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Publication date:
2009

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
Title: Focus and efforts on energy optimisation based on online control pays off well: a detailed case from Avedøre Wastewater Services

Article Type: Submission for Oral Presentation

Keywords: wastewater; on-line control; energy savings; nitrogen removal; improved effluent quality

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Manuscript Region of Origin: DENMARK
Focus and efforts on energy optimisation based on online control pays off well: a detailed case from Avedøre Wastewater Services

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Abstract
Focus and efforts on optimisation of biological nitrogen and phosphorous removal processes based on automated online control not only results in improved effluent qualities but at the same time gives energy savings and savings in chemical consumption, thus resulting in win-win situation for the total environment – wastewater treatment and carbon footprint.

Avedøre Wastewater Services (AWS) is a municipal company jointly owned by 10 municipalities and is situated 10 km west of Copenhagen, the capital of Denmark. AWS ensures that the wastewater from an urban area measuring 400 km² and population of ca. 2400000 inhabitants is thoroughly treated before being discharged to the recipient, Køge Bay, thus benefiting the aquatic environment and a recreational beach area that is visited by 750,000 people a year.

AWS has for the past many years had a persistent focus on improving effluent qualities and at the same time decrease energy consumption based on online control and research and development activities in cooperation with research community. In 2001 on-line nutrient sensors – ammonia, nitrate and phosphate – were installed in process tanks and daily used by operator’s for improving the biological nitrogen removal and chemical phosphorous removal. In 2004-5 use of these on-line sensors was automated by introducing STAR control® during the R&D project Ø-forsk (funded by the Øresund Environment Academy) and phosphorous removal was optimised by introducing biological phosphorous removal in process tanks. Later in 2007-8 the advanced online control system was further upgraded and various optimisation activities were investigated in the R&D project OpDrift (funded by the EU InterregIII A programme).

Figure 1 Power consumption (left) at the Avedøre Wastewater Services in the years with high focus on energy savings in operation of wastewater treatment and sludge handling. Operational expenses (right) related to wastewater treatment in biological process expressed as power cost and effluent tax calculated per kg effluent BOD, Total-N and Total-P.
Figure 1 shows that the intensive focus and efforts during two R&D projects is very visible on power consumption and effluent quality. Energy savings of 16% from biological wastewater treatment part and 6% from sludge handling as dewatering and incineration were gained along with improved effluent quality. These savings are a result of various activities. For instance the investigations on necessary effect for mixing in aeration tanks showed that 50% of installed mixers could be permanently turned off resulting in a energy savings of 750 MWh/year without any negative effect on oxygen gradient with surface aerators, sludge settling or effluent quality.

Win-win for the environment
By optimising the biological nitrogen removal processes, BNR, based on automated online control, it is not only possible to achieve improved effluent qualities but at the same time optimisation of nitrification and denitrification leads to energy savings as aeration is only performed when necessary and is not wasted on COD removal.

A new step taken at the Avedøre Wastewater Services together with Krüger A/S has been to focus specifically on biological phosphorous removal (BPR) without construction of specific anaerobic volume. This special feature is integrated in STAR control® and the process now patent pending. The paper will present some cases where it is possible to replace chemical consumption for precipitation with high degree of biological on-line control. Being able to reduce dosing of chemicals has two positive effects on the energy balance – first, directly reduce energy consumption for production, transport of fewer amounts of chemicals and second, less chemicals dosed leads to reduced production and handling of chemical sludge from wastewater treatment plants.

Both BNR and BPR based on advanced online controls certainly give a win-win situation for the total environment – wastewater treatment and carbon footprint.

Cases to show energy savings by on-line control
The paper will present various cases of energy saving results from existing wastewater treatment plants from different situations. One case will be where the energy consumption is evaluated as hours of operation by surface rotor brushes equivalent to kWh – less hours of operation/day equals less kWh.

Energy saving perspectives with on-line control
There might be several reasons for the introduction of on-line control at a wastewater treatment plant, but the most important is to achieve operational savings by reduction of the energy and chemical consumption. From this point of view it is important to be able to evaluate the Return-of-Investment as advanced on-line control has its own costs such as on-line nutrient sensors and control software whether this is implemented in a SCADA system or in a superior software system like STAR control®. The paper will include some evaluation of Return-of-Investment from advanced on-line control.

The change of operation from SCADA level to advanced control level shows at Table 1, a rather significant decrease in the energy consumption, even if evaluated as kWh per flow (decrease 11%) or kWh per kg BOD removed (decrease 7%).

Table 1 The table shows the 2-year average of energy consumption per m³ water treated at polish wastewater treatment plant Poznan STP where consumption has decreased 11% by operation with advanced system, STAR control®, compared to operation by traditional SCADA control.

<table>
<thead>
<tr>
<th></th>
<th>Energy consumption (kWh/m³)</th>
<th>Energy consumption (kWh/kgBOD removed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional SCADA control</td>
<td>0.510</td>
<td>1.14</td>
</tr>
<tr>
<td>Advanced on-line control</td>
<td>0.455</td>
<td>-11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-7%</td>
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