

The Conversion Process

The production of biomethane as a fuel, and digestate as an organic fertilizer, through the process of anaerobic digestion, plays a critical role in the efforts to realize both environmental and economic benefits. Conversion of biowaste to energy and usable digestate is a movement away from wasted resources and towards the utilization of waste as a usable resource. The process not only decreases the volume of waste; it also saves natural resources such as land and water.

It makes a contribution to long-term environmental and climate protection efforts by reducing carbon dioxide (CO₂) emissions, and by reducing the need for natural gas through drilling, thereby offsetting fossil carbon emissions. It also protects the air and climate because it reduces the greenhouse gases coming from the landfill. Such a process effectively delivers a closed and environmentally friendly carbon cycle.

Anaerobic digestion is a multi-step biological process with four fundamental steps that include hydrolysis, acidogenesis, acetogenesis, and methanogenesis. Throughout this entire process, large organic polymers that make up biomass are broken down into smaller molecules by microorganisms. Upon completion of the anaerobic digestion process, the biomass is converted into biogas, namely methane (CH₄) and carbon dioxide, as well as into digestate—liquid and solid.

To feed the anaerobic digestion process, organic waste in the form of lawn and tree cuttings, and food waste, such as fruit and vegetable waste, is recovered as source segregated organic (SSO) waste. When households or restaurants produce organic waste, it is collected separately from residual waste.

This ensures that the SSO does not come into contact with any contaminants that might be in the residual waste. In addition to the production and collection of biomethane, the anaerobic digestion process recovers and recycles the nutrients contained in this organic material. From the produced digestate, top-grade solid compost is produced, which is made available to nurseries, farmers, and market gardens. The process also pro-

duces liquid digestate, which is distributed for agricultural use as a certified organic liquid soil conditioner.

Continuous Dry Anaerobic Digestion

Although a number of processes can be employed to produce biogas, as well as solid and liquid digestate within an anaerobic environment, one approach in particular provides the most efficient method for the production of biomethane. That process is continuous dry anaerobic digestion, which is capable of producing the highest biogas yield from organic input material. One of the most efficient of these processes is Kompogas continuous dry anaerobic digestion, developed by Hitachi Zosen Inova, a global Engineering, Procurement, and Construction (EPC) contractor for thermal and biological energy-from-waste (EfW) plants. Understanding how Kompogas functions gives critical insight into the unique advantages of continuous dry anaerobic digestion for the production of biomethane, and solid and liquid digestate for nutrient-rich fertilizers.

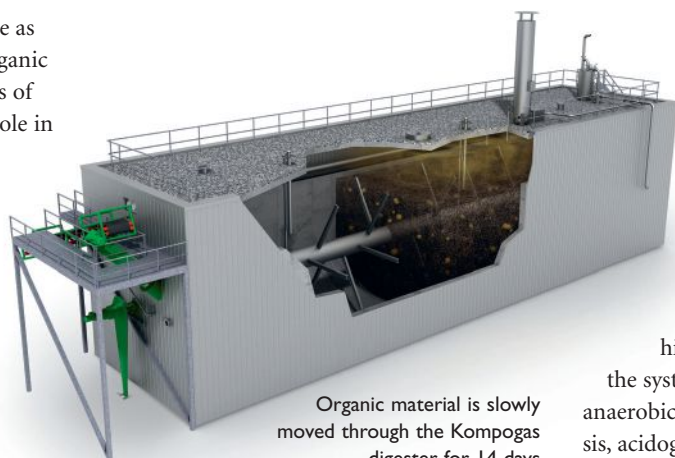
Uniquely different from other anaerobic digestion processes, due to the plug flow, the Kompogas digester creates an extremely efficient microorganism environment. This separates and optimizes the different steps of biomass degradation throughout the process much more effectively than conventional anaerobic digestion, making for very stable microbiology inside the reactor. The process recirculates approximately one-third of the digestate, rich in thermophilic micro-

organisms, from the output and back up front into the digester to activate and accelerate the anaerobic digestion process of the fresh material fed into the digester. This allows a perfect adjustment of the hydrolysis and acidogenesis rate in the digester feeding section and facilitates

high bioprocessing efficiency within the system. Conversely, with conventional anaerobic digestion, the key steps of hydrolysis, acidogenesis, acetogenesis, and methanogenesis are completely mixed. Each step takes place at the same time and at the same place in the digester. This does not permit optimum conditions for the microorganisms to digest the organic material.

If required, additional process water creates the optimal consistency for decomposition, with humidity residing around 70%. A specially developed heating system regulates the temperature during processing at 131°F (55°C). The thermophilic microorganisms decompose the organic matter and produce carbon-neutral biogas.

An anaerobic digestion retention period of 14 days at 131°F (55°C) and the plug flow ensure that spores and bacteria are eliminated. The digestate is completely sanitized during processing, and the biogas potential



Organic material is slowly moved through the Kompogas digester for 14 days



is fully exploited by the time the substrate comes out of the digester; hence, the system does not require any upstream pasteurization, compared to other solutions.

After receiving biomass into a Kompogas plant, the organic waste undergoes a pre-treatment process before entering the digester. To prepare for anaerobic digestion, a shredder chops the organic matter into small pieces which then are sieved to a maximum particle size of about 2 inches to remove impurities such as stones, plastics, and metal. The prepared biomass is then automatically conveyed to the digester feed-in point.

The Kompogas process is based on using a horizontal plug-flow digester. The organic material is transported inside the digester, with the material moving horizontally through the system by feeding on the inlet side and discharging on the outlet side. A slowly-turning agitator ensures that the substrate is optimally mixed within the digester, and the biogas bubbles are permitted to vent for a high-yield formation of methane. This facilitates the biological strength of the Kompogas anaerobic environment, enabling it to make maximum use of the organic waste's energy potential.

Once through the Kompogas dry anaerobic digestion processes, digestate is separated into a solid and a liquid phase. The solid digest can be treated further to produce high-quality compost that is utilized as organic fertilizer. Similarly, the liquid digestate is collected for use within the digester and as organic fertilizer. Liquid digestate-free organic waste treatment technology can also be implemented. Here, the digestate is mixed

with shredded green waste and coarsely structured sieved fraction from the composting process. The mixture then undergoes an intense two-week closed-tunnel composting process. This aerobic treatment substantially increases the dry material content by evaporating water due to self-heating of the biological activity.

Biomethane Upgrade

The raw biogas produced in the anaerobic digester, which is approximately 56% methane, is collected and can be used directly for power and heat generation in combined heat and power cogeneration units. It can also be used for heat generation in highly efficient gas-fired condensing heating systems.

But before distribution into the natural gas grid, the biogas must be upgraded, undergoing either physical (membrane) or chemical (amine scrubbing) processing. One of the leading systems utilizing these technologies is BioMethan upgrade, developed by HZI, which is profiled here for example.

By means of membrane-based gas permeation, the raw biogas is dried, then desulphurized, and the low-calorific carbon dioxide is subsequently separated using membrane modules. These consist of several thousand extremely fine hollow fibers—the ends are embedded in resin and bundled in stainless steel pipes. The membranes are characterized by high pressure and temperature resistance, pressure stability, and different gas permeability.

The above-average carbon dioxide and methane selectivity allow for methane purity of 97% and methane slip of below 0.5%.

Then there is the heat-driven amine scrubbing process. The raw biogas is dried and desulphurized, and the low-calorific carbon dioxide is separated, with the CH₄ upgraded to natural gas quality—so-called biomethane. Amine scrubbing is a highly efficient and economical process technology, with methane purity of up to 99% and methane slip of below 0.1%.

The membrane process has an electricity demand of 0.24 kWh/m³ biogas. The amine scrubbing process has an electricity demand of 0.24 kWh/m³ biogas and a heat demand of 0.6 kWh/m³ biogas.

Determination of which gas upgrade process would be more applicable for a given situation would depend on several factors, including a) the quality of biomethane required; b) availability of heat; c) cost of

electricity; and d) the biomethane slip.

The upgrading of biogas to biomethane offers particular potential, with a wide range of possible applications. Injected into the natural gas grid, biomethane is efficiently stored and transported to the nearest, most suitable location. This flexibility is beneficial for both municipalities and large industries in generating energy, providing an economical heat supply, and improving their carbon footprint. Due to its high quality, biomethane is perfectly compatible with existing technical facilities. It is comparable to conventional natural gas and is used as a renewable fuel in natural gas vehicles. Comparatively, for the same amount of heat or electricity generated, the biomethane produced from upgrade processes produces 80% less greenhouse gas emissions compared to burning natural gas as a fossil fuel. For many municipalities and their residents who are largely environmentally conscious, biomethane is the energy preferred over natural gas.

Integration of Continuous Dry Anaerobic Digestion with Biomethane Upgrade

Conventional plants providing anaerobic digestion with subsequent biomethane upgrade are typically constructed using process systems from different suppliers. This presents limitations in system continuity and design flexibility, which can inhibit overall plant performance.

With the integration of Kompogas continuous dry anaerobic digestion and BioMethan upgrade processes—both systems provided by Hitachi Zosen Inova as a singular fully-integrated and completely automated system—plant design flexibility and operational efficiency can now be optimized for maximum production. This allows plant operators to more efficiently design for both small-batch or large-scale production operations.

Continuous dry anaerobic digestion, coupled with biomethane upgrade, contributes to a versatile energy mix, along with reducing dependency on natural gas imports, ultimately contributing to the reduction of climate change due to reduced carbon dioxide emissions. Recent improvements in these systems' technology, design flexibility, and operational performance have made major strides toward supporting these initiatives. **MSW**

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