Benchmarking in Waste Water Treatment
Full Scale Experience in Austria

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PERFORMANCE INDICATORS AND BENCHMARKING

In 2003 the IWA report on „Performance Indicators for Waste Water Services“ (MATOS et al.) was published containing a great variety of performance indicators for utilities providing sewerage and waste water treatment irrespective of public or private ownership. The main aim of this report was to make the information on performance of waste water services comparable not only within a country but worldwide in order to finally improve cost effectiveness and cost efficiency.

The Austrian Benchmarking system developed from 1999 to 2004 (KROISS et. al. 2001) also comprised sewerage and waste water treatment, but the following report is restricted to waste water treatment. The Austrian benchmarking system is using similar performance indicators as IWA. The main goal of the Austrian initiative is to detect cost reduction potentials by comparison of costs which are related to well defined specific processes, in order to detect best practice and thus enable all the treatment plant operators to learn from the best. In order to achieve this goal it is necessary to have reliable data bases and to organise the exchange of experience from one utility to the other.

The Austrian benchmarking system uses process indicators which are either equal or can be made comparable to the IWA performance indicators. The Austrian approach put less emphasis on the economic utility management as most of the treatment plants in Austria have public ownership and are also operated by either public or publicly owned private enterprises. Competition between the utilities on the market has no importance up to now. As a consequence the main goal of the Austrian benchmarking system is not to improve competitiveness on the market but to minimise the costs for services which have to be delivered in order to fulfil legal requirements for waste water treatment efficiency and those for health and safety at work. The differences between these legal requirements for different treatment plants are generally low in Austria which enhances the comparability of specific costs related to processes if they are clearly defined and data quality assessment is effective.

It has to be indicated that the original goal of benchmarking process in private industry was to learn from the “best” normally not competing on the same market. In Austria there is actually no relevant competition between waste water treatment utilities. If these utilities would be privatised and would have to compete on the market it will become difficult to have access to the detailed economic data required for exact comparison and to enhance the exchange of knowledge and experience between the utilities.

The Austrian benchmarking system concentrates on process benchmarking. It has primarily not been developed for utility management benchmarking, e.g. return of investment and professional qualification of the staff members are not included. The main goal is to optimise effectiveness and cost efficiency of treatment plant operation. Indicators related to investment costs are based on a common formalised transformation of investment into yearly capital costs for all treatment plants related to the treatment plant capacity. In such a way also investment costs can be compared. As the history of the construction and investments plays an important role all the investment costs have been transformed to a common basis which reflects the costs for newly building the existing plant at the same year as the operating costs are investigated for process indicators. Indicators for capital costs are mainly interesting for future decision making of public or private investors. For the operators of existing treatment plants these calculated yearly capital costs cannot be influenced on a short term run. From the technical and scientific point of view indicators for capital costs are of interest for e.g. answering the question whether there is a correlation between high investment costs and low operating costs or the relation between size of a treatment plant and specific construction costs.

Summarising it can be stated that the Austrian performance indicators developed for a country wide benchmarking process are compatible with the IWA performance indicators but with a restricted goal and a strong emphasis on treatment process optimisation. Austria has a nearly uniform legal requirement in regard to waste water treatment efficiency irrespective of the size of the plant the influence of treatment efficiency on the specific costs can only be derived by special calculations and specific assumptions. Many of the process performance indicators can only be compared at an international basis if treatment efficiency requirements are comparable too, otherwise certain assumptions will have to be made in order to make them comparable. Benchmarking systems developed in Germany are quite similar to the Austrian. In Germany several slightly different are on the market and compete for customers.

THE AUSTRIAN BENCHMARKING SYSTEM

In order to be able to compare costs and performance of waste water treatment plants a methodology has been developed in Austria which enables the comparison of performance indicators even for different treatment process schemes and operational modes (KROISS et.al. 2001, LINDTNER 2004). In order to be able to quantify the cost reduction and optimisation potential of waste water treatment plants this methodology includes the definition of one best performance indicator for different processes called “benchmarks”. This is only relevant if the sample of treatment plants investigated with this method is large enough and is applied over a period of several years. In Austria the benchmarking process has already been applied at more than 80 treatment plants of different size from 2.000 to 1 million p.e. spread all over the country.

For the calculation of process performance indicators and benchmarks the waste water treatment plant performance is assigned to 4 different main processes as well as 2 support processes. The 4 main processes are defined as

1. mechanical pre-treatment (influent pumping, screening and grit removal)
2. mechanical-biological treatment (primary sedimentation if existing, biological treatment)
3. sludge thickening and stabilisation (digestion)
4. further sludge treatment and disposal (dewatering, storage, incineration, composting etc. transport and disposal)

The 2 support processes are defined as

1. obligatory processes (laboratory and monitoring, administration, operation building and infrastructure)
2. optional processes (workshops, motor pool)

During the development of the benchmarking system at the beginning the costs for the support processes have been distributed to the costs for the main processes. As the support processes turned out to contain important cost reduction potential on the one hand and important inaccuracies on the other hand it was decided to keep them as separate cost factors. This development also shows that for practical application the number of performance indicators should be kept as small as possible in order to avoid confusion and as detailed as necessary to easily find the most important cost reduction potentials. The main processes have been defined in a way that the differences between different plants are either low (well comparable) or high (only comparable in details) but not medium. For the large plants (>50.000 p.e.) the main processes are further subdivided in order to achieve better comparability and more detailed information about optimisation potentials while at the small plants (<10.000 p.e.) it is useful to combine two or even three main processes in order to increase comparability and to ease comprehensibility by lowering the number of performance indicators. This also results in lower costs for the benchmarking process which is essential for participation of the small treatment plants in the benchmarking process.

Each main process is described by defined input and output data, and e.g. the input of process 2 is the output of process 1. In such a way it is possible to make mass and energy balances for each process and for the treatment plant as a whole. Using this mass and energy balance methodology a data quality assessment can be performed before the technical data are linked with cost data for the calculation of process performance indicators.

The following figure 1 shows the development of these indicators

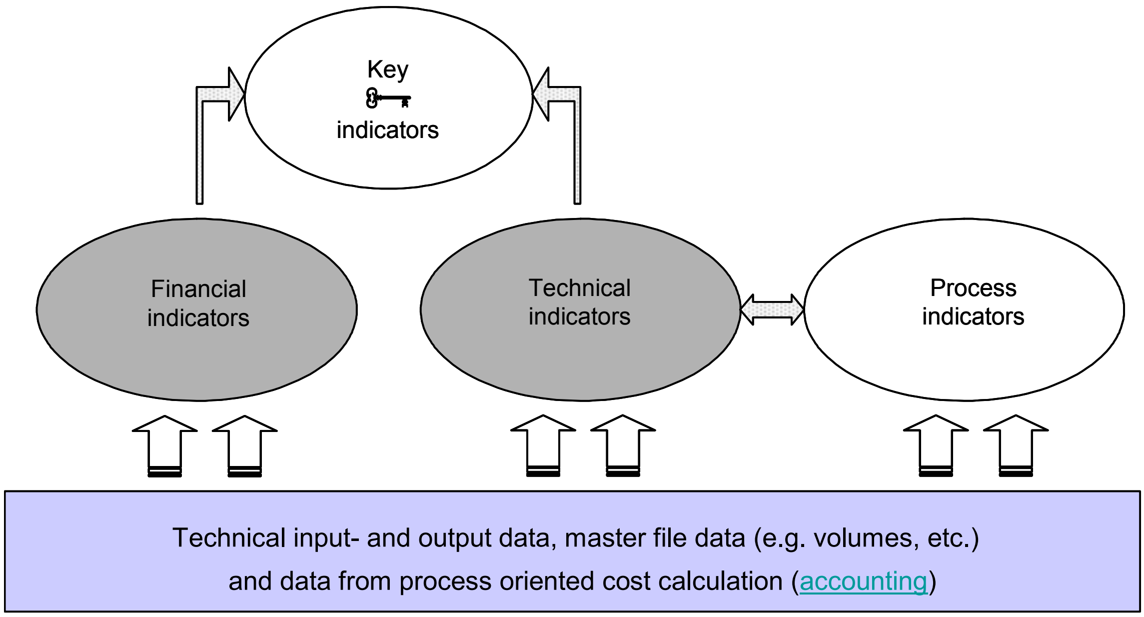

Figure 1: Performance indicator system

Technical and economic master file data remain unchanged until there is a change in the process scheme or in the asset value (renovation, extension, etc.). Technical input and output data as well as the operational costs change from year to year. If benchmarking is understood as a continuous process of performance optimisation it is important to communicate that the start up in the first year needs much more manpower and results in higher costs than the continuation of the benchmarking process during the following years. In order to overcome this barrier in Austria the benchmarking start up for 76 treatment plants was subsidised by the federal government and the Provinces.

At the beginning of the benchmarking procedure it is of great importance to introduce an accounting system at each treatment plant which enables a clear attribution of all the different costs to the defined processes. This needs thorough investigations and sometimes a complete review of the existing accounting system. In many cases it was necessary to install a new system for the attribution of working time to the different processes. Once the new system is installed there is no additional work necessary to use the aggregated cost data for the calculation of process performance indicators and benchmarks for the following years.

The so called key performance indicators represent those indicators which have a high potential for controlling and optimising the processes. Financial indicators relate costs to specific processes, while technical indicators show a correlation between specific technical data, e.g. the specific energy consumption for the pollution reduction achieved (kWh/ kg COD removed).

The first acquisition of the technical data is based on a questionnaire which is sent to the treatment plant managers. In order to achieve comparable and reliable data special trained experts help the managers in responding to the questionnaire. The goal of the data acquisition is a reliable and accurate technical description of the different processes according to their definition in order to be able to attribute the correct costs to these processes. The same is with the economic data acquisition. At the first time an expert has to support the treatment plant managers in adapting the accounting system to the specific requirements for the benchmarking process.

RELATING COST TO TECHNICAL PARAMETERS

In order to calculate relevant and sensitive indicators it is necessary to relate the costs to the most sensitive technical parameters. An extensive sensitivity analysis (LINDTNER 2004) showed that the best technical parameter for process indicators calculation is the mean yearly organic load (MYL-COD) in the influent of the treatment plant if the following costs are concerned:

- total yearly costs,
- total operating costs and
- operating costs for the 4 main processes

The organic load is based on population equivalents (pe) defined as 110g of COD/d in the influent. This specific pollution load corresponds to 60g of BOD_5/p.e./d, commonly agreed worldwide and used by IWA report (Matos et al. 2003). COD was used because of better data reliability and availability. Also mass balances can only be based on COD and not on BOD_5.

Only for the comparison of capital costs for process 2 (mechanical biological treatment) a standard design load (SDL-COD) was used for indicator calculation. SDL-COD represents the maximum load of the treatment plant at which the effluent standards of the Austrian regulation for municipal waste water treatment can be met with the existing plant. The calculation of this “standard design load” is based on the ATV design guideline A 131 (ATV 2000). In this way the costs are related to the same efficiency requirements which enable a direct comparison of the related costs. It has to be stated the Austrian effluent standards require full nitrification down to 8°C at any time, a 70% nitrogen removal and 1mg total P as yearly means.

For the Processes 1, 3 and 4 the capital costs were related to the real design load (RDL-COD) of the treatment plant expressed in p.e. of organic loading as indicated in the project documents of the treatment plant.

Table 1: Relations used for process indicator calculation

<table>
<tr><th></th><th>Capital costs</th><th>Operational costs</th><th>Yearly costs</th></tr>
<tr><td>Total</td><td>SDL-COD</td><td rowspan="5">MYL-COD</td><td>MYL-COD</td></tr>
<tr><td>Process 1</td><td>RDL-COD</td><td></td></tr>
<tr><td>Process 2</td><td>SDL-COD</td><td></td></tr>
<tr><td>Process 3</td><td rowspan="2">RDL-COD</td><td></td></tr>
<tr><td>Process 4</td><td></td></tr>
</table>

Classification of treatment plants according to their size (MYL) in subgroups

The investigation of the very heterogeneous sample of 76 treatment plants spread all over the country clearly showed that there is a strong influence of the size of the treatment plants on the specific costs. In order to obtain comparable financial indicators it was necessary to group the plants according to their size (expressed as the actual MYL-COD). The size groups were selected so that the influence of the size on the financial indicators is in the same range as the accuracy of the data.

Definition of Benchmark bands, Benchmarks, and Benchmark plants

Benchmark bands have been defined for external use only, i.e. for publication of the results of the study. A benchmark band exists only for total costs and not for specific process indicators, which are for internal use at the treatment plants. Benchmark bands are defined for each group and represent the lowest specific costs achieved in a benchmark plant increased by a percentage which has been fixed on the basis of experience in regard to data quality and inaccuracies of the whole procedure (Table 2). The goal was to present lowest specific cost figures for public use which can be achieved taking into account the inaccuracies of the data and the methodology used.

Benchmark plants have to meet the following criteria:

- The effluent quality must comply with the legal requirements laid down in the respective Austrian regulation (comparable to EU UWW Directive 271/91 for sensitive areas).
- Compliance with technical quality criteria (mass balance check, etc.).
- Waste water characteristics have to be municipal (no dominant influence of industrial waste water).
- Specific costs within the benchmark band.

A *benchmark* is defined as the lowest specific operating costs for one of the processes (process performance indicator) within one group of treatment plants defined by a range of size. Data uncertainty is not considered for the benchmarks as it plays a minor role for the processes as compared to the total costs and special data quality assessment is applied.

Benchmarks for capital costs of processes were not calculated as the quality of investment cost data for processes does not allow reliable and comparable results. They are not interesting for the operators as these formalised capital costs cannot be influenced by short and mid term measures. This is not the case for real capital costs which were not investigated.

ORGANISATIONAL DEVELOPMENT OF THE BENCHMARKING PROCESS

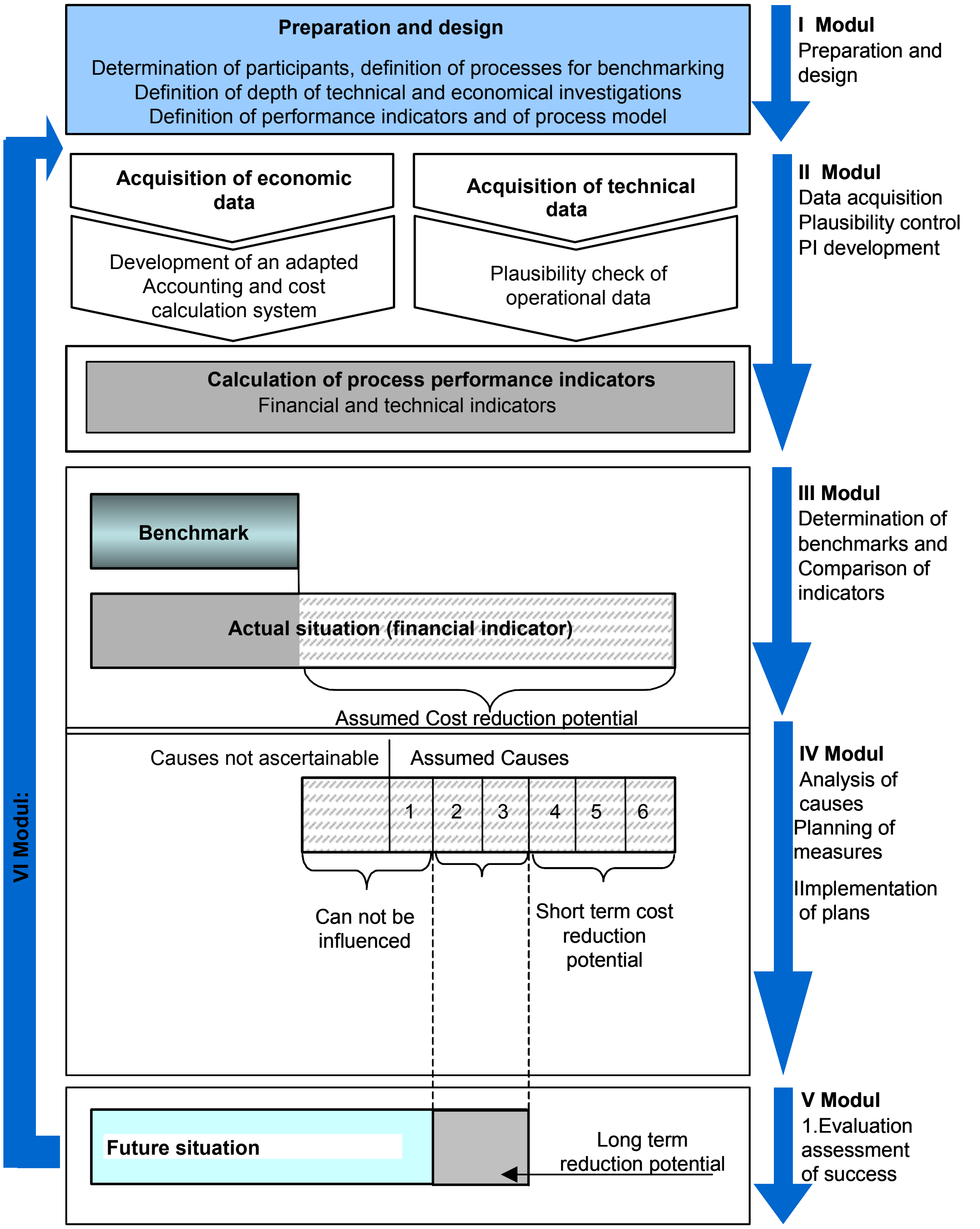

Figure 2: Development of a benchmarking project (compare Schulz, 2000)

The schematic of the benchmarking development process in Austria as shown in figure 2 is in accordance with international experience and consists of 6 modules. Module VI represents the replication of the process from year to year which is called continuous benchmarking process.

If the process is successful also the benchmarks for different processes will decrease over time due to technical and organisational innovation. Nevertheless it has to be assumed that the cost reduction potential will be decreasing over time but also the effort for the continuous participation at the benchmarking process will decrease. It is obvious that the whole system will only be successful if the results of the country wide benchmarking are continuously used for improvements. It therefore is recommendable to link the benchmarking process with an adapted environmental management assessment like EMAS as it is planned in Austria for the next period of time.

Meanwhile there is also experience in applying the methodology to large municipal and industrial treatment plants (>100.000 p.e.). It turned out that the results are well in accordance with the previous investigations at the 76 municipal treatment plants from 5.000 to 200.000 p.e. The influence of the size of treatment plants on the indicators is decreasing as compared to the plants below 50.000 p.e. The differences between the performance indicators of these large plants are unexpectedly high. This means that the cost reduction potential is economically relevant at most of the plants i.e. the costs for the introduction of the benchmarking procedure are much lower than the cost reduction potential.

LINDTNER (2003) used statistical methods in order to show to which extent the results of the benchmarking project are representative for the Austrian situation. It turned out that the results are representative for ~ 90% of the Austrian municipal treatment plant capacity if the Main Treatment Plant of Vienna (3,2 mio p.e.) is not taken into account. Only the very small plants (<5000 p.e.) are not well represented by the investigation results. At these small plants the percentage cost reduction potential can be high but in absolute figures it is low as the overall treatment capacity o these plants is low despite their great number.

In Austria the development of the whole benchmarking system was executed by a team of three organisations. The Austrian Water and Waste Association acted as an organisational platform linking the treatment plant managers with the public administration. This is of great importance for the start up process. The second partner is the Institute for Water Quality and Waste Management at the Vienna University of Technology. The institute has a very long experience in treatment plant technology and is responsible for the vocational training system for all treatment plant operators in Austria together with ÖWAV. The third partner is a private business consultant with great experience in optimising public administration (Quantum, Klagenfurt/Austria).

In order to enhance the exchange of experience between the treatment plant managers and operators and especially with the benchmark plants a series of workshops have been organised by the Austrian Water and Waste Association together with the benchmarking team immediately after the delivery of the individual reports of the benchmarking project. An important goal of these workshops was also to get the response of the operators to the results and the benchmarking process in order to be able to improve and further develop the system. In addition a benchmark specialist group was established at ÖWAV consisting of different stakeholders in order to improve the acceptance of this development and achieve continuity in the future. In this group the responsible officials for treatment plant performance in the different provinces play an important role as they have access to the relevant politicians.

BENCHMARKING PLATFORM BASED ON INTERNET COMMUNICATION

In order to facilitate the benchmarking process for all treatment plants in the future a benchmarking platform based on internet communication was developed in Austria. The development of the software was also subsidized by the Austrian Government but it is planned that the costs for operation and maintenance of the platform installed at the Austrian Water and Waste Management Association are fully recovered from the treatment plants using this platform. The basic idea is to minimize the costs for the benchmarking by making optimal use of automated data management and easy accessibility not only in Austria but also worldwide in principle. Adequate professional control of the system and quality assurance is provided by a team of experts derived from the previous development and private initiative.

The automated benchmarking process is subdivided into 3 phases which are repeated every year:

- Data input (from the treatment plant operator/manager)
- Evaluation of the data quality, determination of benchmarks and other process performance indicators, development of individual reports
- Exchange of experience between the treatment plant operators/managers

The whole data transfer as well as the complete communication between all stakeholders is accomplished via internet. This system fulfils all the requirements for data security and for the different rights to access the results. The software has been developed so that the platform can be easily adapted to foreign languages in the future for international application.

PRESENTATION OF BENCHMARKING RESULTS

It is not possible to present the whole information which can be derived from the benchmarking system as it is contained e.g. in the publicly available final report of the benchmarking research project (KROISS et al. 2002). Only some examples can be shown in the following figures.

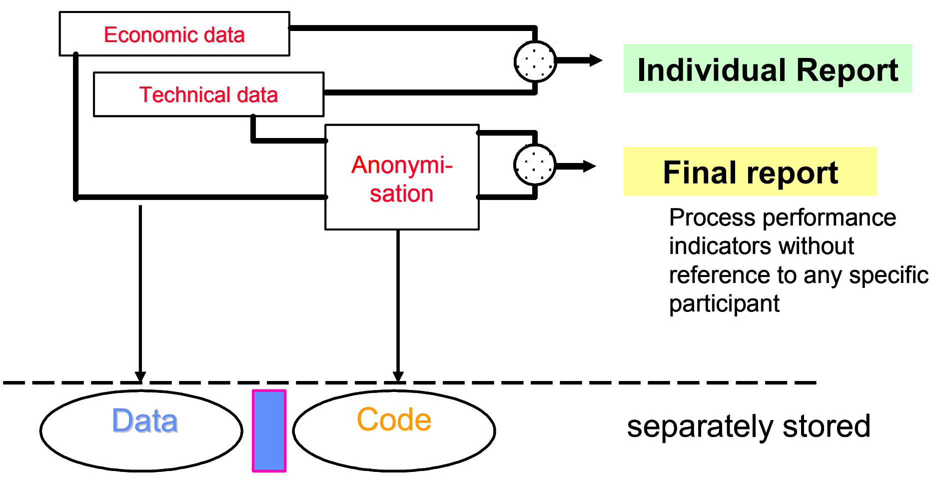

Figure 3: Data confidentiality handling and reporting

The most important information derived from the investigations is contained in the individual report to each of the treatment plant managers which is not publicly available. In this respect only the format of the presentation of the results can be shown. These two aspects of benchmarking have been named “external” and “internal” benchmarking. Results of the internal benchmarking can be made accessible to others only by the owner of the individual report.

One typical result of the external benchmarking is shown in figure 4. The specific costs shown in this figure represent the minimum achievable operational and total yearly cost for waste water treatment plants meeting the legal requirements in the year of investigation. The figure also shows the great influence of the size of the treatment on the specific costs.

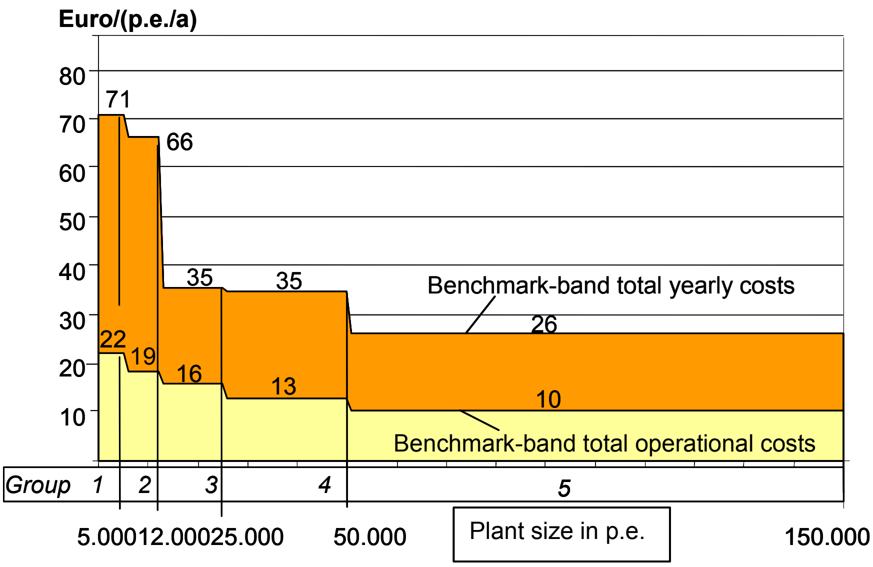

Figure 4: Benchmark-bands for operating and total yearly costs for the 5 subgroups

Figure 5 shows the typical format used for the individual report which was developed in order to give condensed information about the outcome of the benchmarking process for the participant. This report remains confidential and is only accessible by the participant

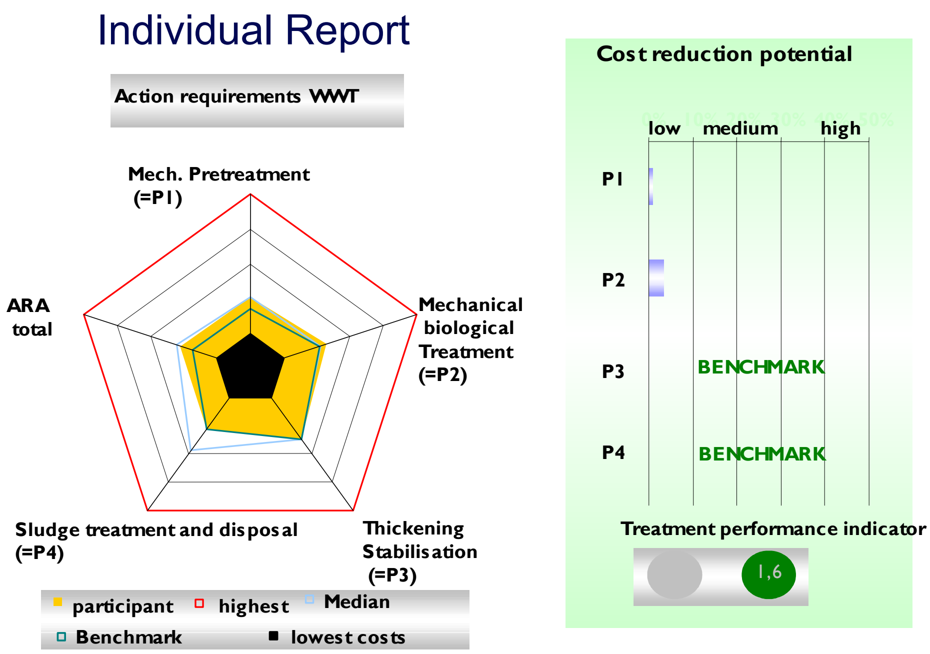

Figure 5: Example of an individual report introductory information page

On the left side the position of the participant in terms of cost efficiency performance indicators is shown as compared to the highest, the lowest and the benchmark in his size group is demonstrated for the 4 main processes. On the right side the cost reduction potential at the 4 processes is indicated and at the bottom the treatment performance indicator (TPI=1,6) can be seen. If the plant meets the legal requirements (TPI< 2,0) the right button shows a green colour if this is not the case (TPI > 2,0) the left button will be red coloured.

Additionally the individual report contains a so called “ABC analysis” (PREISZLER, 1995) for up to 77 cost elements (see fig. 6).

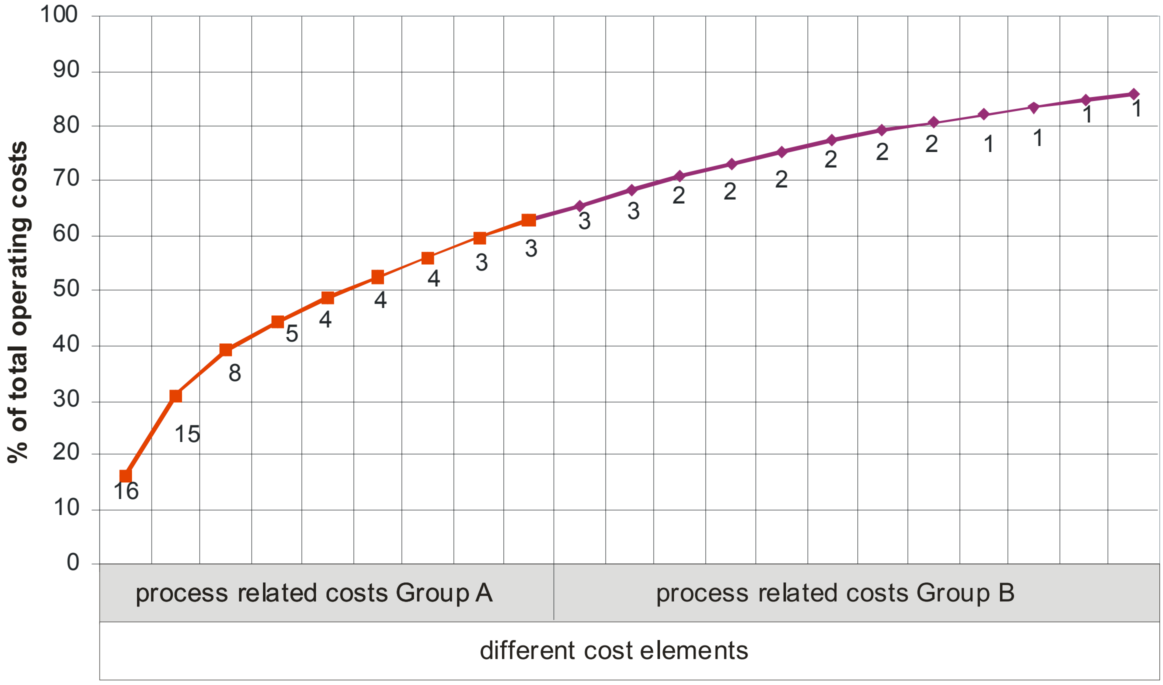

Figure 6: ABC analysis as a result of the benchmarking process

Figure 6 ranks the cost elements for all the detailed sub-processes investigated according to their relevance for total operating costs. This figure enables the responsible operator to easily concentrate on the processes where improvements can have the greatest influence on the total operating costs (left side of the diagram) while on the right side the processes and related cost elements are indicated where the influence on total costs will be in the range of the accuracy of the data and the derived calculations.

A typical consequence of the benchmarking process is shown in the following example. At a treatment plant with a design capacity of 180.000 p.e. the process indicators for process 4 (additional sludge handling and disposal) showed a marked cost reduction potential (fig.7).

The benchmark was 3,8 €/p.e./a while for the participant a value of 4,8 €/p.e./a was determined. The cost reduction potential is the difference i.e. 1€/p.e./a. The analysis of the situation and the contact with the benchmark plant manager revealed that this difference could mainly be attributed to the cost for sludge conditioning with polymer addition for dewatering. The specific cost of the polymer and the specific polymer dosage where both higher than at the benchmark plant.

Changing from liquid to dry polymer application and optimisation of polymer addition resulted in an operational cost reduction of 89.000€/a. The necessary investment costs of 120.000€ can be recovered within 1,3 years.

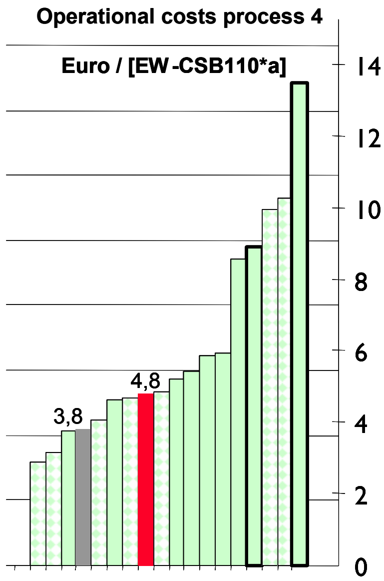

Fig.7: Specific operational costs (€/p.e./a) for process 4 (sludge handling and disposal) for all the treatment plants investigated with a design capacity between 50.000 and 200.000 p.e.

CONCLUSIONS

The Austrian benchmarking system developed over the last years has proved in practice to be a powerful tool for cost efficiency optimisation of waste water treatment plants. Special emphasis was given to the data quality assessment and to data security, as especially the economic data are sensible

The Austrian benchmarking system is now in a maturation process which will enable its application to all treatment plants in Austria via an internet platform operated on a full cost recovery basis. The system will be operated by a multidisciplinary team consisting of the Austrian Water and Waste Management Association, 2 private engineering and business consultants and the Institute for Water and Waste Management at the Vienna University of Technology. The benchmarking system also comprises sewerage operation, where Vienna University of Life Sciences is involved in addition.

The Austrian system is compatible with the international system of process performance indicators developed by a working group within IWA (MATOS et al. 2003). The Austrian system primarily aims at improved operation of treatment plants and was developed for a situation where most of the treatment plants are publicly owned and operated by public or publicly owned private utilities which are not competing on the market. Most of these utilities are small and medium sized enterprises. The system is completely open for private utilities, too.

The Austrian system has been developed in close contact with German and Swiss experts in this field (SCHULZ et al. 1998; WIESMANN 1999) and together with the relevant authorities in Austria. The internet based Austrian benchmarking platform can easily be adapted to other countries and to other languages. Successful application is linked to a continuous flow of information and a close contact between the benchmark participants on the one hand and between the participants and the platform management on the other hand. In this respect the long term involvement of the Austrian Water and Waste Management Association into treatment plant performance optimisation played a very beneficial role.

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