EDITORIAL OPEN ACCESS

Renewable energy: Wastewater nexus

Veera Gnaneswar Gude

Current wastewater treatment processes, especially, aerated systems are energy intensive. In developed countries including the USA and the UK, water and wastewater treatment plants and their infrastructure operations together contribute up to 3–5% of national electrical energy demands. This portion can be anywhere between 25 and 40% for small communities which is quite alarming [1]. In general, energy costs account for 5–30% of the total operating costs of water and wastewater utilities worldwide [2]. With increasing population, elevating living standards and escalating environmental pollution issues, it is crucial to consider alternative energy sources and treatment processes to provide sustainable wastewater treatment as this is the most fundamental step towards environmental protection.

A secondary wastewater treatment process includes a primary treatment step followed by a biological treatment process. Primary treatment involves removal of suspended solids and other non-biodegradable contaminants by physical separation in a sedimentation unit and or chemical adjustment or precipitation. A biological process is employed to remove the dissolved and particulate biodegradable organic matter through either suspended medium or attached growth processes. Sedimentation, filtration and disinfection follow the biological treatment process before the effluents are returned to the surface waters. The entire process is called a secondary treatment technique which is a required level of wastewater treatment around the world [3]. Various steps involving energy consumption in wastewater treatment are shown in Figure 1. It should be noted that aeration step in wastewater treatment requires large amounts of energy which also adds to operational costs. Other significant energy-demanding steps include pumping, anaerobic digestion and lighting and building heating and cooling operations. The nature of the energy requirements (electrical and thermal types) provides opportunities for implementation of different renewable energy sources such as solar, photovoltaic, and geothermal and wind energy sources. Figure 1 shows various opportunities for utilization of renewable energy sources in wastewater treatment operations.

Solar thermal energy has been evaluated as a viable energy source for heating requirements in anaerobic digestion process treating waste sources from municipal wastewater, agricultural wastes and other food and industrial operations [4–6]. Geothermal energy source was also considered for anaerobic digestion process heating applications [7]. Solar driven photovoltaic energy was also implemented in water and wastewater pumping operations around the world [8]. Solar energy can be utilized to generate both thermal and electrical energy suitable for various applications by employing concentrated solar panels or photovoltaic thermal collectors [9]. It is also important to note that the environmental, energy and economic payback periods for solar energy applications and technologies are very short-term (less than 2.5 years) and generated or expected benefits are long-term (up to 25 years) [10]. Application of wind turbines for water pumping operations was also evaluated [11].

Wastewater contains a multitude of components that can be used to derive energy which is several times higher than the energy requited for its treatment [1]. Biomass or excess sludge produced from wastewater treatment can be purposely utilized to produce different forms of energy [2]. While wastewater treatment can be energy intensive, several options are available for making this process energy-yielding rather than an energy-consuming one. As shown in Figure 2, the embedded energy in wastewater can be recovered in one or more of the following forms [1, 3, 12, 13]:

Veera Gnaneswar Gude

Affiliation: Associate Professor of Civil & Environmental Engineering, Department of Civil & Environmental Engineering, Mississippi State University, Mississippi State, Mississippi, United States of America.

Corresponding Author: Veera Gnaneswar Gude, PhD, 501 Hardy Rd, PO Box 9546, Mississippi State University, Mississippi State, Mississippi 39762; Email: gude@cee.msstate.edu; gudevg@gmail.com

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- Electrical energy or heat from the utilization of biogas from anaerobic digester which consists mainly of methane and carbon dioxide.
- Electrical energy and heat from thermal conversion of biomass (bio-solids).
- Heating or cooling energy using plant influent or effluent as heat source or sink.
- Biofuel generation from microalgae grown in wastewater.
- Biofuel, biochemical and other valuable metals via bioelectrochemical systems.

Wastewater sanitation continues to be the most fundamental need for sustainable development. The inevitable energy consumption and excess sludge production issues should be dealt together by employing concepts of sustainable production and operations. Co-digestion with other organic wastes and integrated microalgae systems may result in sustainable biofuel and biogas production.

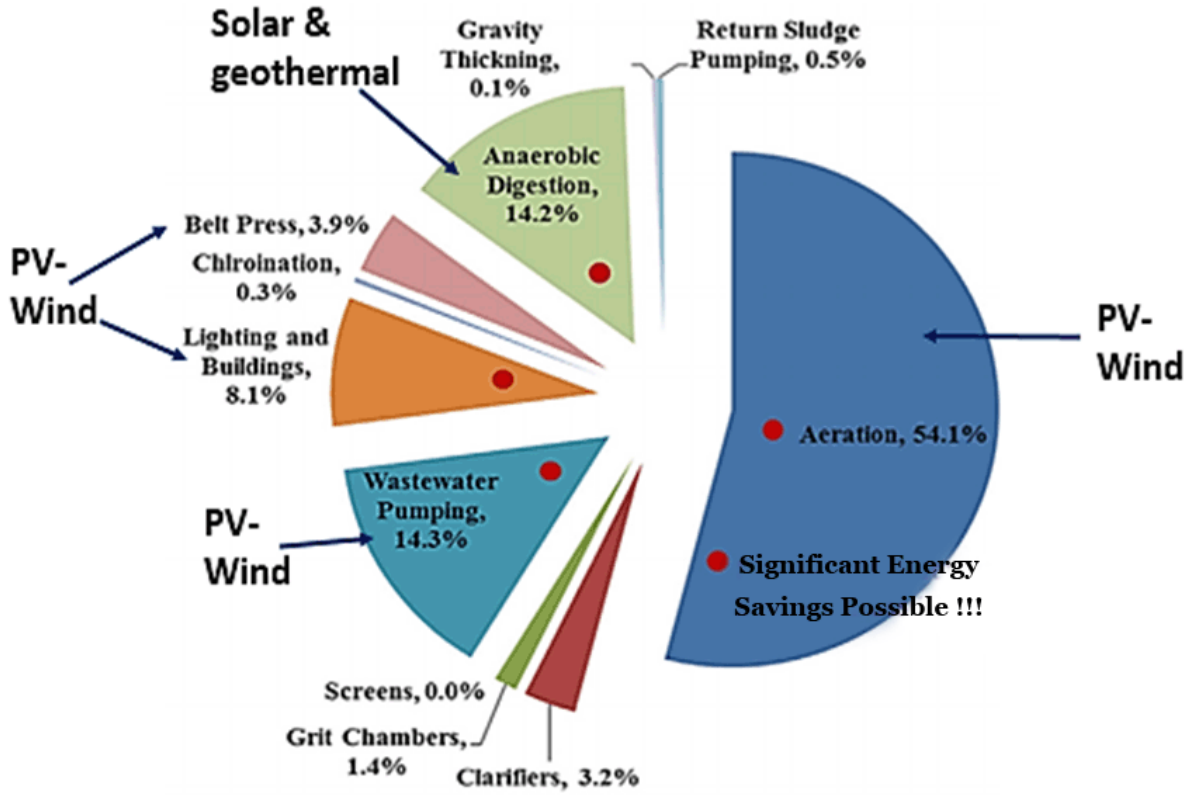

Figure 1: Various opportunities for utilization of renewable energy sources in wastewater treatment operations adapted from [1].

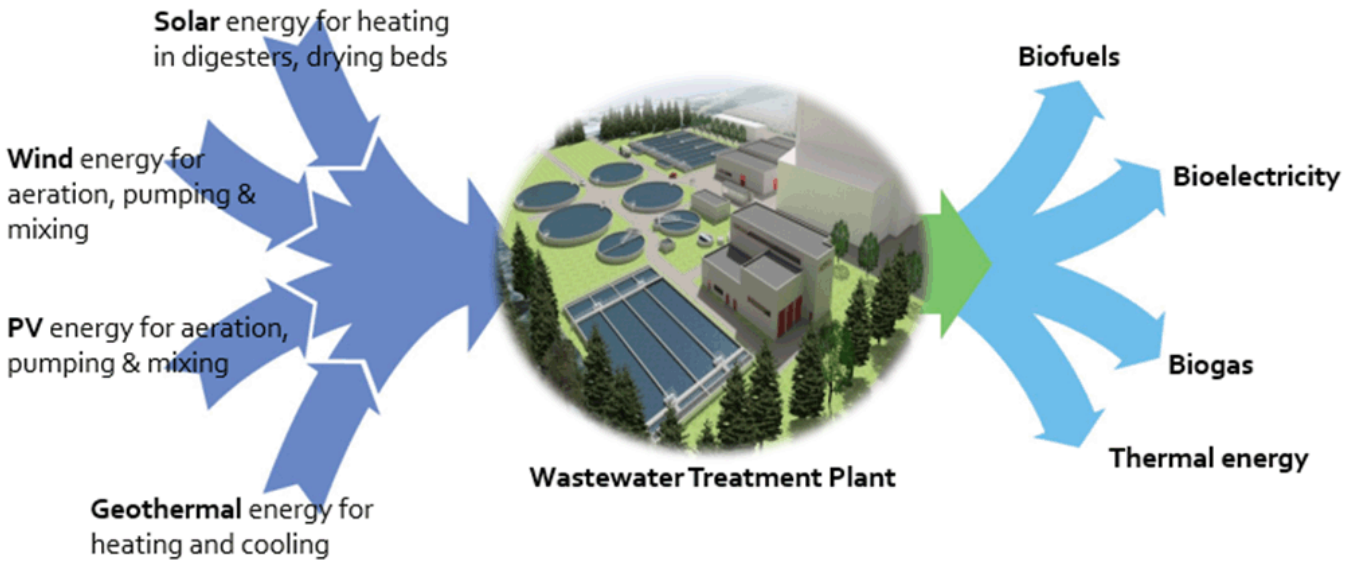

Figure 2: Renewable energy utilization and generation opportunities in wastewater treatment operations.

Techno-economics should be considered in detail prior to utilization of renewable energy in wastewater treatment. Sustainable application of these renewable systems is influenced by various factors such as location, size, treatment capacity, available renewable energy sources and support from local communities and government agencies. If these issues can be resolved, renewable energy application may transform wastewater treatment into a sustainable endeavor.

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Keywords: Biofuels, Renewable energy, Sustainability, Solar, Wastewater

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Veera Gnaneswar Gude – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

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The corresponding author is the guarantor of submission.

Conflict of Interest

Authors declare no conflict of interest.

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