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Comparison of Select Food Waste Utilization Options

This document provides a comparison of several food waste utilization options: landfill gas capture, anaerobic digestion, and composting, across various metrics. These options are the most prevalent pathways for energy and resource recovery. Other options, not considered here, include food donation, animal feed, incineration, and gasification. The table below describes the differences or similarities between these processes and provides information about products, the number of current projects in the United States, capital and operation and maintenance (O&M) costs, job development potential, emissions, and incentives associated with each pathway, as well as other parameters, such as level of complexity, land requirement, and revenue type. Sources for the data in the table are listed in the references at the end of the document.

	Landfill Gas Capture	Anaerobic Digestion	Composting
Process	**Anaerobic (without air):** a biological process in an enclosed environment where microorganisms break down biodegradable material in the absence of oxygen		**Aerobic (with air):** a biological process in open air environment where microorganisms break down biodegradable material in the presence of oxygen
Product	Biogas is an intermediate product used to produce: • Electricity • Heat • Renewable natural gas (RNG) for use as a transportation fuel (compressed natural gas/liquefied natural gas) or injected into the natural gas pipelines.		Compost is the product.
		Other products include digestate (solid and liquid) that can be used as fertilizer, animal bedding, building materials, pellets, for crop irrigation, etc.	
Number of Projects in the United States	• 550 sites (2021) – 93 direct use in thermal applications – 386 sites creating electricity – 71 sites creating RNG • 11 sites under construction (most RNG) • 57 sites planned (most RNG)	• 209 sites processing food waste (2019) – 68 stand-alone facilities – 59 on-farm co-digesters – 82 co-digestion systems at water resource recovery facilities • Most facilities produce heat and/or power and several produce RNG.	• 3,013 total sites (2020) • 10% of these site process food waste either alone or combined with other organic materials. • About 31% of facilities have not specified their feedstock; thus, more sites likely accept food waste. • About 51% of sites use yard waste either alone or combined with other organic materials. • The remaining sites use biosolids and manure either alone or combined with other organic materials. • Most sites use multiple organics.
Capital Cost	See tables below	**Capacity in tons/year:** modeled cost (million USD)* • 2,500: $3.0 • 5,000: $4.7 • 25,000: $12.3 • 50,000: $18.6 • 100,000: $28.2 • 200,000: $42.7 *Biogas production only, no upgrading costs included. Numbers are adjusted to $2020.*	**Capacity in tons/year:** examples of costs (million USD)* • 1,800: $1.7 (ASP) • 5,200: $2.6 (ASP) • 30,000: $4.3 (Windrow) • 40,000: $8.9 (ASP) • 180,000: $25 (ASP) *ASP is aerated static pile. Numbers are adjusted to $2020.*

Landfill Gas Capture – Capital Cost

Projects With No GCCS Installed (million USD)*

Waste in Place (million tons)	Direct Use	Electricity	RNG
< 5	$4.3	$7.3	$12.5
5–10	$6.9	$15.7	$19.5
10–20	n/a**	$23.3	$29.3
> 20	n/a**	$33.4	$47.0

Projects With GCCS Installed (million USD)*

Waste in Place (million tons)	Direct Use	Electricity	RNG
< 5	$2.5	$5.6	$10.7
5–10	$3.6	$12.4	$16.1
10–20	n/a**	$19.1	$25.1
> 20	n/a**	$25.7	$39.4

**GCCS is gas collection and control system. Modeled cost data are for 2020.*
***n/a – not applicable. Outside of the recommended project size for direct use projects in the LFGcost-Web model.*

	Landfill Gas Capture	Anaerobic Digestion	Composting
Operation and Maintenance (O&M) Cost	see tables below	**Capacity in tons/year:** modeled cost (thousand USD)* • 2,500: $85 • 5,000: $171 • 25,000: $854 • 50,000: $1,707 • 100,000: $3,415 • 200,000: $6,830 *Biogas production only; no upgrading costs included. Numbers are adjusted to $2020.*	**Capacity in tons/year:** example costs (thousand USD)* • 1,800: $247 (ASP) • 25,000: $362 (Windrow) • 30,000: $437—$765 (Windrow) • 40,000: $1,000 (ASP) *ASP is aerated static pile. Numbers are adjusted to $2020.*
Jobs	see tables below	**Job development potential:** 1.03 jobs per 1,000 tons.* *2020 data*	**Capacity (tons/year):** full-time equivalent jobs:* • < 5,000: 1–8 • 5,000–20,000: 2–10 • > 20,000: 5–26 *2013 data*

Landfill Gas Capture

Operation and Maintenance (O&M) Cost

Projects With No GCCS Installed (thousand USD)*

Waste in Place (million tons)	Direct Use	Electricity	RNG
< 5	$426	$939	$1,632
5–10	$890	$2,375	$3,971
10–20	n/a**	$3,732	$6,230
> 20	n/a**	$5,792	$9,167

Projects With GCCS Installed (thousand USD)*

Waste in Place (million tons)	Direct Use	Electricity	RNG
< 5	$156	$670	$1,361
5–10	$312	$1,797	$3,393
10–20	n/a**	$2,923	$5,420
> 20	n/a**	$4,018	$7,393

**GCCS is gas collection and control system. Modeled cost data are for 2020.*
***n/a – not applicable. Outside of the recommended project size for direct use projects in the LFGcost-Web model.*

Jobs

Construction*

Waste in Place (million tons)	Direct Use	Electricity	RNG
< 5	11	23	38
5–10	15	51	52
10–20	n/a**	79	75
> 20	n/a**	106	112

Operation*

Waste in Place (million tons)	Direct Use	Electricity	RNG
< 5	1	5	8
5–10	2	13	18
10–20	n/a**	20	28
> 20	n/a**	28	37

**2020 data*
***n/a – not applicable. Outside of the recommended project size for direct use projects in the LFGcost-Web model.*

	Landfill Gas Capture	Anaerobic Digestion	Composting
Emissions	**Net GHG Emissions from Landfilling ($MTCO_2E$/ton)*** • Landfills without Landfill Gas Recovery: 1.39 • Landfills with Landfill Gas Recovery and Flaring: 0.54 • Landfills with Landfill Gas Recovery and Electricity Generation: 0.42 **Estimates are for 2020. $MTCO_2E$/ton - metric tons of CO_2 equivalent per short ton*	**Net GHG Emissions ($MTCO_2E$/ton)*** • Dry AD with digestate curing: -0.04 • Dry AD with direct land application: -0.10 • Wet AD with digestate curing: -0.06 • Wet AD with direct land application: -0.14 **Estimates are for 2020. Negative values denote net GHG emission reductions or carbon storage from a materials management practice.*	**Net GHG Emissions ($MTCO_2E$/ton)*** • -0.12 **Estimates are for 2020. Negative values denote net GHG emission reductions or carbon storage from a materials management practice.*
Incentives	• **Federal:** renewable fuel standard • **Regional/State:** renewable energy certificates • **State:** California and Oregon low-carbon fuel standards, state loan programs, renewable portfolio standards, personal tax credit, corporate tax credit, state grant programs, sales tax incentives, property tax incentives, green power purchasing • **Utility:** rebates, net metering, performance-based incentives		**State and Local** programs, incentives, rebates, free services and materials, for example: • New York State Food Waste Reduction and Diversion Reimbursement Program • Austin, Texas, Zero Waste Event Rebate • Richmond, California, free residential composting • Denver, Colorado, free public schools composting.
Other	• No source separation required	• Source separation required	• Source separation required
	• The systems produce about half the amount of biogas from a given volume of organic material processed in anaerobic digesters	• Optimized to maximize the conversion of organic material to biogas	• No biogas production
	• Energy input is required in the process and can be supplied by own production	• Energy input is required in the process and can be supplied by own production	• Energy input is required in the process but can't be supplied by own production
	• Revenue from tipping fees, selling electricity or RNG, and relevant incentives	• Revenue from tipping fees, selling electricity or RNG, and relevant incentives. Additional revenue from digestate sale.	• Revenue from tipping fees, compost sale, and relevant incentives
	• Moderate to high complexity	• Moderate to high complexity (modern systems have become easier to operate and maintain)	• Low (windrow), moderate (ASP), or high (in-vessel) complexity
	• High level of training needed to run the system	• High level of training needed to run the system	• Lower level of training needed to run the system
	• High standards of maintenance and management are required	• High standards of maintenance and management are required	• High standards of maintenance and management are required
	• A properly designed and operated system is very safe. Strict gas-handling standards must be maintained.	• A properly designed and operated system is very safe. Strict gas-handling standards must be maintained.	• A properly designed and operated system is very safe. Safety risks associated with operating large, mobile machinery.
	• Land area: 1–2,290 acres	• Land area: 3–6 acres. Modern systems are streamlined to reduce footprint.	• Land area: 15–20 acres for windrow, 6–8 acres for ASP, and 3–6 acres for in-vessel composting

	Landfill Gas Capture	Anaerobic Digestion	Composting
Other (cont.)	• Increased community traffic	• Increased community traffic	• Increased community traffic
	• NIMBY concerns	• NIMBY concerns	• NIMBY concerns
	• Reduction of landfill odor	• Enclosed systems designed to contain odor. However, if run inefficiently, may cause odor (e.g., digester spills)	• Heavy odor associated with windrow composting; odor control possible with ASP; no odor issues with in-vessel composting

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Operation and Maintenance (O&M) Cost

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Emissions

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Incentives

- Database of State Incentives for Renewables & Efficiency (DSIRE): https://www.dsireusa.org/
- New York State Food Waste Reduction and Diversion Reimbursement Program: https://www.rit.edu/affiliate/nysp2i/collaborations
- Austin, Texas, Zero Waste Event Rebate: http://www.austintexas.gov/zweventrebate
- Richmond, California, free residential composting: https://www.ci.richmond.ca.us/1718/Residents
- Denver, Colorado, free public schools composting: https://denvergov.org/Government/Departments/Recycle-Compost-Trash/Resources/Denver-Public-School-Partnership#section-6

Other

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