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Energy Savings at WWTPs in Line with the Applicable Legislation †

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Abstract

Wastewater treatment technology is constantly evolving not only to respond to changes in the composition and quantity of incoming water, but also to ensure that the process and result of wastewater treatment comply with applicable legislation. This article will focus on the integration of energy regulations into the wastewater treatment process. One of the key documents is Lex OZE III, which is an energy law, but has a direct impact on WWTPs, especially in the field of renewable resources and energy self-sufficiency. The entire energy sector is undergoing dynamic changes, and the increase in energy prices is increasing pressure regarding the optimization of its costs and use of new energy trends in the field of wastewater treatment, ensuring effective local production using the potential of the WWTP to cover its own energy consumption.

Keywords: energy saving; WWTP; determination of energy neutrality

1. Introduction

The entire energy sector is undergoing dynamic changes, and rising energy prices are creating pressure to optimize costs and take advantage of new energy trends in the area of securing local production and effectively utilizing its potential to meet society's consumption needs. In addition to the ongoing changes, it is necessary to include in a company's energy policy the obligations arising from international and national regulations, which stipulate an increase in the share of consumption from renewable sources and set the level of self-sufficiency for individual sectors and technologies.

Wastewater treatment is an essential process for environmental protection. Wastewater treatment technology is constantly evolving to not only respond to changes in the volume and composition of incoming wastewater but also to ensure that WWTPs operate efficiently and economically. This article focuses on the integration of energy regulations into the wastewater treatment process. The water management sector is also experiencing the Green Deal, where the evaluation of economic infrastructure operations is beginning to be assessed from several new perspectives, with the issue of energy savings, the production of own "green" energy, and the related issue of sustainability coming to the fore.

2. Czech Legislative Requirements

Nowadays, however, the European Commission considers the quality of treated wastewater to be a routine matter, and the requirements for green operation of water management infrastructure and the obligation to achieve energy neutrality are coming

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to the fore. This should be helped by the revision of Directive 91/271/EEC and LEX OZE III. With the amendment to Directive 91/271/EEC, the European Commission has set relatively ambitious targets regarding the fight against climate change, the circular economy, and the reduction of environmental degradation. In the wastewater sector, the European Commission's goal is to reduce greenhouse gas emissions (approximately 0.86% of total EU emissions come from the water sector), reduce energy consumption (approximately 0.8% of total EU consumption), and improve sludge management.

The European Commission has set a relatively clear and measurable target for the water sector, namely, to achieve energy neutrality in the wastewater treatment sector, to be phased in by 2045. The precise definition of energy neutrality is given in Article 11, Directive 91/271/EEC, as follows [1,2]:

"Member States shall ensure that, at national level, the total annual amount of energy from renewable sources produced on the premises of urban wastewater treatment plants that treat loads equivalent to a population equivalent of 10,000 PE and above, or outside them by their owners or operators or on their behalf, regardless of whether the owners or operators of urban waste water treatment plants use this energy on or off their premises, corresponds to at least:

(a) 20% of the total annual energy consumption of these facilities by 31 December 2030;
(b) 40% of the total annual energy consumption of these installations by 31 December 2035;
(c) 70% of the total annual energy consumption of these installations by 31 December 2040;
(d) 100% of the total annual energy consumption of these facilities by 31 December 2045 [1]."

It should be emphasized that this is a target set for European Union Member States, not for individual wastewater treatment plants. Nevertheless, to achieve this target at national level, it is necessary to consider the specific characteristics of each wastewater treatment plant, optimize the necessary investments, and ensure that the potential for energy production from renewable sources is fully exploited.

In the Czech Republic, no methodological guidelines have yet been established for determining the energy neutrality of wastewater treatment plants. For this reason, we have developed a methodology for calculating the energy neutrality of wastewater treatment plants. This methodology is based on monitoring the following parameters [3]:

- Actual load of WWTP (COD);
- Biogas production;
- Purchased electricity;
- Purchased natural gas;
- Electricity to produce thermal energy in a heat pump (part of purchased electricity);
- Electricity produced in a cogeneration unit;
- Thermal energy produced in a CHP unit;
- Electricity produced from a photovoltaic power plant;
- Electricity produced from a small hydroelectric power plant;
- Overflow of electricity into the distribution network;
- Thermal energy produced in biogas boilers;
- Thermal energy produced in a heat pump;
- Energy not related to wastewater treatment plants.

Determination of the Total Annual Energy Consumption of a WWTP (EC)
EC (kWh) =
Purchased electricity

+ purchased natural gas
+ electricity produced in a cogeneration unit
+ thermal energy produced in the CHP unit
+ electricity produced from a photovoltaic power plant
+ electricity generated from a small hydroelectric power plant
+ thermal energy produced in biogas boilers

- overflow of electricity into the distribution network
- energy not related to the wastewater treatment plant

Determination of the Total Annual Consumption from Renewable Sources (OZE)
OZE (kWh) =
Electricity produced in a cogeneration unit

+ thermal energy produced in the CHP unit
+ electricity produced from a photovoltaic power plant
+ electricity generated from a small hydroelectric power plant
+ heat energy produced in the heat pump
+ thermal energy produced in biogas boilers

Determination of energy neutrality of wastewater treatment plants (EN)
EN % = OZE/EC

Energy neutrality is calculated as the ratio of total annual energy from renewable sources (OZE) to total annual energy consumption at the WWTP (EC).

The water company operates 12 WWTPs with a capacity of over 10,000 PE. Currently, it is possible to produce energy at six WWTPs, where sludge is processed anaerobically and the biogas produced is used to generate electrical and/or thermal energy. The results of the energy neutrality assessment of all the treatment plants above 10,000 PE are shown in Table 1. For the sake of objectivity, it should be noted that the total electricity consumption of the Blansko WWTP does not include the electricity consumed by the inlet pumping station, which has a separate consumption point, thus overestimating the results of the Blansko WWTP compared to other treatment plants. At the same time, this demonstrates the impact of the inlet pumping station on the overall balance and overall assessment of the WWTP, which should be eliminated when developing the national methodology. The table clearly shows that WWTPs using OZE meet at least the first legislative milestone, i.e., 20% by 2030. Similarly, if WWTPs were taken as a whole, we would be slightly above 20% and the requirement for 2030 would be met. To comply with the legislation from 2035 onwards, it will be necessary to introduce measures at other WWTPs and increase the amount of energy from renewable sources [4].

The Table 1 shows that the first six WWTPs do not achieve energy neutrality; i.e., the WWTPs do not have photovoltaic panels, do not use biogas, and do not have any other source that could provide electricity generation. Photovoltaic panels have been installed at the last six WWTPs, with their size always based on the roof area where the PV system could be located and on the specific electricity demand so that the electricity produced is consumed at the WWTP in question. The possibility of using biogas produced during sludge treatment also plays an important role in electricity generation at the WWTPs. These WWTPs do not yet have any sources of electricity generation other than those listed in the "Determination of Total Annual Consumption from Renewable Sources (OZE)", nor do they share electricity or otherwise trade in green electricity at present.

Table 1. Energy neutrality at the WWTPs.

WWTP	EN [%]
WWTP Boskovice	0
WWTP Ivancice	0
WWTP Tetcice	0
WWTP Bystrice nad Pernstejnem	0
WWTP Nove mesto na Morave	0
WWTP Velke Mezirici	0
WWTP Zdar and Sazavou	26.3
WWPT Znojmo	35.98
WWTP Tisnov	40.82
WWTP Moravske Budejovice	40.83
WWTP Trebic	53.74
WWTP Blansko *	65.23 *
Total for WWTPs OVER 10,000 PE fulfilled	21.91

* The total balance of the Blansko WWTP does not include the energy of the input pumping station.

3. Sustainability and EU TAXONOMY

In recent years, the word "sustainability" has become part of the water industry vocabulary. Anything that is modern and has a future must be sustainable. Sustainability is defined as a way of developing human society that brings economic and social progress into harmony with the full preservation of the environment.

Following the publication of the "Green Deal for Europe", the European Union issued a regulation of the European Parliament and of the Council establishing a framework to facilitate sustainable investment, known as the EU TAXONOMY. The aim of this regulation is to redirect financial resources towards sustainable activities and investments. Regulation (of the European Parliament and of the Council EU) 2015/1017 set a target that under the European Fund, 40% of investments should be directed towards climate-sustainable infrastructure and strategic innovative projects. To assess which economic activities and projects are appropriate, a uniform classification system has been developed for environmental sustainability. This system provides a set of technical criteria, known as Technical Screening Criteria (TSC), which, when met, allow us to say that the economic activity in question is environmentally sustainable [5].

In the field of water management, we are currently most concerned with the sustainability of wastewater treatment plant operations. Economic activity is defined in the EU Regulation Taxonomy as the construction, expansion, and operation of wastewater collection and treatment systems. This activity is considered sustainable if the net energy consumption of the wastewater treatment plant does not exceed

- A level of 35 kWh per population equivalent (PE) per year for treatment plants with a capacity of less than 10,000 PE;
- A level of 25 kWh per population equivalent (PE) per year for treatment plants with a capacity between 10,000 and 100,000 PE;
- A level of 20 kWh per population equivalent (PE) per year for treatment plants with a capacity greater than 100,000 PE.

Net consumption energy in wastewater treatment plant operations may consider energy-saving measures related to source control (limiting rainwater or pollutant loads at the inlet) and, where applicable, energy production within the system (e.g., hydro, solar, thermal, and wind energy).

As with the calculation of energy neutrality, we have developed a methodology for determining the net energy consumption of WWTPs (TSK) for the assessment of our wastewater treatment plants.

For the determination of the net energy consumption of WWTPs (NEC),

TSK = (EC-OZE)/PE;

EC—total annual energy consumption of WWTP;

OZE—total annual energy consumption from renewable sources;

PE—population equivalent, a unit that expresses the load on the WWTP, expressed by the COD parameter.

According to legislative requirements, treatment plants above 10,000 PE should achieve a TSK value of less than 25 kWh/PE, and in terms of energy neutrality, treatment plants should ideally achieve a value of more than 20% by 2030. As can be seen from the Table 2, only two of the wastewater treatment plants listed achieve the required values, and by 2030 it will be necessary to invest considerable resources in the development of wastewater collection and treatment systems.

Table 2. The values of the technical screening criteria for our WWTPs.

WWTP	TSK [kWh/PE]
WWTP Boskovice	25.77
WWTP Ivancice	44.60
WWTP Tetcice	43.52
WWTP Bystrice nad Pernstejnem	66.24
WWTP Nove mesto na Morave	48.05
WWTP Velke Mezirici	37.27
WWTP Zdar and Sazavou	44.66
WWPT Znojmo	19.37
WWTP Tisnov	37.27
WWTP Moravske Budejovice	56.79
WWTP Trebic	36.48
WWTP Blansko	18.67
Average for WWTPs above 10,000 PE met	38.34

4. Basis for Achieving Energy Neutrality

Currently, considerable attention is being paid to the connection between wastewater treatment and energy and greenhouse gas production in municipal wastewater treatment plants. All these activities are based on serious concerns about global climate change. The ongoing transformation of wastewater treatment plants into water resource recovery facilities (WRRFs) also includes achieving energy neutrality as one of its main objectives.

In connection with the proposed energy neutrality of WWTPs, a number of opinions have emerged on how to achieve this goal or, conversely, that it cannot be achieved without the involvement of external sources. It can be said that achieving energy neutrality in WWTPs is mostly rejected by the professional public as unattainable. Despite serious concerns, it is necessary to respond to the legislation so that its objectives can be gradually fulfilled. Currently, most of the proposed solutions involve the use of external sources: solar energy, thermal utilization of sludge, purchase of energy from renewable sources or, for example, energy sharing. Further legislation is again responding to the above-mentioned options. The revision of Directive 91/271/EEC already considers a significant limit on the share of purchased external energy to cover WWTP consumption to a maximum of 35% of purchased energy from external sources. On the other hand, energy sharing is enabled by the long-awaited amendment to the Energy Act, Lex OZE 3, which brings a significant shift in the possibility of energy sharing and the use of batteries in connection with renewable energy sources (OZE). This amendment supports community energy and enables energy sharing, as well as significant energy storage in batteries, which can be used even when there is no sunlight. Lex OZE 3 enables energy sharing between consumers

who are connected to a single sharing group. This means that surplus energy from PV or other RES sources can be shared with other members of the group without having to sell the energy to the grid. It also supports the use of batteries to store surplus energy, which in turn enables more efficient use of renewable sources and reduces dependence on grid energy. Among other things, the amendment simplifies the licensing of smaller photovoltaic power plants (PV), which facilitates the development of renewable energy sources. In simple terms, this amendment helps to modernize the energy system, increases its flexibility and resilience, and contributes to reducing emissions [2,4,6].

It is already certain that future solutions will have to include synergies between a whole range of measures and changes that will lead to improved energy recovery and electricity consumption. The requirement to achieve energy neutrality necessitates a technological change in the wastewater treatment processes used to date while maintaining or even improving treatment efficiency and sustainable economic costs.

5. Conclusions

To address the current energy challenge of WWTP energy neutrality and related standards, it will be necessary to seek new process configurations and emerging technologies, together with the effective use of renewable energy sources, and to find ways to utilize so-called green energies. Currently, most water management companies are trying to cope with the requirements of all legislation, which on the one hand requires greater energy self-sufficiency and on the other hand requires an increase in the quality of treated water, which, however, may complicate previous efforts to reduce energy consumption.

A study conducted by our company clearly shows that society will meet its obligations by 2030. However, according to the Table 2 above, six WWTPs clearly contribute to this average, and it is apparent that, regardless of the overall balance, two WWTPs will meet the legislative requirements by 2030, and another four will meet them by 2035. Unfortunately, six WWTPs have zero energy neutrality, which will require high investment costs in renewable sources, and some WWTPs will undergo complete or extensive reconstruction in order to reduce consumption electricity during the wastewater treatment process, primarily by installing pumps and aerators, and at the same time, it will be possible to install some elements for the production of renewable sources.

First and foremost, it will be necessary to focus WWTP on the gradual installation of equipment to produce renewable energy sources, which are mainly photovoltaic power plants, but also on the use of biogas as an efficient energy source. The main objective of water companies will be to find solutions at specific WWTPs that will improve energy recovery and at the same time minimize energy consumption at WWTPs in the above-mentioned ways.

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Abbreviations

WWTP	Wastewater Treatment Plant
EN	Determination of energy neutrality of wastewater treatment plants
OZE	Determination of the Total Annual Consumption from Renewable Sources
EC	Determination of the Total Annual Energy Consumption of a WWTP
EU	European union

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