act which promoted biogas via long-term feed in tariffs.

[27] The impact of German biogas production on European and global agricultural markets, land use and the environment. Wolfgang Britz and Ruth Delzeit. Energy Policy. Volume 62, November 2013, Pages 1268-1275. https://www.sciencedirect.com/science/article/abs/pii/S0301421513006307

[28] Case Study 3: Nature Energy. World Biogas Association. May 19, 2020. https://www.worldbiogasassociation.org/8-case-study-3-nature-energy/

[29] Experiences with biogas in Denmark. Prepared by Sirid Sif Bundgaard Anders Kofoed-Wiuff. Technical University of Denmark. June 24, 2014.

***The United Kingdom (U.K.)***

According to the Anaerobic Digestion & Bioresources Association (ADBA), there were 727 AD plants in operation in the U.K. by the end of Q1 2023, with a combined installed biogas-based power capacity of 2,814 MW. From 2011 to 2022, the total number of AD plants saw rapid growth and the number of plants upgrading biogas to biomethane grew massively. A combination of policies drove rapid growth across the AD industry (both for combined heat and power as well as for biomethane), including meaningful, long-term incentives in the form of Feed In Tariffs (FITs), Renewable Obligation Credits (ROCs), the Renewable Transportation Fuel Obligation (RTFO), etc.[30] Perhaps most influential, the launch of the Non-Domestic Renewable Heat Incentive (NDRHI) in 2011, which rewarded plants for biomethane/RNG injection into the national gas grid with a set tariff for 20 years, was critical in driving this rapid growth (see Figure 7.1 below).[31]

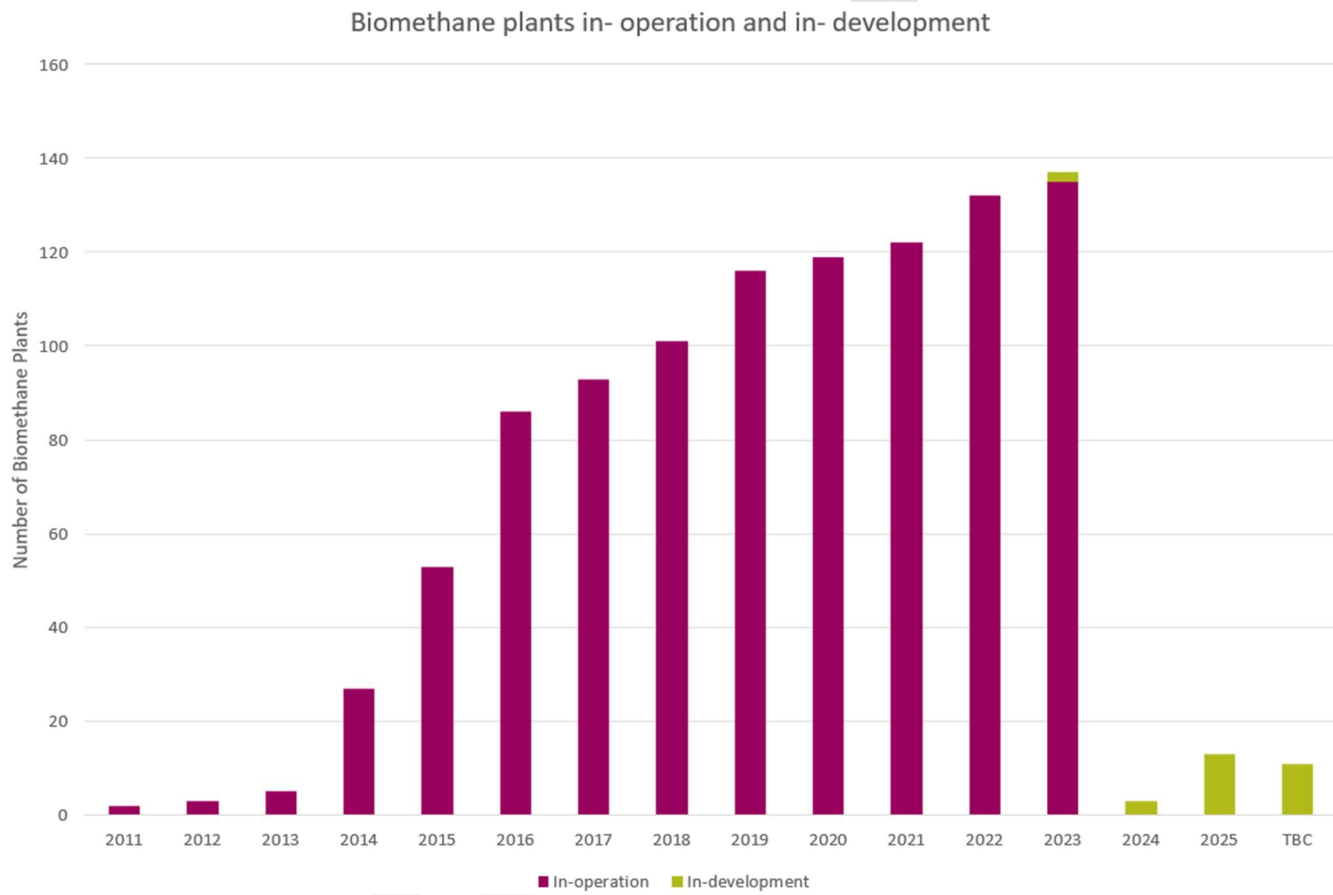


Figure 7.1. Biomethane/RNG Plants In-Operation and In-Development in the U.K. Source: Anaerobic Digestion Policy Report. ADBA. April 2023.

The UK's continued policy support through multiple channels has enabled the continued success and growth of the food waste management sector, centered around AD projects. Specifically, the RTFO is still in place and the new Green Gas

[30] A Feed in Tariff (FIT) is a policy mechanism designed to accelerate investment in renewable energy technologies by offering long-term contracts to renewable energy producers. This means promising renewable energy producers an above-market price and providing price certainty and long-term contracts that help finance renewable energy investments.

[31] Anaerobic Digestion Policy Report. ADBA (Anaerobic Digestion & BioResources Association). October 2022.

Support Scheme was implemented recently in place of the RHI injection tariff. Currently, the U.K. is pushing hard on food waste diversion and RNG supply, and thanks to the NDRHI and the RTFO, it has an installed base of infrastructure that can be used/upgraded to recycle the food waste alongside crop waste. Generate Upcycle is actively investing in this trend, having acquired seven digesters in the U.K. in the last year for the purpose of upgrading them to take food waste. This is compared to North America where Generate has invested in only six AD sites over six years. The distinction of "high-quality" is important here; as described in Section 6, neither California, nor the U.S. more broadly, has an installed base of high-quality AD infrastructure, despite throwing hundreds of millions of dollars of taxpayer money at the sector since the global financial crisis.

One cautionary tale from the U.K. experience involves annual subsidy step downs. Industry experts credit annual deadlines, after which subsidy levels were significantly reduced, with causing rushed and sometimes sub-optimal construction of ADs. "Every March we knew the subsidy would be reduced so there was a mad rush to lock in the FIT before it dropped down," said one industry veteran who did not wish to be named.

A more recent cautionary tale involves the delay in food waste collection program development. A lot of AD capacity growth since 2018 was driven by the expectation of new food waste collection programs. However, those programs have yet to be introduced, and local authorities continue to wait for the federal government to announce what financial supports they will provide to help cover the increased costs they will incur implementing these residential food waste collection programs. Once the U.K. government does get its food waste diversion support programs up and running, the pivot from energy crops/agricultural residues to food waste recycling via anaerobic digestion will be relatively straightforward on the waste processing end because they have so much AD infrastructure built already.

*Wales*

Within the U.K., Wales stands out for its high organic waste recycling rates (approximately 65% in 2021/22),[32] the highest in the U.K. and third in the world (behind Germany and Taiwan). Wales collects food waste separately each week from a whopping 99% of its 1.4 million households. One Wales government official claimed that, "you will find a food caddy in virtually every kitchen across the country."[33]

A number of policies and programs have contributed to this success, with the main policy driver being a statutory target of recycling 70% of waste (all waste, not just organics) by 2024/25. Furthermore, they aim for zero waste by 2050. Local authorities are fined £200 for every tonne of waste that is not recycled (in excess of the target). This results in a large incentive to reach the target (and a strong disincentive for non-compliance). For example, Flintshire Council was fined £662,800 for missing recycling targets in 2021/22.[34]

Other critical elements of their strategy include public funding commitments, government procurement, and educational programs. For AD in particular, the Waste Infrastructure Procurement Programme oversaw the awarding of seven regional AD contracts which created partnerships between operators and local authorities.[35] Public investment also included £23 million in ring-fenced funding to local authorities for food waste collection.

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[32] Local authority municipal waste management: April 2021 to March 2022. gov.wales/local-authority-municipal-waste-management-april-2021-march-2022#:~:text=In%20its%20current%20waste%20strategy,of%20waste%20by%202024-25.

[33] "Waste not, want not: What the world could learn from Wales' food waste programme: Wales leads the world in its food waste recycling. So what's its secret?" The Energy from Waste Network. Published May 29, 2020. https://network.efwconference.com/posts/waste-not-want-not-what-the-world-could-learn-from-wales-food-waste-programme

[34] Flintshire facing £663,000 fine for missing recycling targets - letsrecycle.com

[35] Microsoft Word - 2021-05-11 - Distribution Sub Group (DSG) - Paper 07 - Gate Fees Transfer in.docx (gov.wales)

Their success can also be attributed to close work with all 22 Welsh local authorities.[36] "These [government investment and community education] initiatives work alongside the government's eco-schools programme, which provides resources to 90% of Welsh schools to help educate students about the importance of reducing food waste. Plus, the government makes it easy for citizens to do their bit, providing all residents with kitchen caddies and most households with free liners, and restricting residual waste collections so people are more likely to use their food waste bins."[37]

***Canada***

Residential organic food waste collection programs in Canada also provide instructive success stories. The Province of Ontario has been phasing in these programs over time, and now all cities of a certain size and population density (generally 50,000-100,000 residents or larger) have implemented green bin programs. A number of factors have helped drive this progress, including the passage of the Resource Recovery and Circular Economy Act in 2016, which restricts landfill capacity.

Ontario's organic waste diversion policies have focused on single-family residential generators and utilize a three-bin collection system. In these systems the food waste is collected separately from the solid waste, and from the conventional recyclables, to allow for recycling at organic waste processing facilities. This is typically established through weekly collection of organic waste and other recyclables and bi-weekly pickup of solid waste. This schedule has been successful because it reduces hauling and collection costs for cities trying to contain the costs.

It was the organic waste diversion programs in Seattle and Vancouver that pioneered this model. Metro Vancouver and King County/City of Seattle have been diligently working on organic waste diversion policies that divert green waste and food waste from single-family residential generators to organic waste processing facilities for a decade. The implementation of these programs was not without significant challenges. However, these jurisdictions have persevered and as a result have developed key knowledge of the entire supply chain. This experience could be useful to the government of California and the various stakeholders impacted by the implementation of SB 1383. California can learn from the feedback of the homeowners and municipalities that worked closely with King County and Metro Vancouver on the implementation as well as from the organic waste collectors and processors regarding the infrastructure requirements for effective handling and management over the long term.



[36] Hannah Blythyn, Deputy Minister for Housing and Local Government in Wales from 2018-2021 was reported to have said this in 2020 by the Energy from Waste Network.

[37] "Waste not, want not: What the world could learn from Wales' food waste programme: Wales leads the world in its food waste recycling. So what's its secret?" The Energy from Waste Network. Published May 29, 2020. https://network.efwconference.com/posts/waste-not-want-not-what-the-world-could-learn-from-wales-food-waste-programme

## 8. Conclusions and Proposals from the Investor/Operator Perspective

Anaerobic digestion is an optimal solution for landfill diversion and upcycling of food waste and needs to be deployed rapidly to get California on track to meet the requirements of its waste reduction and climate laws. To enable the large-scale buildout of this solution by companies like Generate Upcycle, a suite of waste diversion and renewable energy valuation policies and programs need to be implemented simultaneously.

While there is no single perfect example for California and other U.S. States to copy, experiences in other countries provide clear guidance on the essential elements required to spur the buildout of the entire infrastructure "ecosystem" needed to collect, process, and recycle food waste specifically. For instance, long-term clean energy price support was essential for the successful buildout of food waste style digesters in the U.K. and Germany.

In each case, the presence of a long-term offtake contract, at relatively high prices, spurred significant investment in high quality AD infrastructure by development companies with significant financial backing, whether on their own or in partnership with a financial company. We also recognize that, from the policymaker perspective, long-term FITs are costly for the government; therefore, if our goal is to balance responsibility for costs among various stakeholders, a coordinated suite of policies and programs would be most advantageous to Californians.

Table 8.1 - Comparison of Key AD Policy Incentives.

| | | | Contract Terms | | | Contract Value | |
|---|---|---|---|---|---|---|---|
| Country | Policy Tool | Year Initiated | Price in Local Currency | Price in USD / MMBTU[1] | Tenor | $/MMBTU[1] | Lifetime $/MMBTU[2] |
| Germany | Feed In Tariff | 2000 | EUR 0.22/kWh | $47.63 | 20 | $48 | $953 |
| Denmark | Feed In Tariff | 2012 | DKK 115/GJ | $26.29 | 10 | $26 | $263 |
| U.K. | Feed In Tariff | 2014 | GBP 0.1064/kWh | $22.66 | 20 | $23 | $453 |
| California | SB 1440 Tier 2 Low | 2023 | $17.70/[MMBTU] | $17.70 | 10 | $18 | $177 |
| | SB 1440 Tier 2 High | 2023 | $26/[MMBTU] | $26.00 | 15 | $26 | $390 |

(1) Calculated using the exchange rate at the time of the policy and a 2% inflation rate through 2023.
(2) $/MMBTU multiplied by tenor.

As shown in Table 8.1 above, SB 1440 Tier 2 pricing and contract length provides a range of project lifetime revenue from $177/MMBTU to $390/MMBTU – some of which is comparable to that of the Feed In Tariff's implemented in Denmark and the U.K. At the low end of SB 1440 Tier 2 pricing, the lifetime revenue value is less than that of the U.K. and Denmark tariffs, and at the high end it is higher than Denmark's tariff, but lower than the U.K.'s. What is not clear from this table is the other food waste AD project revenue driver and risk factor for these projects: tip fees and availability of waste. Both Denmark and some parts of the U.K. had more mature food waste collection, and high tip fee SSO collection in particular, when establishing these policies than California does today, meaning that food waste projects in those jurisdictions could earn more from tip fees.

Germany's Feed In Tariff was based on a zero tip fee agricultural residual digester business model and therefore the energy price had to be very high as it was the sole source of project revenue; thus it is not directly comparable to California's food waste AD situation.

We recommend SB 1440 Tier 2 pricing be increased. On the low end of price increases, we recommend increasing Tier 2 pricing from a range of $17/MMBTU to $26/MMBTU to a range of $25/MMBTU to $30/MMBTU to produce lifetime revenue per MMBTU in the range of $250/MMBTU to $450/MMBTU. This range assumes that food waste collection can be improved such that tips fees, availability, and contractability of waste are all improved for food waste AD projects in the short term.

On the high end, assuming no change in food waste collection in the near term, we recommend increasing Tier 2 pricing to a range of $35/MMBTU to $40/MMBTU to produce lifetime revenue per MMBTU in the range of $350/MMBTU to $600/MMBTU. Given how difficult it is to implement changes in food waste collection, availability and contracting, we recommend this higher range of pricing.

The start-stop pattern of providing grants and other incentives in the U.S. has led to an overall low quantity and quality of AD infrastructure being built. Our experience with the four food waste digesters we own in the U.S. illustrates this point. All of them needed significant retrofitting, expansion, or complete rebuilding to be functional. Why? Because there has never been sustained policy support for the buildout of a robust AD sector. Many of these digesters were built by amateurs who were able to secure grant funding but did not have the knowledge or financial backing to otherwise design, build or operate high-quality infrastructure.

Upcycle has performed investment due diligence on essentially every food waste digester in the U.S. built before 2021 – approximately two dozen – and in most cases was not able to offer a meaningful purchase price to the seller due to the need for complete re-design/rebuild.

Government grant funding aimed at reducing the capex of ADs in the past has been expensive for taxpayers and unsuccessful. Therefore, it is important for California to put an effective suite of policies in place to enable the private sector to both invest in building *and* operating fleets of high-quality food waste digesters, otherwise it will not meet its goals. These conclusions are based on extensive experience and lessons we've gleaned from:

- The barriers we have experienced in our work to finance, build, and operate high-quality fleets of ADs,
- Our comparison of food waste AD relative to dairy manure AD, and
- The proven success of food waste AD targeted policies in many countries in Europe, Scandinavia, and Canada.

Accordingly, we recommend a list of policies and incentives below to help spur rapid investment in high-quality food waste anaerobic digestion infrastructure in California.

*What is Needed to Make Food Waste Recycling a Success in California?*

Generate Upcycle proposes the following actions to enable the achievement of SB 1383's organics diversion requirements:

**Site Availability**

- Facilitate the use of public sector owned land and sites where possible to expedite infrastructure buildout.
    - Assess state-owned sites, including POTWs, for use as food waste ADs.
    - Rezone publicly owned land since little properly zoned land exists, let alone sites near major population and food manufacturing hubs.
- Incentivize private landowners to sell properly zoned property through tax exemptions or other incentives for the purpose of building food waste AD facilities.

**Permitting**

- Establish a department within CalRecycle to oversee food waste recycling project permitting and development and vest this body with sole responsibility for issuing the appropriate permits in a streamlined manner.
    - Approve a streamlined permitting process for food waste AD projects that encompasses:
        - Zoning / Conditional Use Permits,
        - Waste permitting,
        - CEQA,
        - Regional Water Quality Board, and
        - Air Permits.
    - Create a robust definition of food waste and develop a new Food Waste Permit that allows for all types of food waste included in this definition to be received at food waste AD facilities.

**Development Costs**

- Create a development cost risk reduction program. This could be designed as a cost share, or partial reimbursement, or similar mechanism.
    - This would spur progress and incentivize development capital, the hardest capital to source.
    - This would stretch public dollars much further than capital/construction grants since development costs are a fraction of total project capital costs.
    - This kind of subsidy would enable far more developers to get involved in food waste recycling.

**Waste Collection**

- Continue with implementation of SB 1383 and create stronger incentives and prohibitions for food waste diversion of all types via a mix of strategies, including:
    - Phase in stricter enforcement of SB 1383, including the implementation of fines where diversion plans have not been put in place. Ensure that revenues from fines collected are dedicated to organic waste program enforcement efforts.
    - Focus on/incentivize single family residential separation and broader SSO collection via educational programs, collaborations with large generators (like grocery stores and universities), etc.
    - Allow for changes to existing waste collection agreements with private sector franchisees to force implementation of residential SSO collections.
    - Incentivize long-term commitments/pass throughs from waste generators to haulers to food waste AD facilities.

        - Create a "Landfill Diversion Credit" from the state for each ton diverted by a waste generator, in the form of a $/ton value that could be implemented as a tax credit for, or direct payment to the waste generator.
    - Prohibit the land application of non-digested industrial food waste (Note: it is unclear whether this is currently allowed in CA or not.)
    - Mandate food waste generators of a certain size (i.e., tons per week) to divert to the nearest operational facilities (compost for now, AD in the future).
        - Mandates do not work when exemptions are easily obtained and/or when they are not enforced. This has been the experience thus far in New York State.
        - Practically this is hard to enforce without an army of waste auditors; so either strict prohibitions on landfill diversion to sites other than ADs or compost facilities, or incentives will be the most effective way to achieve this goal.

**Energy**

- Create access to reliable, high-value and long-term PPA or RNG offtake contracts for food waste AD projects, in the range of $200-300/MWh or $30-40/MMBTU with inflators for both.
    - In general, it is easier to transmit policy change through utility companies regulated by PUCs than through the waste industry. Making the energy revenues of food waste AD projects high enough that the feedstock procurement cost and low tip fees become less relevant to the financial return of the project (i.e., follow the European policy model) will accelerate the deployment of food waste management infrastructure in California.

**Digestate**

- Direct CDFA to make a state designation for digestate to be treated as an organic fertilizer.
    - Allow digestate to be valued as a fertilizer product, not categorized as a waste product.
    - Establish the regulatory framework required to ensure digestate meets certain quality standards (i.e., related to nutrient value, absence of contamination, etc.), and is applied properly as any fertilizer is (i.e., using approved nutrient management plans).

**Workforce**

- The skilled workforce needed will ultimately be developed by private markets, but it will take time and resources, so state governments can help accelerate workforce development by:
    - Providing tax incentives to companies who provide on-the-job retraining of fossil fuel industry workers in food waste AD jobs as part of a just transition, and
    - Providing scholarships for AD training schools.

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