UNISENSE ENVIRONMENT

Kerteminde Forsyning

Nitrous Oxide Data Directly from Sensor to Sustainability Report

Climate Goals

Denmark's water sector aims to become climate neutral by 2030. In 2025, the Danish Parliament's Climate Plan will require limit values for nitrous oxide at plants larger than 30,000 PE.

The carbon footprint of wastewater is a significant share of the total emissions for the water sector. Nitrous oxide is the largest contributor due to its high climate potential (273 CO_2-eq according to IPCC). The Danish EPA reports that Danish wastewater treatment plants emit 268,000 tonnes of CO_2-equivalents, of which 130,636 tonnes are nitrous oxide emissions from ammonium conversion in biological tanks.

Nitrous oxide is a direct emission from wastewater treatment plants and therefore qualifies under Scope 1 emissions. In order to make reliable climate accounts, it is therefore crucial for utilities to know the actual nitrous oxide emissions.

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In March 2021, Kerteminde Forsyning (WWTP) commissioned a report identifying baselines and hotspots for process emissions. The report used the default emission factor of 0.32% for nitrous oxide emissions, which accounted for 34% of total emissions in 2020.

However, in 2020, the Danish Environmental Protection Agency conducted a Danish measurement campaign. Based on the measurements, a new Danish emission factor was determined to be 0.84%. The change would mean an increase in Kerteminde Forsyning's nitrous oxide emissions of approximately 250,000 kg CO_2-eq.

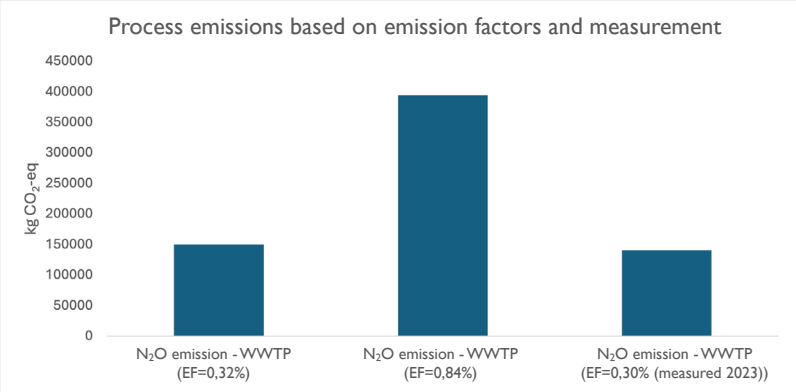

Figure 1 shows the impact of the two different emission factors on the utility's total nitrous oxide emissions and the actual measurements taken by the facility in 2023.

Located on the east coast of Funen, Kerteminde Forsyning operates a wastewater treatment plant that treats wastewater from the municipality and the entire catchment area. The wastewater is treated mechanically, then chemically, and finally biologically, after which it is discharged into Romsøsund.

The utility has set a goal of reaching climate neutrality by 2030, which means that net CO_2 emissions for the entire utility must go to zero.

Kerteminde WWTP has a capacity of 25,000 PE and treats approximately 2.5 million m³ of wastewater annually.

Kerteminde WWTP consists of 4 tanks with bottom aeration in tanks 2 and 3. The nitrous oxide sensor measures in the aerated field in tank 2. Since 2021, the plant has measured nitrous oxide emissions and established a baseline for actual emissions.

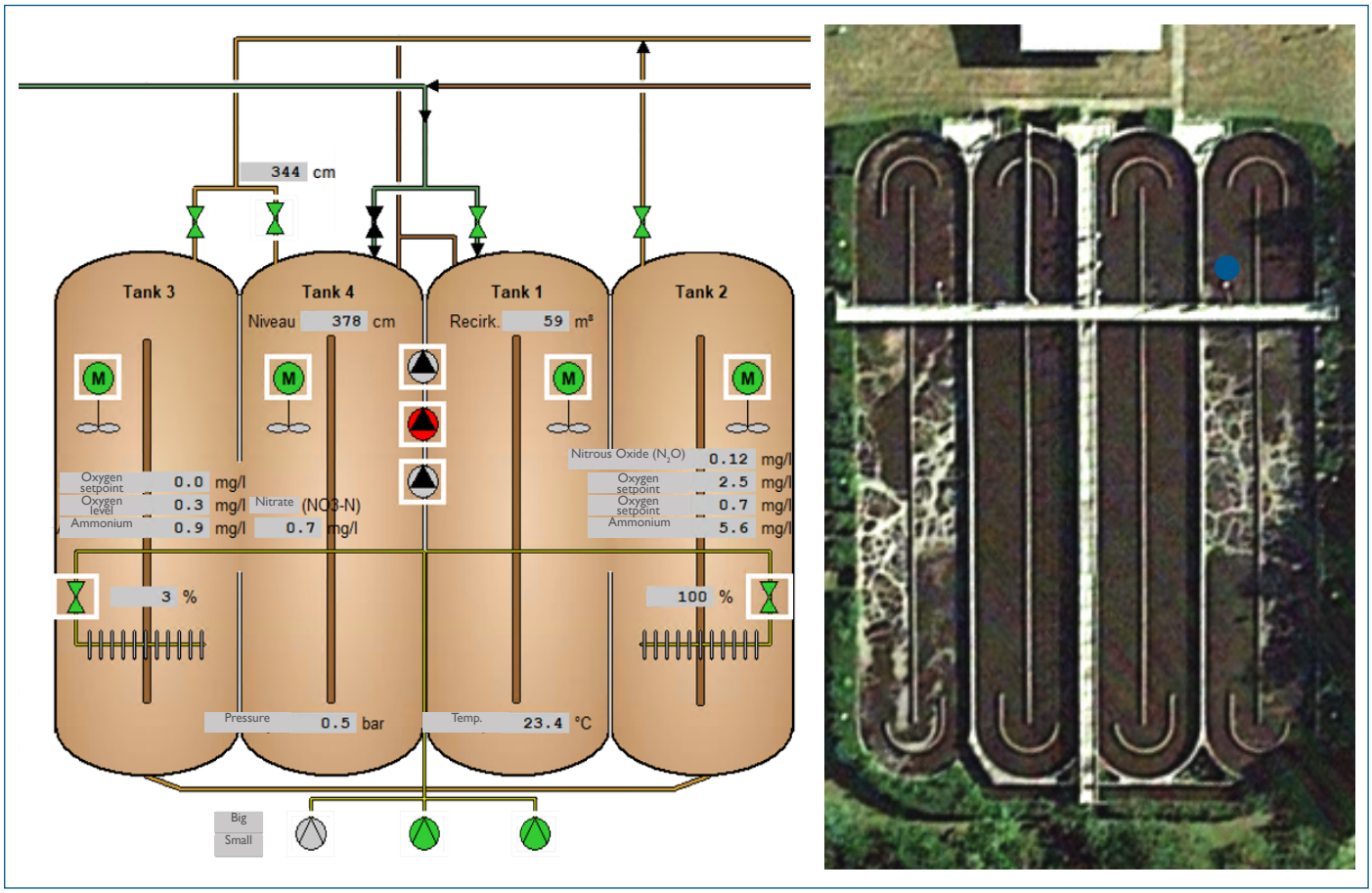

Figure 2: Drawing of the 4 tanks at Kerteminde WWTP and aerial photo of the tanks. Blue dot: Location of the sensor.

Reduction opportunities

At Kerteminde WWTP, two of their own employees developed a method to control the formation of nitrous oxide in their own PLC system through observation and analysis of data. One of their key observations was that the formation of nitrous oxide increased significantly at the end of the aeration period.

To avoid the increase in nitrous oxide formation, they adjusted the ammonium setpoint that controls aeration. By raising the ammonium setpoint, the oxygen setpoint is lowered, resulting in both reduced nitrous oxide formation and lower energy consumption. At the same time, they maintain low nitrogen emissions.

In 2023, Kerteminde WWTP was able to update the treatment plant's emission factor to 0.30%. This time based on actual measurements of nitrous oxide emissions. With this improved data, the treatment plant has now begun further process optimization to meet their ambitious goal of achieving climate neutrality by 2030.

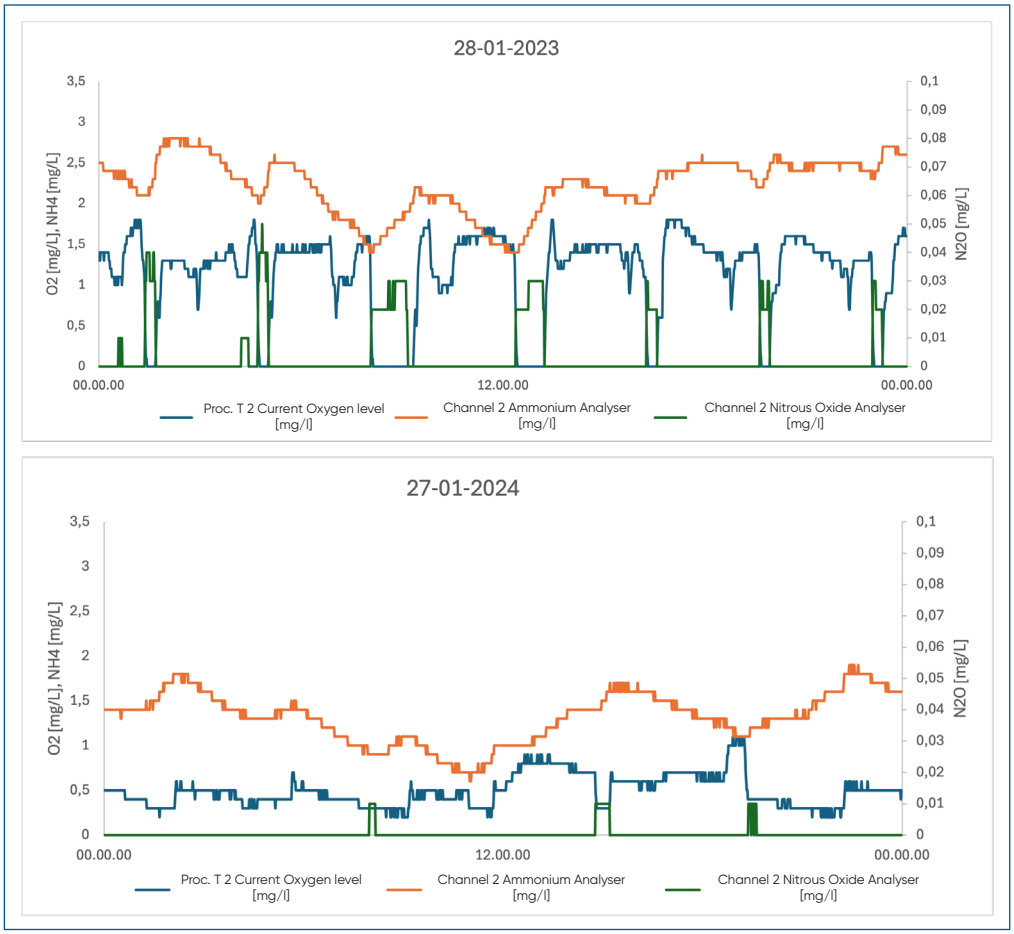

Figure 3: Kerteminde WWTP has adjusted the ammonium set point between 2023 and 2024. By raising the ammonium setpoint, the oxygen setpoint is lowered and there is less aeration in the tanks. In this way, they have managed to reduce the formation of nitrous oxide and maintain low nitrogen emissions.

Reliable sustainability accounting

Nitrous oxide emissions can vary significantly depending on the season and facility. To obtain an accurate sustainability account, it is crucial to perform long-term measurements. Here are the factors Kerteminde WWTP considered when using nitrous oxide data from Unisense Environment's sensors in their sustainability accounting:

1. ***Location of sensors.*** Nitrous oxide is formed as a by-product of ammonium conversion and must be measured in the biological processes. At Kerteminde WWTP, they have a single sensor located in tank 2, as they know that this is where the greatest conversion of ammonium takes place.
2. ***Analysing the data.*** Data from the sensors must be analysed to identify patterns in the formation of nitrous oxide. In Kerteminde, they have measured for a whole year and compared nitrous oxide data with other data they receive in their management system. Their own employees have looked for correlations and factors with optimization potential.
3. ***Calculation of emissions***. Kerteminde WWTP has calculated the emissions based on the measured data following guidance in the calculations from Unisense Environment. To calculate the emissions from the tank, the tank is divided into aerated and non-aerated zones. The actual air flow from the tank must be used, and in addition, the depth of the tank and the aerated area must be known. The method has been validated by direct comparison with off-gas measurements at several plants and is considered to be the best calculation method globally. **[MUDP[1]]**
4. ***Reduction potentials***. With long-term data, factors can be identified and changed to reduce nitrous oxide emissions. Results from previous projects show that potential reductions of 30-80% can be achieved through specific process changes.

Conclusion

Kerteminde WWTP has prioritised getting an overview of and a method to reduce nitrous oxide emissions in the biological tanks at the treatment plant. Their efforts bring them closer to their goal of climate neutrality by 2030 and show how precise measurements and data analysis can play a key role in reducing the carbon footprint of wastewater treatment plants.

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Literature

IPCC - Intergovernmental Panel on Climate Change, "*2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*", 2019.

[1] Miljøstyrelsen, 2020, "*MUDP Lattergas pulje - Data opsamling på måling og reduktion af lattergasemissioner fra renseanlæg*", https://www2.mst.dk/Udgiv/publikationer/2020/12/978-87-7038-254-0.pdf

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Nitrous Oxide process sensor for online wastewater treatment optimization, low-cost greenhouse gas reduction, and reliable sustainability accounting

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