Transparent Energy Balance by Online Energy Analysis

Energy efficiency studies and feasibility studies are the basis for modernization projects at wastewater treatment plants. In these studies, engineers evaluate the status of plants, determine the potential and develop optimization proposals. These are one time projects that review the status of a plant at a specific time. A major shortcoming is, that they do not provide any information on how the energy balance will change after optimization measures have been implemented. In order to verify sustainability, it should be possible to check and trace the operation modus at every time.

At the Asselbrunn wastewater treatment plant of the Mittlere Mümling Wastewater Association, analysis tools were used to automatically generate the energy savings potential from process data and manual input data at any time. This means that the energy efficiency analysis is no longer a one-off project, but provides the energy status of a wastewater treatment plant, water supply or other technical systems at any time during ongoing operation.

Picture 1 WWTP Asselbrunn, Abwasserverband Mittlere Mümling

The Asselbrunn wastewater treatment plant has been modernized step by step in recent years. In the process, attention has also been paid to recording the energy data of the electrical consumers and generators as completely as possible. This makes it possible to automatically generate the parameters required by the GWA standard DWA-A 216 from the process data and manual input data at any time using a tool for energy analysis.

Through the online energy analysis with the PROVI ENERGY tool, key values, ideal values, potentials, consumer matrix and many other results can now be generated at any time for a selected period. The energy analysis is thus not a one-time project as a study, but enables the continuous evaluation of the energy situation of a wastewater treatment plant or other process plants.

The Database

At the Asselbrunn sewage treatment plant, the operating hours of almost all machines are recorded. For most of the machines, the power consumption is also available, and for the blowers, the power is measured. On the basis of the operating hours, electricity consumption can of course only be estimated inaccurately. If the current consumption is given, the uncertainty is only in the cosine-φ. If the power is measured directly, one has an exact consumption value. For motors with a frequency

converter, the measured value for the current consumption or the power can also be tapped here with sufficient accuracy, although the internal losses of the frequency converter are not recorded.

In order to determine characteristic values, the load of the treatment plant is also determined automatically. For this purpose, PROVI ENERGY accesses the manual input database and the process data directly via an interface. For the load, this is usually the manual input value **COD** in the influent and the process value **Inflow** measured online. Filter options also allow extreme values to be filtered out or only the dry weather inflow to be evaluated. The additional calculation of the median value also shows how strongly extreme values influence the mean value.

Very important for the energy balance are the electricity purchases, the output of generators and the feed of surplus energy back to the supply network. These values were available for the most part. Missing values could be added in the course of the modernisation measures. It is important that the opportunity of an ongoing project is definitely used to fill in missing values. This requires a planner who is aware of such overriding aspects.

Characteristic Values

Once the load has been determined, the characteristic values etotal [kWh/(E*a)], eAeration [kWh/(E*a)] or the specific gas production eFG [l/(P*d)] can be determined and presented very easily.

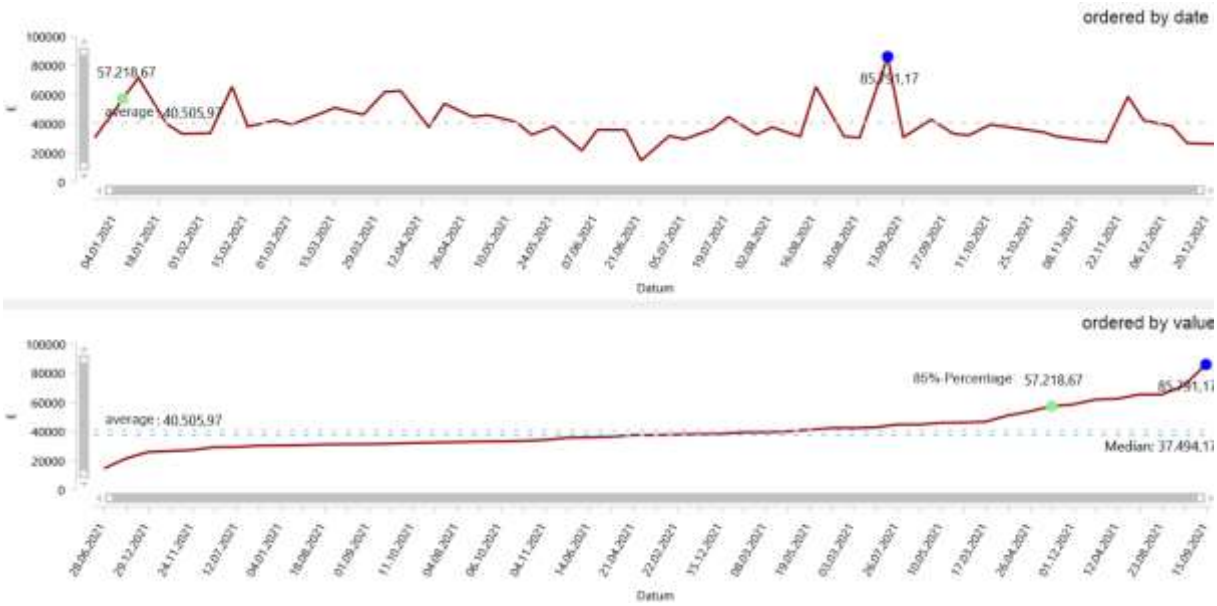

Fig. 1: Load for the year 2021

For pumping stations, the flow rate is required in addition to the electricity consumption of the pumps. For screw pumping stations, the head can be derived from the design. For pumping stations with pressure pipes, the manometric head must be estimated or taken from hydraulic calculations if no pressure measurement is available.

All the necessary online data are available in databases at the Asselbrunn sewage treatment plant. The PROVI ENERGY analysis tool accesses this database and automatically generates the characteristic values on a daily basis and classifies the result in the statistical curves of DWA-A 216.

Fig. 2: Dashboard/Overview

Characteristic values, power consumption of stages and machines, ideal values and potentials

Coarse and Fine Analysis

The dashboard shows, among other things, the steps for coarse and fine analysis. Since the data of the electrical consumers are available in great detail, the electricity consumption can be defined and displayed for the individual machines, the stages and for the entire system according to the plant structure.

Ideal Values and Potentials

The formulas for calculating ideal values are available in the DWA (German Water Association) standard DWA-A 216. The determination of the oxygen demand is more complex. This is based on DWA-A 131. Input data are the actual loads such as COD or TKN from the manual input database and process values such as temperature or flow rate from the process database. The ideal values are compared with the actual consumption of the considered stage. The result is the savings potential. In Figure 2, this is shown in the right-hand graph by the green bars for the ideal value and blue bars for the actual power consumption of the stage.

Details

If you want to look at an aspect in detail, the PROVI INTERPRET tool offers the possibility of analysing the process data in high resolution on the same data basis. In this way, it is possible to go from the energy analysis to a deeper evaluation of the process.

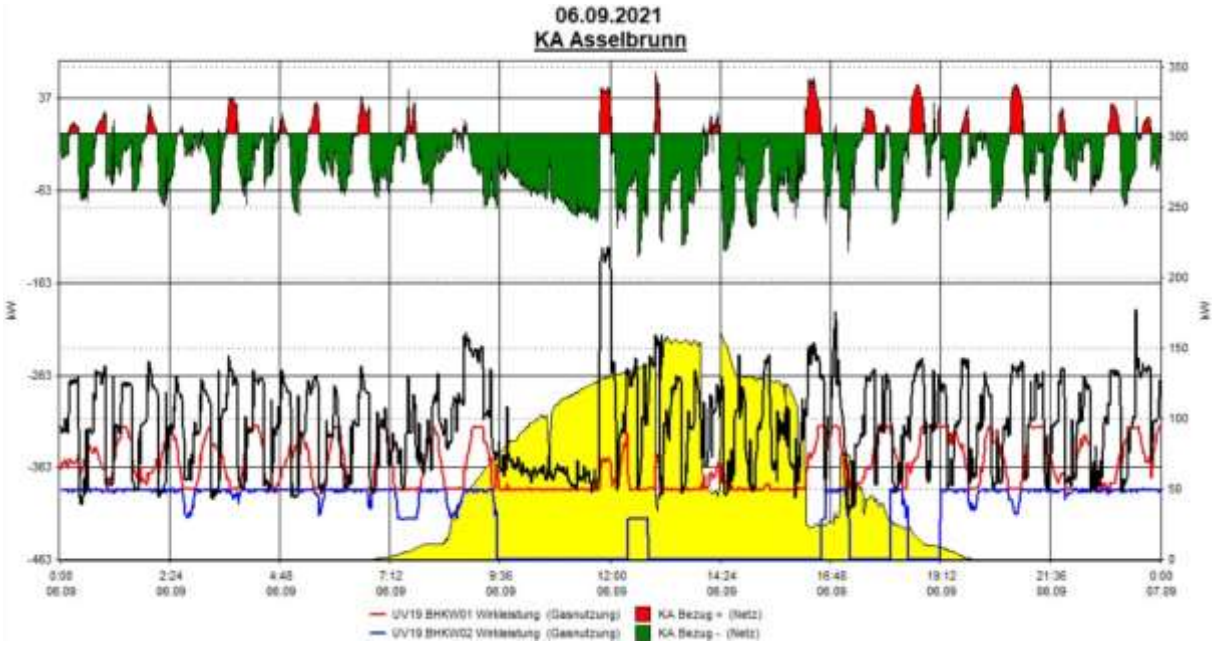

Fig. 3: Minute values of the energy balance,

Bottom: total electricity consumption of the treatment plant (black), generator of CHPs blue and red and PV (yellow).

Top: purchase (red) and surplus (green)

It can be seen very clearly that the external electricity supply (red areas on the top) can be minimised through the implemented load management.

Further Results

The consumer matrix provides detailed information on how the consumption data of the electrical aggregates were determined. An add on of the calculations is a detailed energy report as a monthly and annual report. An always up-to-date machine list can be exportet from the machine data. The DWA-A 131 model is also used to calculate the required MLSS content and compare it with the actual operation value.

An Analysis in Detail

The load of the wastewater treatment plant differs significantly from 2020 to 2021, with the mean value increasing from 40,930 PE to 43,341 PE. The specific parameters refer to these values.

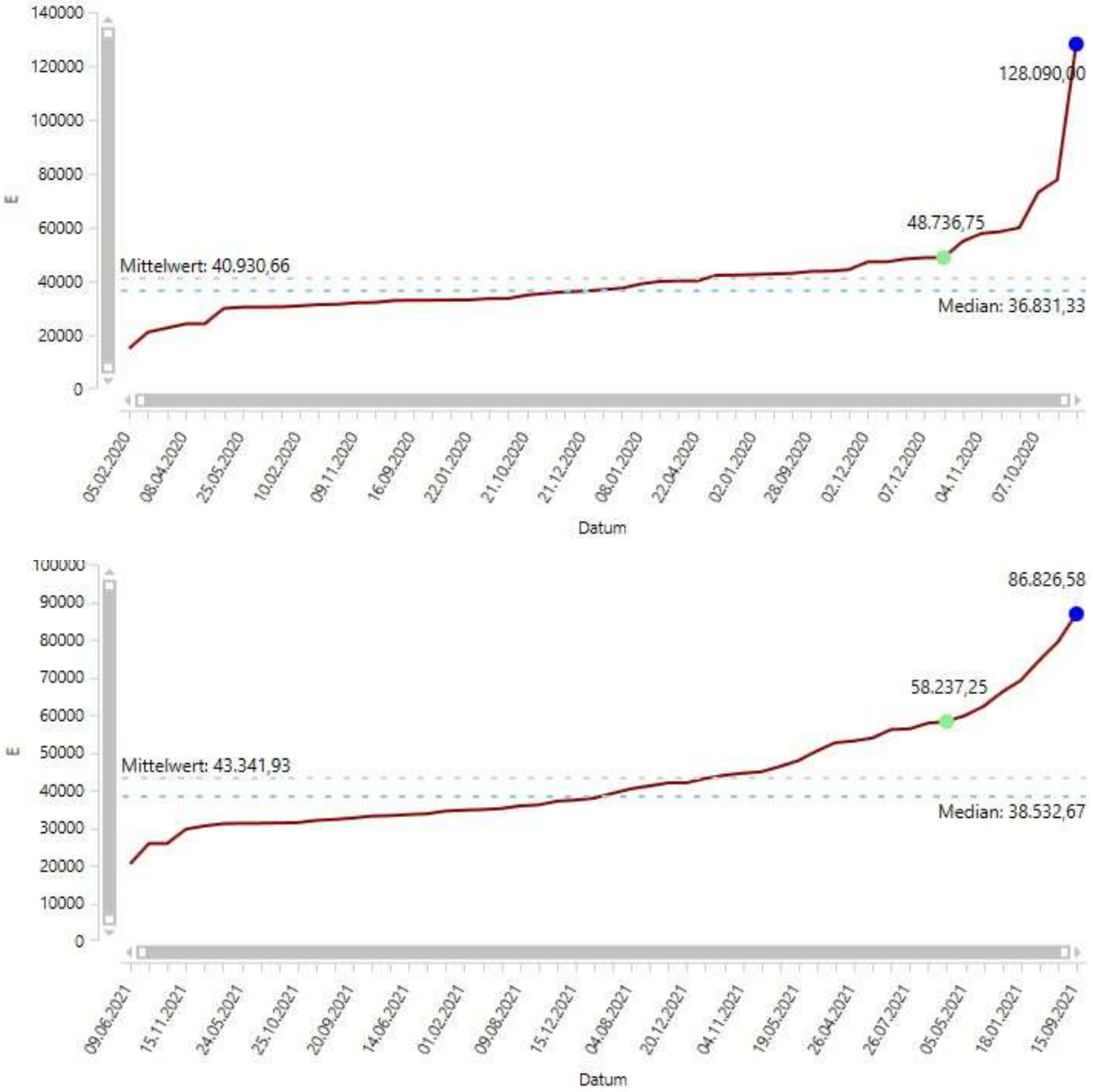

Fig. 4: Load EWCSB,I

If we look at the total electricity consumption of the Asselbrunn wastewater treatment plant for 2020 and 2021 in comparison, the specific characteristic value etotal increased from 20.3 to 23.9 kWh/(P*a) from 2020 to 2021. The specific energy consumption for aeration has remained the same.

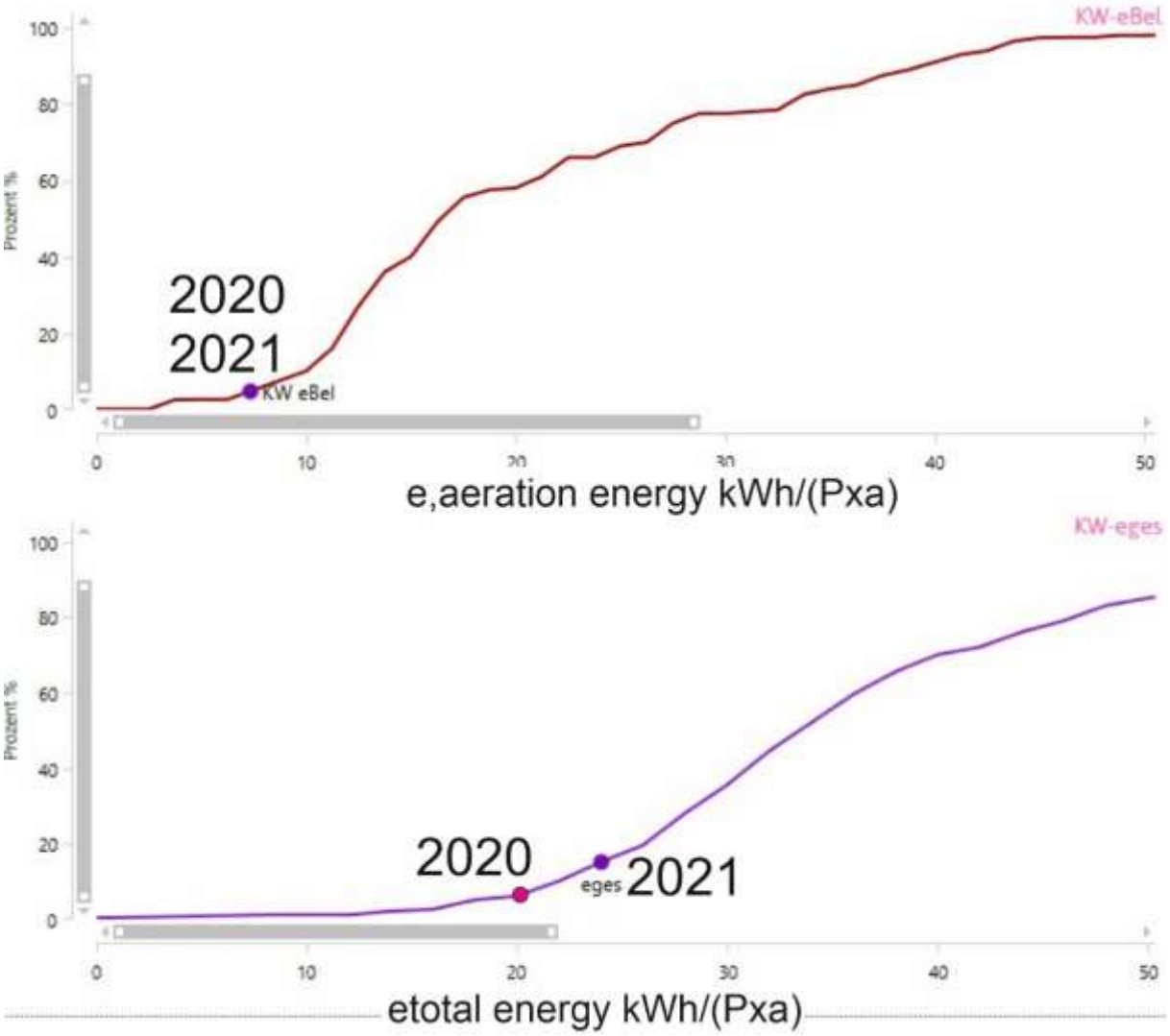

Fig 5: Characteristic values e,total and e,aeration [kWh/(E*a)].

Where can be the cause for the increased specific total energy consumption? We see above that the specific total energy consumption for ventilation has not changed.

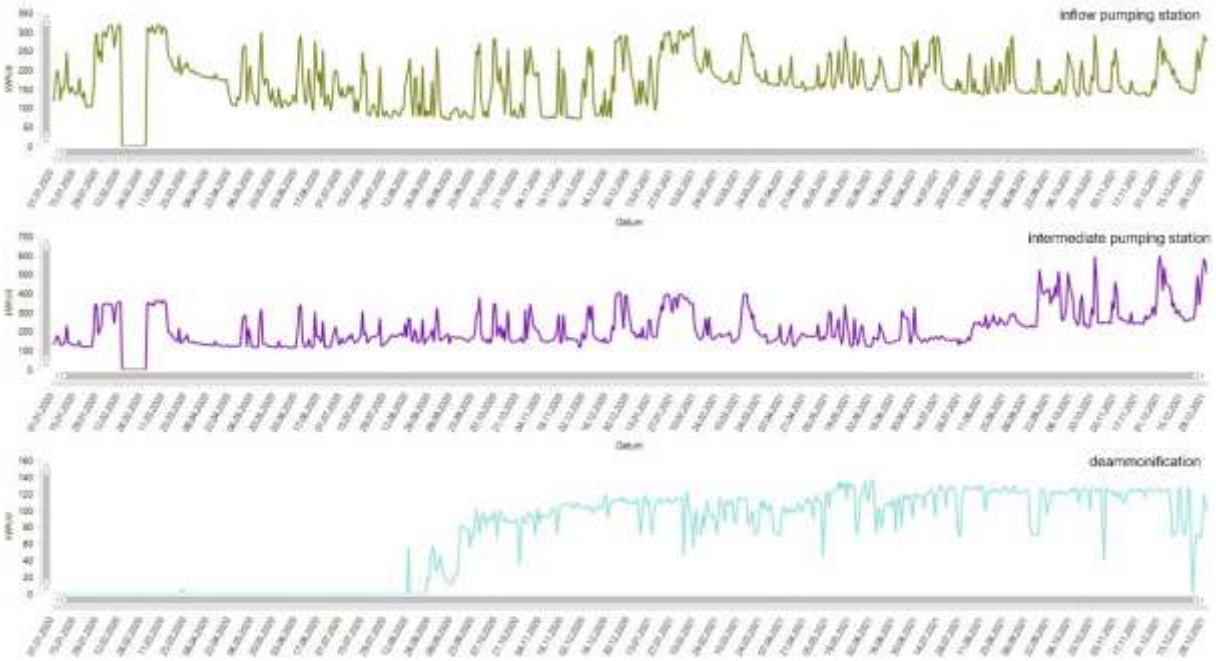

Fig. 6: Long-term graph at pumping stations and deammonification 2020 to 2021

If we look at the long-term evaluation of the electricity consumption of the intake pumping station and intermediate pumping station, we can already see a reason for the increased electricity consumption and perhaps also for the increased load. It probably rained more in 2021 and therefore they had to pump more. In addition, the deammonification system was put back into operation in the summer of 2020. This did not result in any savings in aeration, although the biology was relieved. An additional consumption of 110 kWh/d already corresponds to about 1 kWh/(P*a).

The optimisation of aeration has certainly been recognised everywhere as an important measure. But the pumping stations also deserve special attention, especially when there is multiple pumping in the system.

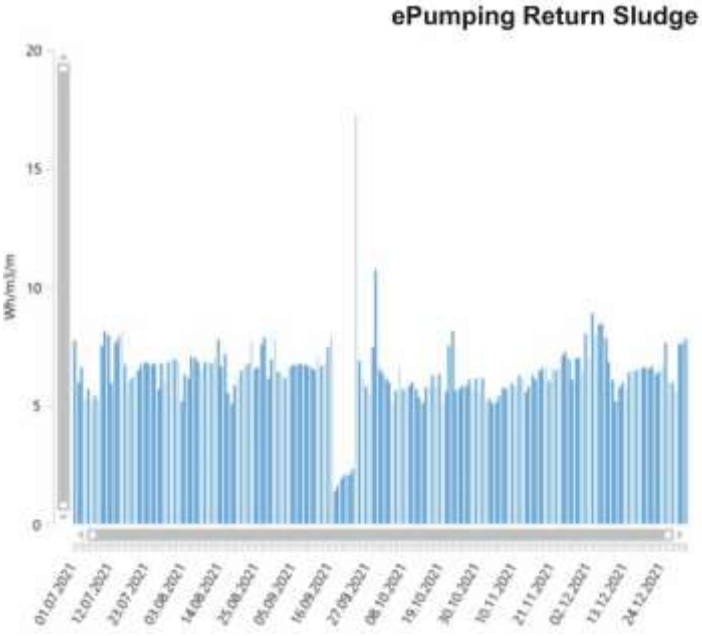

Fig 7: Key Value for Pumping by Time

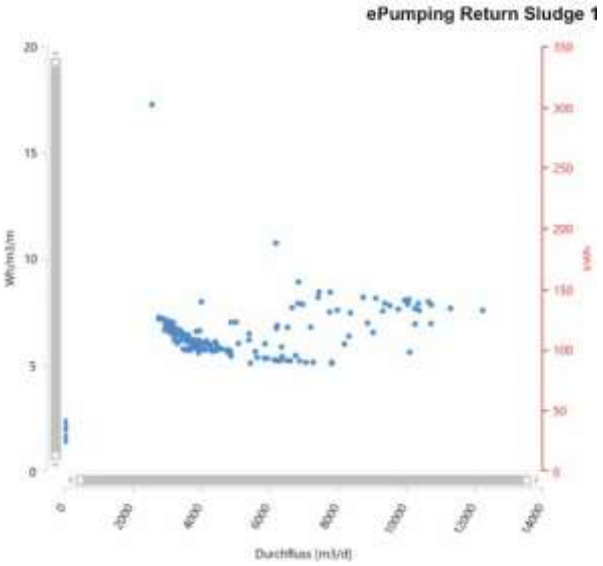

Fig 8: Key Value for Pumping Wh/(m3xm) by Daily Flow

Here, more detailed graphical evaluations are possible, which show the operating behaviour of a pumping station at different operating points. Figure 7 shows the pump characteristic value plotted against time. Figure 8 shows the same characteristic values plotted against the daily flow rate. If one looks at the time-dependent development of the pump characteristic value, this looks quite even. However, if we look at the pump characteristic value over the flow rate, we see that the specific energy consumption is clearly worse at the higher flow rates. It is therefore advisable to take a closer look at the control behaviour of the pumping station.

Cross-sectoral evaluations

The balances are based on process data, especially the consumption of the machines and the energy suppliers. The balance sheet is built up on this basis and the operating behaviour is analysed. The PROVI ENERGY analysis software is therefore not only used in wastewater disposal, but also in water supply. The operator can thus build up his energy balance across sectors.

Conclusion

Sewage treatment plants were once considered the largest energy consumers in municipalities. In recent years, much has been done to move towards energy neutrality, at least for plants with anaerobic sludge stabilisation. Plants with simultaneous aerobic sludge stabilisation are also becoming more energy-efficient step by step. In order to permanently reduce electricity consumption and bring production and consumption into balance, the energy situation must be made transparent. This is the only way to ensure that savings achieved are maintained over the long term. PROVI ENERGY prepares the data according to the requirements of DWA-A 216 and operation purposes and visualises it in a meaningful form, going into further depth with additional useful graphics and evaluations. This enables the operator to operate his wastewater or water supply systems in a permanently energy-efficient manner.

Norbert Meyer
BITControl GmbH
www.bitcontrol.info
20.07.2022