D4.4 FIWARE4_Intelligent Control for Wastewater Treatment

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Project Consortium

Executive Summary

Waternet's (WNT) wastewater treatment plant (WWTP) Amsterdam West has a capacity of 1 Million population equivalent and serves the city of Amsterdam. The process automation (PA) of WWTP Amsterdam and the IT architecture of WNT is in continuous development to allow the support of upcoming technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Business Intelligence (BI) and streaming analytics to improve operational efficiency and asset management, and to reduce climate impact and costs.

Currently the control loops of WWTP Amsterdam West are for a large part locally distributed and dedicated to a single wastewater treatment unit process. The objective is to demonstrate the integration of the Fiware4Water architecture (F4W) using FIWARE in the legacy system with better use of real-time plant data and the use of data-driven AI smart applications in practice, to achieve a more optimal plant-wide control with respect to its climate footprint and costs while meeting effluent quality criteria.

To meet the objective, one of the seven parallel treatment lanes at WWTP Amsterdam West is made available as a full-scale research lane for the F4W project. In this research lane additional sensors are deployed and integrated, and an on-site research facility is built to gain more insight in the wastewater treatment process. Furthermore the F4W architecture is deployed and integrated in the WNT legacy system, including (near) real-time (ranging from no delay up to maximum of 2 minutes delay) F4W WWTP AI smart applications developed in Deliverable 3.3, and F4W data models developed in Deliverable 2.3. Finally intelligent real-time AI control is implemented in the legacy system. The F4W AI smart applications deployed are software (soft) sensors for determining the influent flow per lane, for prediction of the influent flow and for determining the airflow per lane. A soft sensor, for this case, can be defined as a virtual sensor, whose output is based on (AI) calculation of multiple observed measurements. Next to the soft sensors an AI smart application for (near) real-time data validation is deployed. The implemented AI control model has a control objective to minimise nitrous oxide (N_2O) emissions and energy consumption at minimum costs whilst meeting effluent water quality targets. Half of the WNT climate footprint is determined by nitrous oxide emissions of the WWTPs. Thus, minimising N_2O emission has a large impact on GHG emissions reduction and optimal control of these emissions is therefore considered to be of key importance in reaching climate neutrality.

From the Amsterdam demo case it can be concluded that F4W architecture can be integrated in a water utility legacy system with AI smart applications running in (near) real-time. Furthermore it is possible to use real-time AI control for optimizing nitrous oxide emissions and energy for wastewater treatment plants in practice. By integrating in the legacy systems that end users are used to work with on a daily basis, it is very easy for them to access and use the smart applications in their work. For the wastewater technologists, one of the end users of soft sensors, there is no difference whether the treatment plant data is from physical sensors or AI soft sensors and whether it comes from the legacy system or from F4W. The same holds true for the use of the control model by the plant operators. By integrating the activation, deactivation, safety constraints and automatic fallback of the AI control in the existing legacy user interface (UI), the AI control is an additional option next to manual and automatic control in the legacy distributed control system (DCS). This has the big advantage that there is no additional training necessary for operating personnel for using new additional UI/systems and identity access management (IAM) is secured in existing processes.

WWTPs are used throughout Europe and the world. They can differ in size, type of treatment processes, level of automation, type of sensors, operation etc. So although the potential for WWTP AI

smart applications is enormous, not all of developed WWTP smart applications can be used directly at any WWTP in Europe. For instance the influent soft sensor per lane is very specific for the plant layout and sensor setup of WWTP Amsterdam West. However, the AI data validation model is highly generic and can be trained for other WWTPs and for other sensors. Also the AI influent flow prediction using rain meter data can be trained for WWTPs at other locations. The control model is applied at the research lane, one of the seven treatment lanes of WWTP Amsterdam West, and can also be implemented to the other six treatment lanes of WWTP Amsterdam West. The applied approach works, so the AI model architectures can be used for other (WNT) WWTPs with practical adaptions (e.g. including or excluding of other (soft) sensors) and model training.

The F4W Amsterdam demo case demonstrates the possibilities for the use of FIWARE in the (waste)water sector. The interoperable properties of the FIWARE-enabled F4W architecture together with the developed F4W data models, enable replication and upscaling. The methodologies, approaches, and developed technologies in the Amsterdam demo case present a successful baseline to guide other water utilities for future digitalization processes. By closely working together in developing the AI models, integrating the AI models and deploying the AI models at WWTP Amsterdam West, WNT, KWR and EUT collaborated transnational in the most extensive way. In F4W the complimentary knowledge on wastewater treatment, sensoring, AI and model deployment from research and practice perspective were brought together. The complementary collaboration made the development of the smart applications, the integration of the F4W architecture in the legacy system and the use of the smart applications for WWTPs possible in practice. The knowledge development on AI in the water sector for the demo case can be used across Europe.

The European added value (EAV) of Deliverable 4.4 is not only in boosting the excellence in AI for the water sector, but also in the knowledge developed regarding nitrous oxide emissions reduction in practice. The F4W project has boosted the knowledge and research about the formation and reduction of N_2O emissions from WWTPs. Also data sets are being extended on N_2O emissions for future use. Therefore it contributes to sustainability and greenhouse gas emissions reduction ambitions of the EU. The demo case Amsterdam West WWTP is therefore directly contributing to the acceleration of the twin – green and digital – transition, which is seen as a necessity in order to reach the climate goals by 2030. The EAV and recommendations are further detailed in the conclusion and perspectives section.

The use of the soft sensors and the AI control model were well received by WNT wastewater technologists and process operators. However, at the time of completion of the present deliverable the AI control model tested was the first version that mimics the current control. The tests with the optimized control agent are done in the last month of the project, so the results are not available before finalization of this deliverable. However, operational personnel stated that since the control agent is very well capable of mimicking the current legacy control in practice, and after seeing the results of the final control agent in off-line tests, the expectations are that it will be able to improve the current operation with regard to nitrous oxide emissions and energy use.

Related Deliverables

D1.1 Requirements from Demo Cases

D2.1 Specification of system architecture for water consumption and quality monitoring

D2.2 Extensions of FIWARE ecosystem with Big Data and AI frameworks

D2.3 Extension of FIWARE for supporting water management and quality monitoring use-cases

D3.3 FIWARE-enabled applications for wastewater treatment

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List of Acronyms

AI	Artificial Intelligence
ANN	Artificial Neural Network
AT	Aeration Tank
BI	Business Intelligence
DCS	Distributed Control System
DL	Deep Learning
DVR	Data Validation and Reconciliation
EAV	European added value
F4W	Fiware4Water project
FAT	Factory Acceptance Test
FEWS	Flood Early Warning System
IoT	Internet of Things
JSON	JavaScript Object Notation
LSTM	Long Short-Term Memory
NaN	Not a Number
NGSI-LD	Next Generation Service Interface for Linked Data
PA	Process Automation
PID	Proportional, Integral, Derivative
PIMS	Process Information Management System
PLC	Programmable Logic Controller
RAS	Return Activated Sludge
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
UF	UltraFiltration membrane
VM	Virtual Machine
WAS	Waste Activated Sludge
WPL	Work Packages Leaders
WWTP	Wastewater treatment plant