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Editorial

Energy Consumption in Water/Wastewater Treatment Industry—Optimisation Potentials

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It is predicted that, by 2050, about 64% of the developing world and 86% of the developed world will be urbanized. This expansion will create colossal social, economic, and environmental challenges, providing opportunities for more efficient energy usage [1]. Access to drinking water and efficient treatment methods for wastewater are essential for the prevention of various types of pollution and waterborne diseases. Water resources are also essential for wildlife and many human activities, such as in industry, for energy production, and in agriculture. Energy is essential for drinking water production, wastewater treatment, water transport and distribution. Water and energy usage have become global concerns, leading to the adoption of new technologies to reduce energy consumption while maintaining the quality of treated water.

The greatest consumer of electricity in cities is the water and sewerage sector, which is responsible for around 40% of total urban energy consumption [2]. Water and energy cannot be separated in the sense that energy is used to produce clean water and water is used to produce energy. Water and wastewater treatment plants are operated by energy: pumps, air compressors, surface aerators, dewatering machines, analysis equipment, mixers, moving parts and other machinery are essential units in any treatment plant. A water treatment plant with 20ML capacity consumes approximately 255,000 kWh per month at a cost of AUD 55,000, water pumps consume approximately 170,000 kWh, and a sewer treatment plant with 5 ML capacity consumes around 130,000 kWh per month worth at a cost of AUD 29,000. Therefore, it is evident that sewer treatment plants consume more energy than water treatment plants. A sewer treatment plant (one-quarter the size of a water treatment plant) still consumes 64% the amount of energy consumed by the water treatment plant. Additionally, according to data, the major costs in treatment plants are pumping (especially when the plants are located away from residential areas) and aeration. There is no compromise when it comes to the quality of water released as drinking water and/or in the environment; energy consumption should be optimised while maintaining the high quality of drinking water.

Improving the energy efficiency of existing facilities is one of the main strategies for achieving sustainable energy, and this can contribute to increasing global energy and environmental security. Improving energy efficiency is an essential task because both water demand and the amount of produced wastewater are on the rise. Importantly, electricity constitutes about 20% of the costs of the supply and treatment of drinking water, mostly related to pumping activities. Energy consumption in municipal water supply systems is predicted to increase over the next 15 years, amounting to a 60–100% increase [2]. Depending on the technology, plant scheme and quality of the treated water, wastewater treatment plants consume approximately 0.5–2.0 kWh per cubic meter of treated water. The highest electricity consumer in the plant is the aeration of activated sludge due to the need for a continuous air supply for the biological reaction of organic matter digestion by microorganisms. In medium- to large-scale plants, the aerobic digestion system accounts for 50–60% of the total required electricity, followed by the sludge treatment (15–25%) and recirculation pumping (15%) sections [3].

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Water and wastewater treatment plants are starting to consider different aspects of renewable energy transition. For example, hydrogen/oxygen (electrolysis) and methane (anaerobic digestion) can be produced and used at these plants to enhance purification processes and make them more energy-efficient. Additionally, methane and/or hydrogen–oxygen can be used for seasonal energy storage [4]. Photovoltaics (PV) is another option; the synergy of small- and medium-scale treatment plants with PV is of great interest from a 3-E (energetic–environmental–economic) point of view. A PV system and storage battery need to be designed to maximize output as a function of irradiance [5]. However, this will require large footprint and expensive power storage technology in the form of batteries.

One important method is energy storage, which can be used to enhance energy efficiency in both water and sewer treatment plants. However, some storage methods are not suitable in the long term, too expensive, or lack the capacity for extensive use, such as pumped storage plants, batteries, or compressed air systems. One potential method is using electrical surplus or off-peak periods to produce hydrogen and oxygen with an electrolyser, which is suitable for long-term storage in pressurised vessels. Another example is the production of methane at sewer treatment plants via the anaerobic digestion of sludge from primary clarifiers. This methane can also be stored over long periods. These two examples are potential and reasonable approaches that can improve energy sustainability in plants. Unlike solar- and wind-based energy production, biogas, hydrogen and oxygen are renewable energies that can be directly stored. In addition, they can effectively adjust to the production of electricity or heat in plants. Technologies for storing gases are available, and methane storage is already used in many sewer/industrial treatment plants [6].

Sewer treatment plants have more options for energy generation than water treatment plants. Wastewater treatment plants (WWTPs) could potentially be transformed into self-sufficient and resource-recovery facilities. By treating and reusing by-products of water treatment activities, waste production is minimized, and such waste can be used as raw material in a new production cycle [7]. It is important to use any source of energy in sewer treatment plants to mitigate energy consumption, such as sewage sludge to produce an alternative source of energy (biogas) [2]. As aeration consumes the most energy in wastewater treatment plants, optimization can be achieved by increasing aeration efficiency. This is achieved by looping water through piping with the help of a Venturi aspirator. In another example, chemically enhanced primary treatment (CEPT) can increase biogas production by 21%, reduce the weight of sludge by 12%, and may reduce the energy demand for aeration by 8%. Nitrogen removal in an autotrophic manner may lead to a further reduction in energy consumption by 20%. It is possible to operate a sewer treatment plant with up to 93% self-sufficient energy. To improve energy recovery and reduce energy usage in wastewater treatment plants, it is essential to capture organic matter in the sludge phase [8].

The application of CEPT is a very interesting concept. It can help reduce the footprint of the primary treatment infrastructure, which in turn reduces capital costs. In addition, CEPT can increase the capacity of existing treatment units or reduce the size of potential new treatment units. The application of CEPT not only provides an increase in biogas production but also leads to a significant reduction in phosphorous and reduction in sludge production, impacting sludge dewatering, and might have a positive effect on energy consumption [8]. As CEPT captures a large amount of carbon in the inlet wastewater, this leads to reduction in the C/N ratio, which makes it difficult to remove nitrogen via a nitrification–denitrification process. A typical nitrification–denitrification process requires a significant amount of organic carbon. In this case, such as recirculating the filtrate from sludge dewatering back to the plant inlet is required. The treatment can be achieved by partial nitrification with the anammox (PN/A) and is then combined with inlet water. This has become a well-established technology for reducing the amount of nitrogen arriving at the inlet. In the PN/A process, ammonium is oxidized to nitrite by aerobic nitrifiers, and, subsequently, anammox bacteria convert ammonium with the produced nitrite to nitrogen gas and trace amounts of nitrate. The autotrophic PN/A process can reduce the demand for organic carbon and aeration by 100% and 60%, respectively, compared to conventional processes. The expected energy demand of PN/A side-stream treatment systems ranges from 0.8 kWh/kgN to 2 kWh/kgN, while removal efficiency can be maintained at more than 85% [8].

As it is not socially acceptable to reuse wastewater as drinking water, wastewater can be used to aid growth in plants such as microalgae. This reduces the costs and, at the same time, can aid treatment processes [9]. Wastewater can be used for the irrigation of other energy plants for the production of ethanol and biodiesel without the need for fertilisers. Sludge-to-energy and sludge-to-matter treatments are attractive concepts as well. Our main focus should be on identifying suitable sewage sludge treatments (configuration) for the potential recovery of matter and/or energy from sewage sludge, while meeting technological and economic constraints [10].

To conclude, it is very important to understand the effectiveness of existing treatment plants to determine if the magnitude of the consumed energy provides an equivalent level of treatment. Otherwise, improvements are required, such as installing more energy-saving equipment, optimising the operation of this equipment, using the equipment during off-peak hours, and evaluating each unit in the treatment and their contribution to water quality. Hydrogen/oxygen production using off-peak energy and its storage in pressurised vessels had great potential for use in water treatment plants. On the other hand, producing biogas from the anaerobic digestion of waste sludge and storing it in pressurised vessel is much more suitable for wastewater treatment plants. These are energy sources that can be stored and used when needed. Optimising the use of chemicals at treatment plants can also indirectly reduce energy consumption. Finally, treated sewerage water can be used in farming to grow plants that can be used for the production of ethanol and biodiesel. Such farming water quality will require less energy use in treatment plants and significantly reduce the use of fertilisers.

Conflicts of Interest: The author declares no conflict of interest.

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