# Saving Energy with Ammonia Control at Wastewater Treatment Plants

## PRESENTATION ABSTRACT

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## INTRODUCTION

Wastewater Treatment Plants (WWTPs) play a key role in protecting natural water bodies, however they are also one of the largest energy consumers in most countries. In Japan for example, WWTPs consume 0.7% of the country's total electricity [1], and even worse in the European Union at 0.8% [2] and in the USA at 4% [3][4].

Reviewing an entire wastewater treatment plant energy demand (Figure 1), the major usage is wastewater treatment in reaction tanks, contributing to 54% of total energy consumed in Japanese WWTPs [5] and nearly 50% greater than most other countries [4]. Therefore, reducing energy consumption in reaction tanks is the key factor for WWTPs energy-savings.

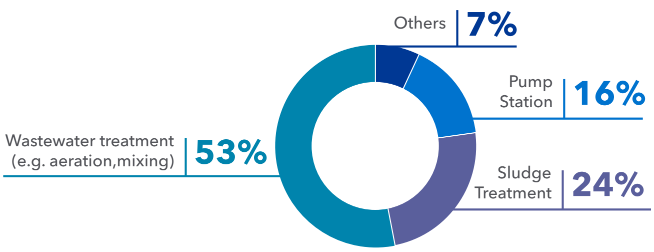


**Figure 1. The breakdown of energy consumed at WWTPs in Japan [6].**

To reduce energy consumption, several energy saving methods have been investigated, such as utilizing higher capacity air blowers & efficient diffusers, installing advanced energy-saving reaction mixers and improving sensor feedback control systems [7].

However, considering the balance of capital costs and energy efficiencies, improving sensor control systems is often preferred.

## SENSOR CONTROL STRATEGY

Aeration control by Dissolved Oxygen (DO) sensors have been widely applied in WWTPs, dominating sensor control systems. Although recently, a new sensor-based system utilizing ammonia sensors has been widely and deeply investigated by the Japanese Government [8].

In order to focus on the dominant sensor-based control systems, this paper will review the following:

- Dissolved Oxygen (DO) sensor aeration control
- Ammonia sensor-based aeration control, including in combination with DO sensors.

Figure 2 is a simplified illustration of the dominant sensor control systems. The important features of process control are on-off control, set-point control and feedback/ feedforward control. These are applied to achieve an optimized result. The focus of this paper is to study the sensors.

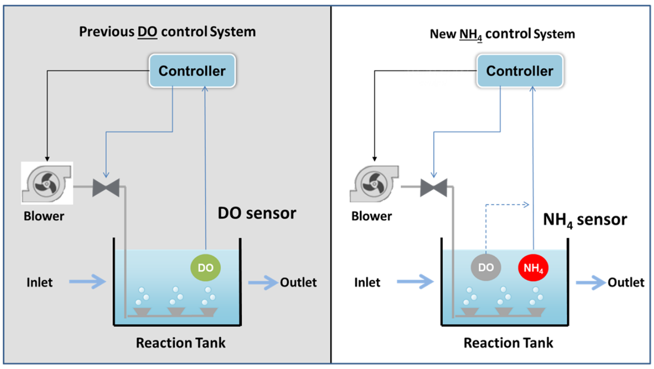


**Figure 2. Comparing DO sensor aeration and Ammonia sensor control systems.**

## ENERGY-SAVING PRINCIPLES

Ideally, there is no wasted energy if oxygen demand within an Aeration tank is just satisfied via aeration from air blowers. But in reality, excess aeration is supplied because DO is used as a parameter to evaluate oxygen demand within a DO sensor-based control system (e.g. DO set-point control).

Alternatively, if ammonia is used as the parameter to evaluate oxygen demand then we are given a much more sensitive and accurate reflection of the real oxygen demand in an aeration tank. The use of an ammonia sensor to control air blowers (ammonia control system) results in the avoidance of excessive aeration.

Figure 3 illustrates the basic mechanism for energy-savings in WWTPs. During low organic loading periods, oxygen demand is correspondingly low, when an ammonia sensor is installed this can stop excess aeration. While during high organic loading periods, an installed ammonia sensor transmits the correct oxygen demand to the controller and ensures appropriate aeration is provided. Under both conditions installing, ammonia sensors will result in good water treatment quality.

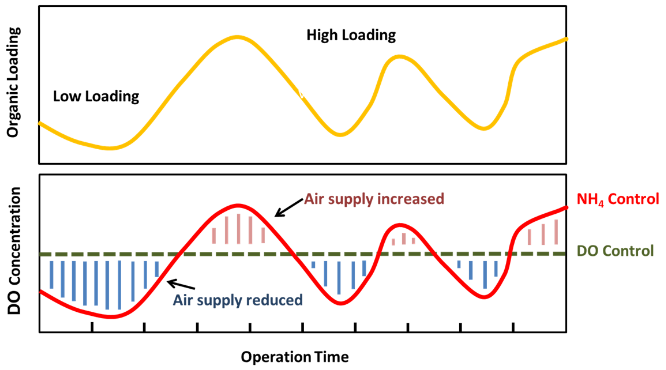


**Figure 3. Air supplied with DO and Ammonia sensor control systems.**

## APPLICATION EXAMPLES

Ammonia sensor control systems use as an energy-saving strategy whereby Nitrogen is removed. This has been recognized for many years [9], though currently it has been demonstrated as a very efficient approach in all biological wastewater treatment processes. In Japan, significant progress has been achieved by utilizing ammonia sensor feedback control systems.
In addition to saving 10%~20% energy, treated water quality meets government discharge regulations (Table 1) [10].

**Table 1, Energy-saving field test in Japan [10]**

| Test No.* | Treatment Process | Energy Reduced |
|---|---|---|
| Case 1 | Standard activated sludge process | 14.8% |
| Case 2 | Standard activated sludge process | 16.9% |
| Case 4 | Denitrification/Nitrification | 23% |
| Case 5 | Denitrification/Nitrification | 40% |
| Case 6 | Standard activated sludge process | 10% |
| Case 8 | Standard activated sludge process | 19% |

**Case 3, 7 and 9 are not referred because energy-saving is not achieved by utilizing ammonia sensor control system*

In addition to the field tests reported by reference 6, there are significant numbers of published research papers summarized in Table 2. Energy savings as high as 25% have been achieved in various treatment processes: standard activated sludge (AS) process, Anoxic-Oxic process (AO, Nitrogen removal) and Anaerobic-Anoxic-Oxic process (A2O, Nitrogen & Phosphorus removal).

**Table 2, Energy-saving by ammonia sensor research reported.**

| Treatment Process | WWTP Capacity | Energy Reduced | Ref. |
|---|---|---|---|
| Anaerobic -Anoxic-Oxic | 40,000 $m^3/d$ | 16% | [11] |
| Anoxic -Oxic | 200,000 $m^3/d$ | 10.4% | [12] |
| Standard AS process | 68,700 $m^3/d$ | 8.7% | [13] |
| Anoxic- Oxic | Not showed | 2.3~8.9% | [14] |
| Anoxic- Oxic | 107,000 $m^3/d$ | 16.9% | [15] |
| Standard AS process | 44,000 $m^3/d$ | 10~15% | [16] |
| Anoxic- Oxic | 7,200 $m^3/d$ | 9.9~17.2% | [17] |
| Anaerobic-Anoxic- Oxic | 830,000 $m^3/d$ | 10~25% | [18] |
| Anaerobic-Anoxic- Oxic | 700,000 p. e. | 18% | [19] |

## WTW AMMONIA SENSOR

WTW (a Xylem brand) AmmoLyt® Plus 700 series Ammonia Sensor (Figure 4) has been utilized globally, in cluding installations in Japan [21], [22].
More than 20,000 (NH4&NO3 sensor included) units have been sold world wide. Noteworthy is that the AmmoLyt® Plus has been adopted by the Tokyo Bureau of Sewerage of the Tokyo Metropolitan Government in Shibaura WWTP and has achieved a more than 20% electricity energy reduction [18].


**Figure 4. WTW ammonia sensor : AmmoLyt® Plus 700**

Features of AmmoLyt® Plus 700 series

- High Accuracy with K+ Dynamic compensation
- Economical by stability over long periods of time
- User friendly with electrode, simply cable exchange
- Maintenance simplified with compress air auto-cleaning.

## SUMMARY

Compared with conventional dissolved oxygen sensor aeration control systems, the ammonia sensor control system saves significantly more energy in various treatment processes. Contact Xylem for more information.

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Let's Solve Water


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