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Management tool to assess, benchmark and support energy efficiency actions in more than 800 WWTP

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Abstract

Águas de Portugal (AdP) group was responsible, during 2014, for the treatment of 547 million cubic meters of wastewater, operating more than 1,000 wastewater treatment plants (WWTPs) in Portugal. Electrical energy (EE) consumption was evaluated in 219 gigawatt hours, representing the largest part of OPEX in these plants. Improving energy efficiency is an ongoing challenge for AdP, being a major challenge for such huge number of facilities as well as for the large number of different technologies applied. However, this scenario has allowed, during the last five years, a systematic analysis and benchmarking of the operational information, and has outputted an important management tool regarding EE consumption, based on real data from more than 800 WWTP. This tool is used to leverage consumptions and identify efficiency opportunities, and represents an operational asset, not only for future EE consumptions prediction, but also as a driver for energy efficiency plans and to the design of new WWTPs.

Key words: benchmark, efficiency, electrical energy, management tool, operational asset

INTRODUCTION

Águas de Portugal (AdP) is a leading group operating in the environmental sector in Portugal and its mission is to contribute to the pursuit of national objectives in the water supply and wastewater sanitation, within a framework of economic, financial, technical, social and environmental sustainability.

AdP group supplies more than 8 million people (80% of continental Portuguese population) which portray the relevance of this group in Portugal and the need to achieve good levels of performance. In 2014, AdP spent about € 63 million for electrical energy (EE) to run drinking water and wastewater, equivalent to approximately 652 gigawatt hours per year (GWh/year). From this, the wastewater facilities' EE consumption has been evaluated in 219 GWh/year. That represented 0.5% of the nation's EE consumption and equals to adding approximately 103 thousand tons of greenhouse gas (CO_2) to the atmosphere. In this framework, energy efficiency represents one of the strategic goals of AdP in order to achieve a high level of efficiency and to drive to continually improve the performance of water services.

Improving energy efficiency is an ongoing challenge for water sector utilities. In Portugal, electricity prices have increased almost 20% in the last 5 years (DGEG 2015) and energy costs represent 50% of AdP's wastewater treatment direct costs (Brôco *et al.* 2014).

Recognizing the importance of the energy efficiency for its activity, AdP has been working, during the past 5 years, on EE efficiency aiming to maximize the equilibrium point between investment and operational efficiency. For this purpose it is mandatory to continually analyse and benchmark data in terms of EE uses to leverage consumptions and identify efficiency opportunities.

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This paper describes the work that AdP group has been doing in order to leverage energy efficiency in wastewater treatment plants (WWTPs).

MATERIAL AND METHODS

After a first important study of data consolidation (Carvalho *et al.* 2014), new and more accurate assessment has been developed in order to characterise and update EE consumptions from different wastewater treatment processes in AdP group.

The methodology used was similar to the previous and included: (1) Data collection; (2) Clustering of data by wastewater treatment process; (3) Calculation of EE use per flow; (4) Individual analysis by wastewater treatment process; (5) EE data range analysis and benchmarking. This methodology is schematically presented in Figure 1.

As a result, a database was developed using the available data from these 5 years of operational data. This data was also used to determine the trendline for each of the adopted baselines, in order to enable the comparison between a specific WWTP with those in the sampling.

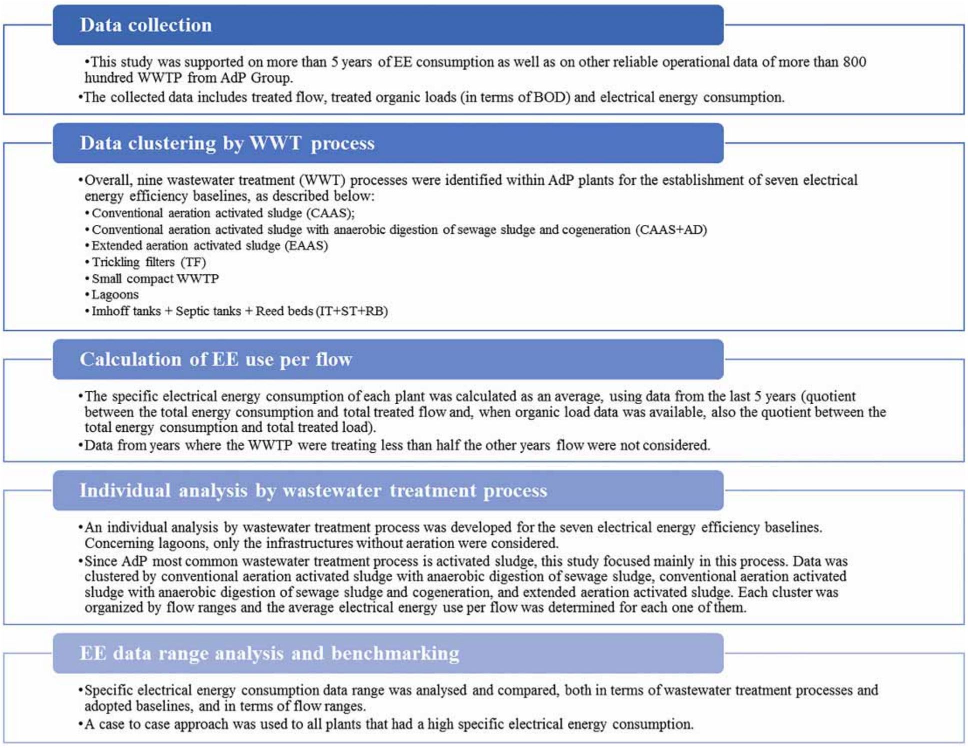

Figure 1 | EE use evaluation and benchmarking methodology.

RESULTS AND DISCUSSION

The outcome of this continued study was an important management tool, regarding WWTP EE consumption, based on real data from more than 800 different WWTPs.

The developed database consists of a management and analysis tool that integrates different inputs such as treated flow, EE consumption and wastewater treatment process. This database offers an integrated analysis of the data and allow a prompt delivery of the outputs through a set of charts, based on a graphical user friendly approach. These outputs include information about EE use per flow and give

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a direct correspondence between specific EE and the treated flow for all major wastewater treatment processes. Moreover, these outputs include graphical methods to assist in the interpretation of the charts that allow a clear understanding about the position of a specific WWTP compared to the sampling.

As an example, Figures 2 and 3 show the average EE use per flow of extended aeration activated sludge (EAAS) and conventional aeration activated sludge (CAAS) treatment process within AdP plants. Each of the points represent a WWTP. The solid line represents the trendline that reflects the regression curve obtained from these points. The broken line represents the upper limit of the allowed confidence interval. The confidence interval was calculated to include 95% of the analysed plants.

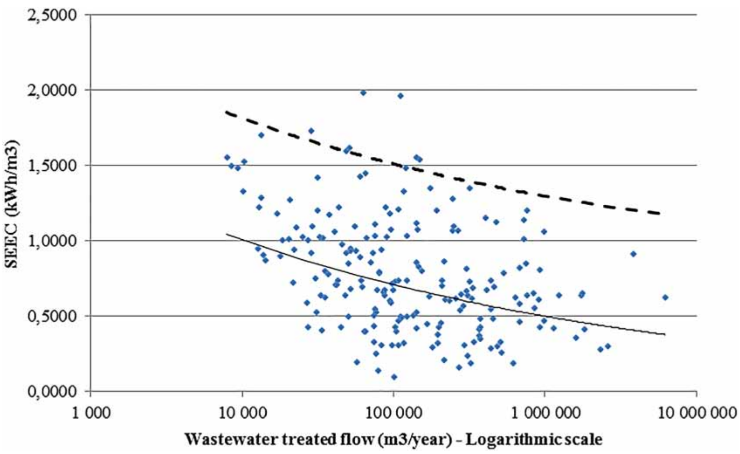

Figure 2 | EE use per flow (kWh/cubic meter) of EAAS.

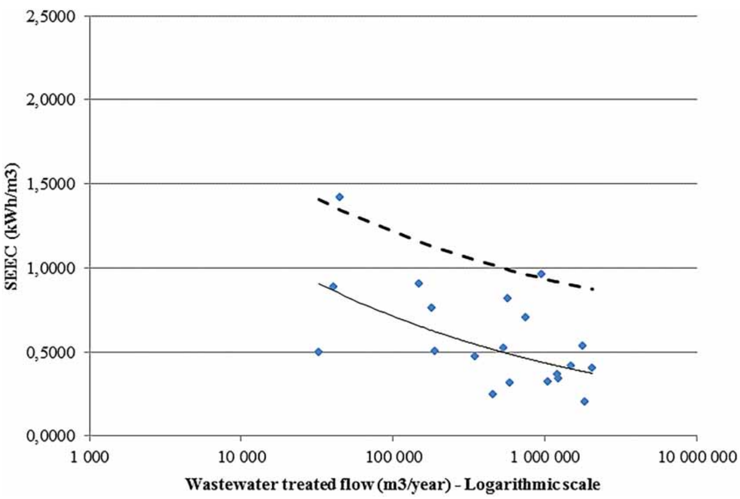

Figure 3 | EE use per flow (kWh/cubic meter) of CAAS.

Concerning these 2 activated sludge treatment processes, the obtained results show that:

- Within the same treatment process, the lower the average flow the greater the specific EE consumption. This output was similar in all the WWT processes analysed.
- The range of application of EAAS varies between 10,000 m^3/year and 8,000,000 m^3/year, while the average EE per flow ranges from 1 kWh/m^3 to 0.4 kWh/m^3 in this interval.

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- The range of application of CAAS varies between 50,000 m^3/year and 5,000,000 m^3/year, while the average EE per flow ranges from 0.9 kWh/m^3 to 0.4 kWh/m^3 in this interval.

This relationship, which was obtained for all treatment processes studied, defines the benchmarking baselines that are being used by AdP utilities to implement energy management systems through the adjustment of the results to their own reality.

So, one of the major outcomes of this study was the integration of specific EE consumption as a parameter in the tender procedures for design and construction of new WWTPs. This knowledge allows to define maximum values for this parameter to be included in the procedure parts, based on the plant capacity and treatment process. The maximum value is also used on the tender Performance Guarantees statement and the contractor must comply with it during the plant startup.

Since 2015 rehabilitation and construction tenders in AdP group include an energy consumption limit forcing the contractor to project the plant with greater focus on the energy efficiency, both in terms of the plant design and choice of equipment. This promotes a huge paradigm shift in the WWTPs design and construction procedures in Portugal, since until now the main drivers were the compliance of wastewater discharge regulations and the initial investment costs.

Moreover, this knowledge allows estimating the plant life-cycle energy assessment with greater accuracy to better understand its energy balance.

The study has also been decisive for the certification according to ISO 50001 standard of the largest AdP WWTPs, in a total of 42. That will allow a better evaluation of existing opportunities to contribute to AdP group financial and environmental sustainability.

CONCLUSIONS

This paper describes the work that AdP group has been doing in order to leverage energy efficiency in WWTPs.

After a first important study of data consolidation, new and more accurate assessment has been developed in order to characterise and update EE consumption from several hundred WWTPs.

The work includes the development of an important management and analysis tool consisting of a database that integrates the available data on volumes of wastewater, EE consumption, plant capacity and treatment process from 5 years of operational data.

The database offers an integrated analysis of the data and allows a prompt delivery of the outputs through a set of charts, based on a graphical user friendly approach.

This management tool allows foreseen EE consumption and is a driver for EE efficiency plans implementation. Since last year, it is also a supportive tool for new WWTPs design and procurement, with the integration of specific EE consumption as an assessment and evaluation parameter in the tender procedures. So, it allows utilities to drive their performance goals to continuous improvement and to become more energy efficient.

To resume, this tool is used to leverage consumptions and identify efficiency opportunities, and represents an operational asset, not only for future EE consumptions prediction, but also as a driver for energy efficiency plans and to the design new WWTPs.

With this project, AdP has now a database with the specific EE consumption of WWTP, that allows a reliable knowledge on EE indicators for this kind of facilities. Nevertheless this is an ongoing project since it is AdP's objective to maintain the database updated in order to have the most reliable data.

Additionally it reflects the importance of the subject to AdP group, representing a step-forward in achieving better efficiency performance in water-energy nexus, which will contribute to AdP group financial and environmental sustainability.

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