ICA2025OSLO
14th IWA Specialised Conference on
Instrumentation, Control and Automation

# EWatLink: Smart advanced real time control of activated sludge process aeration at Bastogne WWTP

Taher Abunama

Center Expertise in Trématent and Management de L'eau (CEBEDEAU), Campus de l'Université de Liège - Sart Tilman, All. de la Découverte 11, 4000 Liège. tabunama@cebeedau.be

**Abstract:**

Wastewater treatment plants (WWTPs) are high-energy consumers and major Greenhouse Gas (GHG) emitters. Aiming at achieving energy efficient operations of treatment processes and reduce emission, it is essential to develop accurate smart real time control strategies and decision support solutions that can achieve that. Thanks to the Belgian Wallonia Researcher (BEWARE) Fellowship for funding the eWatLink project (No. 2110190) which executed by both CEBEDEAU SPGE at Bastogne WWTP which runs by iDELUX. This project aims to develop solutions that benefit from artificial intelligence (AI) to optimize and reduce WWTPs' EC and GHGs emissions, i.e., $N_2O$, etc. This paper presents parts of the currently developed solutions, which relates to a full scale activated sludge aeration process with RTC-N/DN at Bastogne WWTP. The developed nMPC reply on a neural state space (NSS) model of the aeration process. Furthermore, other smart controllers, namely fuzzy controller and rule-based controller were also developed coupled with electricity prices fetched from online sources.

**Keywords**: Wastewater treatment plants (WWTPs); Aeration process; Energy consumption; Real-time control and optimization.

Wastewater treatment plants (WWTPs) are major infrastructure assets that principle on the treatment of the collected wastewater (WW) to prevent negative impacts to human health, aquatic life, and the environment. Wastewater treatment mainly occurs in five stages, i.e. preliminary, primary, secondary, tertiary and sludge treatment. Although, WWTPs play a vital role in the water cycle, they are significant energy consumers, with around 3–5% of the global energy demand (Abunama et al., 2024). The accurate forecasting of the fluctuating wastewater influent flow rate and polluting loads, which are highly influenced by seasonal variations, time of the day, as well as regular evaluation and adjustment of operational criteria are significant in enhancing the WWTP reliability and energy efficiency (Abunama et al., 2023).
The aim of the current paper is to present a solution that developed for a full-scale aeration process at Bastogne STEP, Belgium. This solution, eWatLink, provides advanced smart real time control system based on machine learning to optimize the treatment process and achieve the goal of energy and emissions reduction. eWatLink was applied on a full-scale Bastogne Rhin WWTPs located in Wallonia region, Belgium (Figure 1.1). This 27,500 P.E. plant includes the three traditional stages—primary, secondary and tertiary treatment lines.

**Figure 1.1** Bastogne Rhin WWTPs, Wallonia region, Belgium

The first step in defining the highly consuming process is analysing the energy consumption process and defining the most consuming process, which can be done at looking the energy audits. For the previous few years in Bastogne STEP, the energy audits were analysed. It can be easily concluding that around 35-40% of the total energy consumption can be attributed to the aeration process. The current aeration process is controlled by either AIVE-IDELUX or by HACH regulations by Sequential Function Chart (SFC). Both control logics regulate the air blowing from the aerators based on the data readings from the installed sensors.

Developing advanced smart/economic RTCs, goes through different steps, as illustrated below:

- Problem identification
- System identification//MODELING
- Digitalization /twinning
- Optimization
- Control design
- Control simulation and testing before deploying

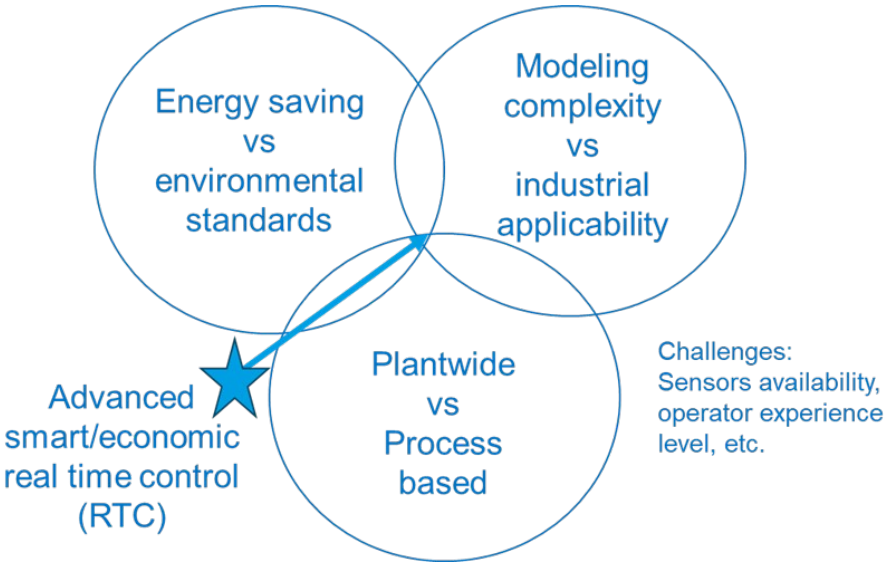


**Figure 1.2** Advanced smart RTC optimization

Three types of advanced economic controllers, were developed:

1. Nonlinear Model Predictive Control (MPC) with Neural State Space balck box model
2. Economic Rule based (RBC) controller
3. Economic Fuzzy controller (FC) (for better tunning)

For the current control techniques that applied in Bastogne STEP, there are two types of controller, as mentioned earlier. First is the Hach control logic that is in the form of SFC PLC code, which regulate the air blowers, based on the DO level. Second is the HACH control logic which is based on the weight between both NH and NO levels.
In order to achieve ewatlink project objectives, its important to establish a logic that is able to control the process of aeration, which considered the highest consuming treatment process. Among the objectives, is to run the treatment processes in respect of the electricity prices variations. Therefore, the adoption of advanced control can help to achieve that.

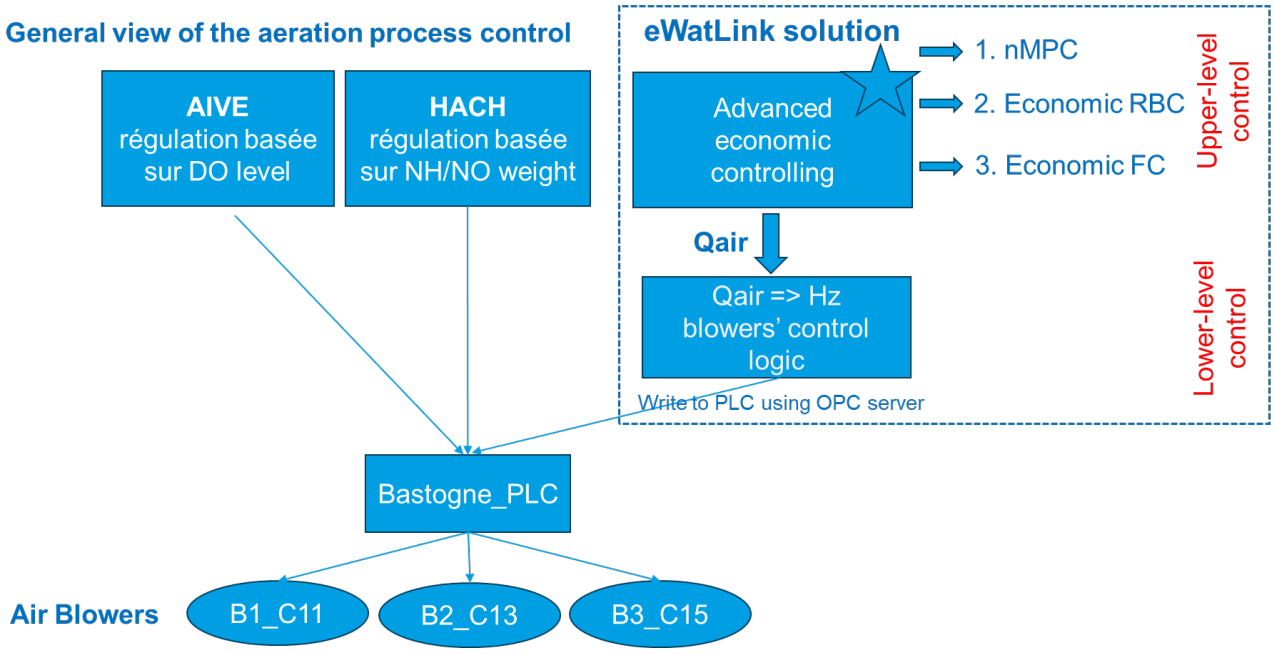


**Figure 1.3** General view of the aeration process control

Different models structures were tested in order to achieve the best accuracy while reducing the model complexity and dependency. 7 days used for developing the black box neural state space NSS model, which collected from the sensors at Bastogne STEP, during the previous periods. These data included, DO, NH, NO, TSS, Temp and TNout. The data were from 29/04/2023 and 05/05/2023. Three data pre-processing iterations were conducted, included data splitting and shuffling of experiments orders. The training structure was consisted of multi inputs and multi outputs MIMO, as follows: DO/NH as inputs and NO/TNout as outputs. The next stage, after training a NSS using data, is to export this model and use it with the integration of nMPC controller.

The results of test of the developed control outputs, without electricity prices fluctuations (left) and with electricity prices fluctuations (right). As can be seen, the applied smart economic controlling, use more Qair when the electricity prices in low range, benefiting from the variation in the electricity prices for economic operation. As overall, for a single day test:

- Accumulative total Qair with Price constrains = 80,687m$^3$/hr.
- Accumulative total Qair without price constrains = 89,633m$^3$/hr.
- Reduction percentage: = 9.98%

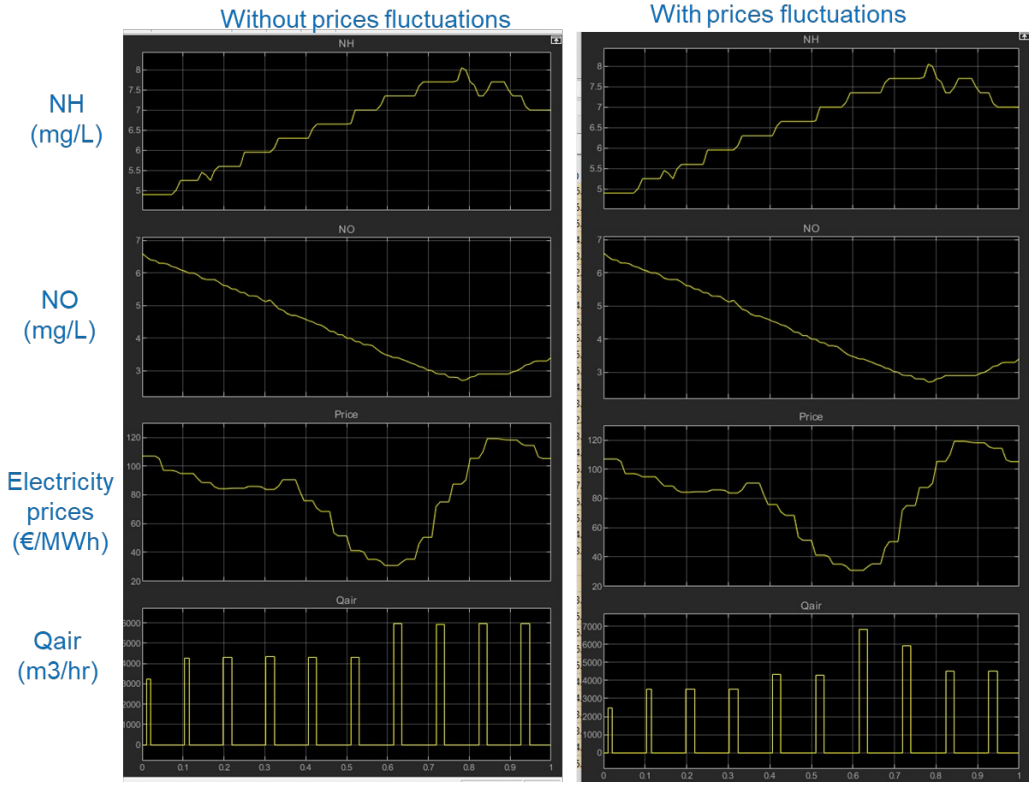


**Figure 1.4** Results of the controllers coupled with electricity prices

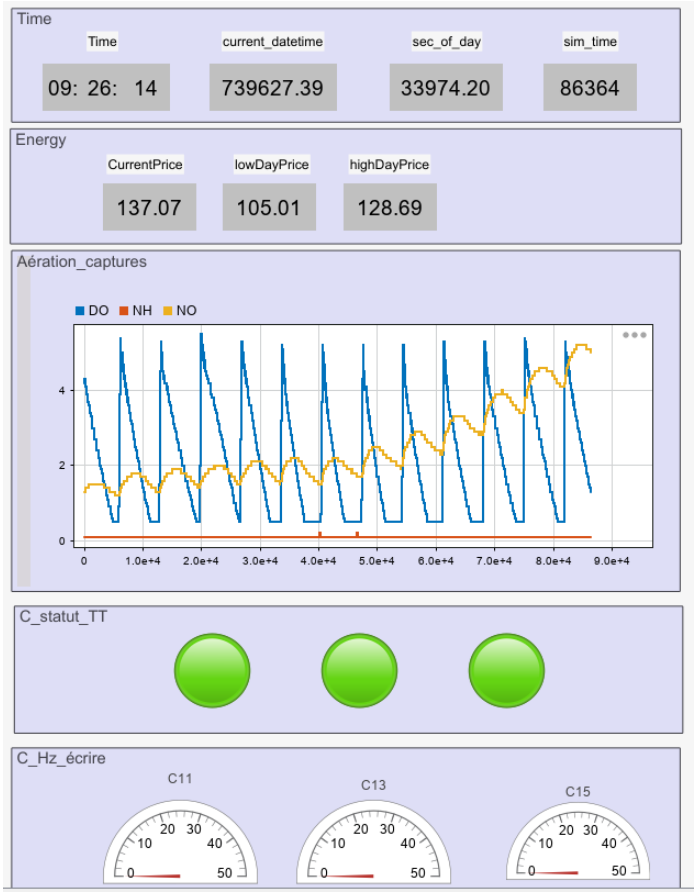


**Figure 1.5** Dashboard for the real time control

**REFERENCES**

Abunama, T., Seyam, M., Ansari, M., Kumari, S., & Bux, F. 2023. Integrated sequential fuzzy logic search models for simulating wastewater treatment plants missing influent parameters. Water and Environment Journal, 37(2), 289-302.

Abunama, T., Dellieu, A., & Nonet, S. 2024. Advancements in machine learning modelling for energy and emissions optimization in wastewater treatment plants: A systematic review. Water and Environment Journal, 38(4), 554-572.

*World Energy Outlook*. 2019. Organization for Economic Co-operation and Development (OECD)/IEA, Paris, France.