ANAEROBIC DIGESTION REPORT 2026





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Overview of Anaerobic Digestion

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Anaerobic digestion (AD) is a biological process using microorganisms to break down organic matter, typically from agricultural materials (e.g. manure or crop residues) or industrial sources (e.g. processing wastes, food wastes, or wastewater) in the absence of oxygen (Rehman, Iqbal, Chang, Li, & Ju, 2019; Samoraj, et al., 2022). This process results in two products: methane-rich biogas and a nutrient-rich fertilizer known as digestate. As livestock production and food waste continue to increase, AD offers a promising solution for waste management, renewable energy generation, and resource recovery. Its simplicity and ability to produce both renewable energy and valuable agricultural inputs can make it a scalable and competitive alternative to traditional waste management methods (Samoraj, et al., 2022).

AD takes place in sealed, oxygen-free environments called digesters. Although digester designs vary, they all rely on the same natural biological processes to break down organic materials into biogas (US EPA, 2025), which is almost identical to the processes that occur during ruminant digestion. This technology has been commercialized and used in a variety of settings, including:

- Farm-based facilities: Use manure, agricultural residues, energy crops, and other plant materials to produce biogas on-site.
- Food, beverage, paper, and pulp facilities: Convert processing waste and residues into biogas, often for on-site energy use.
- Municipal facilities: Process sewage sludge, landfill gas, and collected food waste.
- Industrial facilities: Produce biogas from supermarket waste, catering waste, and other locally available organic materials (European Commission, 2025)

By Products

Biogas

Biogas is the main product of AD and offers a renewable alternative to fossil fuels. It consists mainly of methane and carbon dioxide, with smaller amounts of hydrogen sulfide, ammonia, and moisture (Lima, Appleby, & Li, 2023; Samoraj, et al., 2022). Biogas can be used directly to generate heat and electricity using combined heat and power systems, or to fuel boilers, engines, and vehicles.

The potential uses of biogas depend on its quality. Raw biogas contains carbon dioxide, water vapor, and trace contaminants that reduce its energy efficiency. When purified to separate these compounds, biogas can be used in higher-efficiency equipment, injected into natural gas pipelines as renewable natural gas (RNG), or converted into compressed natural gas (CNG) or liquefied natural gas (LNG) for transportation fuel (Morris, et al., 2025; Lima, Appleby, & Li, 2023; US EPA, 2025). An example is Prairie's

Edge Dairy Farm, a member of Fair Oaks Farms in Indiana, which upgrades biogas to compressed natural gas (CNG) to fuel its 42-truck fleet, reducing reliance on diesel while lowering operating costs and greenhouse gas emissions (US EPA, 2026).

Digestate

One of the attractive benefits of AD is that the process does not consume nitrogen, phosphorus, or potassium. Rather, these agronomically-relevant nutrients are conserved into the digestate. Digestate is the nutrient-rich by-product of AD that can be separated into liquid and solid fractions, both of which contain organic matter and essential plant nutrients such as nitrogen (Samoraj, et al., 2022). When properly managed, digestate can improve soil fertility, soil structure, and crop productivity while reducing reliance on synthetic fertilizers, including in intensive cropping systems such as wheat and maize production (Samoraj, et al., 2022). Long-term field evidence supports these benefits. For example, a 12-year study conducted on a farm in southeast Iowa found that digestate replaced nearly all synthetic nitrogen fertilizer applied to corn fields (Villarino, et al., 2025).

Digestate is often separated into a liquid and solid fraction through a screw press. The liquid fraction contains the majority of the nutrients, particularly nitrogen, and is most commonly applied directly to fields as fertilizer, but also occasionally used in fertigation (applying liquid fertilizer through irrigation systems) or even hydroponics (growing plants in nutrient-rich water without soil). The solid fraction can be used as a soil amendment, livestock bedding, or processed into products such as fiber-based materials and biodegradable flowerpots and seed planters (Morris, et al., 2025; Samoraj, et al., 2022). In addition, emerging post-digestion technologies can recover nutrients such as nitrogen and phosphorus from digestate to produce concentrated fertilizers (US EPA, 2025).

Market Growth

According to Grand View Research (2026), the global AD market is projected to grow from USD 18.07 billion in 2025 to USD 39.42 billion by 2033, representing a compound annual growth rate of 10.3%. This growth is driven by rising demand for renewable energy, increasing organic waste generation, and stricter environmental regulations aimed at reducing greenhouse gas and methane emissions. Governments, municipalities, and industries are increasingly adopting anaerobic digestion to convert waste into biogas and renewable natural gas, helping reduce landfill use and support decarbonization efforts. Market growth is also supported by policy incentives, such as tax credits, feed-in tariffs, and carbon-reduction programs, as well as technological advancements that improve system efficiency and methane yields.

Agriculture currently represents the largest share of the market, while food waste is expected to be the fastest-growing feedstock segment. Regionally, Europe leads the market, while the United States is experiencing strong growth due to supportive policies and increased investment in RNG infrastructure (Fortune Business Insights, 2026; Grand View Research, 2026).

Rural Economic Development

Anaerobic digestion (AD) can support rural economic development by creating new income streams, jobs, and local business opportunities. Farmers can generate additional revenue by supplying manure, winter crops, perennial grasses, and other organic materials to biogas or renewable natural gas (RNG) facilities, creating markets for underutilized agricultural by-products (Grand View Research, 2026; Villarino, et al., 2025). In addition to generating income, AD can reduce farm input costs by using digestate, which can replace or supplement synthetic fertilizers (Villarino, et al., 2025). Because digestate is an organic fertilizer, it may help farmers access organic markets and earn premium prices for their

produce. In addition, digestate can contribute to weed management by improving crop competition and reducing weed pressure, potentially lowering herbicide and weed control costs (Clements, Salter, Banks, & Poppy, 2012).

Furthermore, the economic benefits from AD often remain within rural communities because biogas can be used near the feedstock source, and nearby farms can supply the feedstocks for the technology and receive a payment, similar to how commodities are sold. This technology can support on-farm energy independence, with most farms producing more energy than they consume and selling surplus electricity to the local grid, creating an additional revenue stream while helping utilities meet growing energy demand with locally sourced renewable energy (Morris, et al., 2025; US EPA, 2025). For example, Reinford Farms in Mifflintown, Pennsylvania, converts manure- and food waste-derived biogas into electricity that is sold back to the grid while using recovered heat from the digester to dry corn, heat the houses on site, provide hot water, and pasteurize calf milk, eliminating on-farm energy costs (US EPA, 2026). Similarly, at the municipal level, AD facilities can reduce energy costs by generating electricity for local use, while compost and digestate by-products may be sold or used in public landscaping projects, creating additional savings and revenue (Lima, Appleby, & Li, 2023; Adami, Schiavon, Torretta, Costa, & Rada, 2020).

Beyond benefits to individual farms and municipalities, expanding AD can stimulate broader rural economic development by attracting processing facilities that create skilled jobs and can expand the local tax base. For example, the Green Energy Park, an agricultural waste-to-energy facility in Arlington, Kentucky, is expected to create about 20 high-wage jobs while producing renewable energy, food-grade carbon dioxide, and digestate that will be returned to farmers as fertilizer (Lewis, 2026).

Climate Adaptation

Anaerobic digestion captures biogas, preventing the uncontrolled release of methane, a potent greenhouse gas, while reducing reliance on fossil fuels and helping meet energy demand with lower emissions (Samoraj, et al., 2022; Veolia, n.d.; Chen & Neibling, 2014; US EPA, 2026). The process can also reduce odors by an average of 98% and substantially lower pathogen levels (Orzi, et al., 2015). By stabilizing manure before application, it improves water and air quality by lowering odor emissions and reducing the risk of nutrient runoff and pathogen contamination of water sources associated with untreated manure management (Samoraj, et al., 2022; Chen & Neibling, 2014; Scarlat, Dallemand, & Fahl, 2018).

Furthermore, digestate provides nutrients in forms more readily available for plant uptake, reducing nutrient runoff often associated with synthetic fertilizers and further improving water quality (Samoraj, et al., 2022; US EPA, 2026). Additionally, integrating AD systems on farms can further support conservation practices, such as growing perennial prairie for feedstock, which help reduce erosion and nutrient loss (Villarino, et al., 2025). By reducing waste sent to landfills, recovering valuable resources, and supporting compliance with environmental regulations, AD contributes to a more circular and resilient agricultural system (Morris, et al., 2025; Scarlat, Dallemand, & Fahl, 2018).

Opportunities and Challenges

Opportunities

AD offers several opportunities as a value-added technology. One major opportunity is co-digestion, where manure is combined with food waste, crop residues, grasses, or other organic materials to increase energy production, improve profitability, and increase fertilizer production. Farmers can receive tipping fees for accepting food waste, while the added feedstocks can improve the carbon-to-nitrogen ratio (which is important for process optimization), increase methane production, and improve process stability compared with manure-only systems (Samoraj, et al., 2022; Chen & Neibling, 2014; US EPA, 2026). Another example is Iowa State University's Grass2Gas initiative, which has been studying how the use of herbaceous feedstocks, such as perennial grasses, prairie vegetation, and cover crops, with or without manure, can produce biogas while also improving soil health, water quality, providing wildlife habitat, and bolster the productive use of marginal cropland (Morris, et al., 2025; Villarino, et al., 2025; Iowa State University, 2024). This concept is currently being demonstrated at commercial scales, with one farm in Eastern Iowa already adopting this approach (Villarino, et al., 2025).

AD also presents opportunities at the community scale. Because many individual farms may not generate enough manure or biomass feedstock to support profitable digester projects, community-scale systems can aggregate feedstocks, create local biogas markets, and support the development of biorefineries that produce multiple products beyond energy. To support these opportunities, cooperative business models can bring together farmers and private investors to share costs, risks, and financial returns (US EPA, 2026).

Broader market trends are also improving the outlook for anaerobic digestion. Continued advances in digester technology and biogas upgrading are improving system efficiency and reliability, while expanding renewable gas infrastructure, carbon credit programs, strategic partnerships, and supportive policies are creating additional revenue opportunities and making AD projects increasingly economically competitive (Grand View Research, 2026; Morris, et al., 2025).

In addition, AD systems can support agritourism and educational opportunities by giving visitors opportunities to learn about renewable energy and sustainable agriculture. For example, Fair Oaks Farms in northwest Indiana incorporates its digester system into tours of its dairy and swine operations, using the technology to educate the public about environmental stewardship and food production while generating additional revenue (US EPA, 2026).

Challenges

Anaerobic digestion faces several challenges that can limit its growth as a value-added technology. A major barrier is the high upfront capital required for digesters, biogas-upgrading equipment, feedstock-handling systems, and grid connection infrastructure. For many small and mid-sized farms, municipalities, and businesses, these costs can outweigh short-term financial returns, making projects difficult to pursue without financial support (Grand View Research, 2025; Fortune Business Insights, 2026; Veolia, n.d. (Adami, Schiavon, Torretta, Costa, & Rada, 2020). To help address these barriers, programs such as the USDA's Rural Energy for America Program (REAP) Guaranteed Loans and grants provide financial assistance to agricultural producers and small rural businesses investing in renewable energy and energy efficiency projects (USDA, Rural Development, n.d.). Building out digester projects at the community scale is another potentially viable approach to allow small and mid-sized farms to benefit from this technology.

Operational and logistical constraints also affect project viability. AD depends on a consistent feedstock supply, yet collecting and transporting biomass over long distances can be costly and impractical. Feedstock shortages, poor waste segregation, transportation costs, and supply chain challenges can reduce biogas output and profitability (Samoraj, et al., 2022; Fortune Business Insights, 2026). In addition, digesters require skilled labor, ongoing maintenance, and careful operational control, as system performance can be sensitive to temperature changes, pH imbalance, and inconsistent organic loading (Veolia, n.d.).

Regulatory and market conditions present additional challenges. Lengthy permitting processes, uneven policy support, evolving regulations, and fluctuations in renewable natural gas prices can slow project development and create uncertainty for investors (Grand View Research, 2026; Veolia, n.d.). Anaerobic digestion also competes with other renewable energy technologies such as solar, wind, and battery storage, which have experienced rapid cost declines, attract investment more easily, and can often be deployed faster and at larger scales (Fortune Business Insights, 2026).

Conclusion

Anaerobic digestion is a promising value-added strategy that supports both rural economic development and climate adaptation by converting organic waste into renewable energy and nutrient-rich fertilizer products. It can create new income opportunities for farmers, municipalities, and rural businesses while reducing farm input costs, supporting local jobs, and improving environmental outcomes such as lower greenhouse gas emissions, better air and water quality, and healthier soils.

Emerging opportunities, including co-digestion, community-scale facilities, renewable natural gas production, and biorefineries, could further expand the economic and environmental benefits of AD systems. However, broader adoption still faces challenges, including high upfront costs, feedstock supply and transportation constraints, and policy uncertainty. Continued investment, innovation, financial incentives, and supportive policies will be important for improving the long-term viability and expansion of anaerobic digestion systems.

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