The Other Bioenergy Solution

The case for converting organics to biogas

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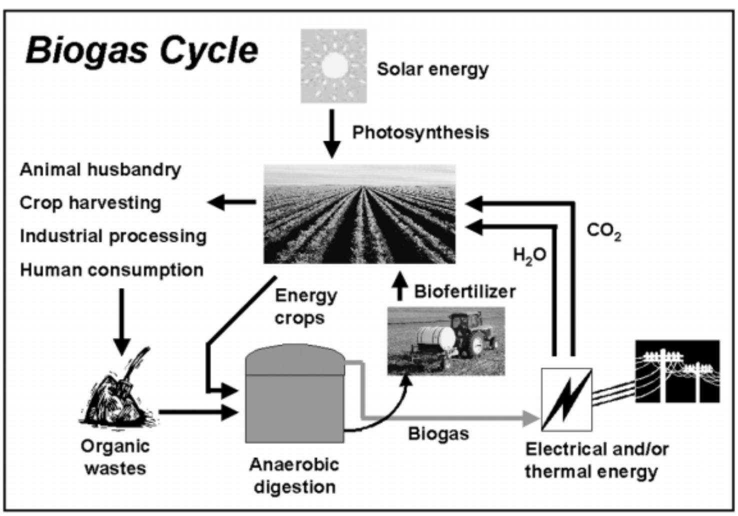
The rising cost of gasoline and electricity has clearly focused attention on the need to develop alternative fuels. Indeed, America's reliance on fossil fuel-based energy sources has major implications not only for our economy and national security, but also for world peace and the global environment. Given the rate at which we are depleting finite energy resources, our current *modus operandi* is obviously not sustainable. To meet world energy demands and stabilize greenhouse gas concentrations, unprecedented technology changes are urgently required – before we reach a crisis point. Engineering a major infrastructure realignment that is based on renewable energy is no small task. However, "the Stone Age did not end for lack of stones."

Despite the general preference for liquid fuels to support our transport-intensive economy, there is another form of energy that merits equal attention. We have technology available today to produce energy from organic wastes, an age-old biological process called anaerobic digestion. Finding solutions to the waste problems generated by human activity has occupied agricultural and biological engineers for decades. But waste is part of the solution to the energy problem. Using anaerobic digestion, we can generate biogas from readily available animal manures, crop residues, and industrial and municipal wastes.

Waste-to-biogas is a sustainable energy solution that is renewable, carbon dioxide neutral, and locally based, thereby protecting the environment, creating jobs, and strengthening local economies.

Also, the potential for biogas production from energy crops (e.g. cereals, grasses) is similar to that for bioethanol and biodiesel production where crops are grown, harvested, and processed into liquid biofuels.



Anaerobic digestion

Anaerobic digestion occurs naturally in anaerobic environments, such as landfills, sediments, saturated soils, and animal intestinal tracts. It is essentially the same process, albeit operating over a much longer period, that has created the world's fossil fuel reserves (coal, oil, natural gas). Thus, the biogas cycle is a natural process that reduces the biological turnover time of carbon energy (see diagram).

Anaerobic digestion is a process by which a complex mixture of symbiotic microorganisms transforms organic materials under oxygen-free conditions into biogas, a mixture of mostly methane and carbon dioxide. In practice, anaerobic digestion is the engineered methanogenic decomposition of organic matter in reactor vessels that are relatively simple to construct and operate. As much as 90 percent of the biodegradable organic fraction of a waste can be stabilized in anaerobic treatment by conversion to methane gas. From the process engineering viewpoint, anaerobic digestion is a relatively straightforward process, even if the biochemical processes involved are themselves rather complex. Since the process uses a mixed microbial culture, no sterilization step is required and the diversity of microbial species confers fermentation stability and substrate independence. Methane is relatively insoluble and cannot build up to inhibitory concentrations in the reaction mixture. Product separation is automatic as the biogas separates itself from the aqueous phase.

Biogas use

Methane, the main constituent of biogas, is a flexible form of renewable energy that can produce heat, electricity,

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and serve as a vehicle fuel. Biogas can be used for all applications designed for natural gas, which is also composed primarily of methane. Biogas can be upgraded and fed into natural gas pipelines, extending the use of existing infrastructure beyond the anticipated decline of natural gas reserves. Unlike fossil fuels, use of renewable resources represents a closed carbon cycle and therefore does not contribute to increases in atmospheric concentrations of carbon dioxide. In effect, anaerobic digestion is a carbon dioxide neutral solution.

Using biogas conserves fossil fuels, allowing limited resources to be utilized more effectively, e.g. reserving oil specifically for transportation. However, biogas can also be used for mobile applications, providing reduced vehicle emissions compared with gasoline. Sweden has the largest fleet of biogas-fueled vehicles (buses and cars) and recently began operation of the world's first biogas-powered passenger train. The retrofitted train runs on biogas produced by co-digestion of slaughterhouse wastes and sewage.

Environmental benefits

The benefits of anaerobic digestion translate directly into practical and economic benefits that contribute to long-term sustainability. Under controlled conditions, anaerobic digestion offers a holistic treatment solution that stabilizes wastes, controls odors, reduces pathogens, minimizes environmental impact from waste emissions, and maximizes resource recovery while simultaneously being a net energy producer. Livestock manure, for example, has significant resource potential – all animal manures are valuable sources of crop nutrients – and manure represents a substantial bioenergy resource if processed by anaerobic digestion.

The co-products of anaerobic digestion – mineralized nutrients and fiber – reduce the need for synthetic fertilizers and soil conditioners that are produced using less sustainable methods, providing cost savings and environmental benefits. Since sludge production in anaerobic digestion is minimal, virtually all of the nitrogen and phosphorous contained in the original feedstock is retained in the digested effluent. Application of digestate to agricultural lands at appropriate rates for nutrient uptake conserves energy by reducing demand for energy consuming synthetic fertilizer production.

Significant energy conservation can also be achieved by the application of anaerobic digestion instead of conventional aerobic processes in wastewater treatment. The energy savings from avoiding aeration for chemical oxygen demand reduction can exceed the energy contained in the biogas produced. These energy savings can reduce electric utility demand and allow this power to be more productively applied elsewhere in industrial or residential sectors. Further, transitioning from aerobic to anaerobic processes for municipal wastewater treatment minimizes production of biosolids and associated disposal problems, thereby avoiding even more fossil fuel consumption.

Anaerobic digestion reduces the potential for global climate change in two ways. First, by capturing biogas, anaerobic digestion reduces natural emissions of methane. By mass, methane has 21 times the global warming potential of carbon dioxide over a 100-year timeframe and methane accounts for almost 10 percent of U.S. greenhouse gas emissions. Second, when anaerobic digestion produces biogas to replace fossil fuels, production of fossil carbon dioxide from burning those fuels is avoided.

Perspectives

Increased bioethanol and biodiesel production leading to oversupply of distillers dried grains and glycerol can lead to lower prices for these commodity co-products. Anaerobic digestion can be used to treat stillage from bioethanol production to produce biogas and biofertilizer. The biogas can be used on-site in the biorefinery, improving net energy balance, and the biofertilizer can be reapplied to the energy crops in an organic nutrient cycle *sans* additional fertilizer input. Similarly, glycerol from biodiesel production can be converted to biogas. Biogas in turn can be converted to methanol, an ingredient used in biodiesel production.

Bioethanol and biodiesel also impact land use and compete with food and feed production and, hence, are susceptible to market forces. Biorefineries could switch to food production depending on market prices, causing disruption to energy supplies. By contrast, biogas from organic wastes is a more reliable energy source, based on abundant feedstocks that do not compete in the marketplace and are largely regarded as a cost and environmental burden.

Almost a quarter of America's primary energy consumption is natural gas. Increased demand has led to escalating prices, leading in turn to higher imports and new exploration. However, fossil fuel exploration and expansion of oil and gas pipelines into wilderness regions, undeveloped lands, and coastal waters is a costly undertaking in pursuit of limited resources, with major environmental impacts. Society would be infinitely better served by directing its intellectual and financial capital to developing renewable energy technologies. Given the diversity of feedstocks and ease of product recovery, methane from organic wastes and energy crops can be a major sustainable energy source. The technology is flexible, being applicable at any scale and location. Expanded implementation of biogas technology can make society more resource efficient, foster innovation in environmental technologies, and build local bioenergy capacity, creating new jobs, supporting economic growth, and improving quality of life for all. **R**

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