Lesson C2

Operation Costs of wastewater Treatment Plants

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1. Introduction

The objective of the installation and operation of wastewater treatment systems is to assure an environmentally friendly effluent quality meeting the determined border values. The high costs for construction, maintenance and operation of conventional treatment systems exert economic (and social) pressure, even in developing countries. Therefore, all over the world engineers look for creative, cost-effective and environmentally sound ways to control water pollution. Wastewater technology has been improved substantially during the last few decades.

When selecting a wastewater system, initially many processes are theoretically competitive. To determine the most economical alternative a cost-effectiveness-analysis including investment costs and operation costs has to be conducted [Tsagirakis et al, 2003; Medina, 2005]. For example a simple treatment system with low investment costs may have high operational expenses and therefore will be the alternative with the highest total costs.

An evaluation done early during the design process has the advantage of providing an early warning if an alternative design is too costly relative to the available resources, saving the trouble of preparing final designs for those technologies that are outsides the bounds of affordability. The evaluation can be seen as an early screening of the options, which have passed the basic tests of technical and social feasibility.

This module will give detailed information about operation costs for wastewater treatment systems. The main components, which are affecting the extend of operation costs, are identified.

2. Operation Costs

2.1 General

Operation costs can be differentiated as personnel costs, maintenance costs, energy costs, chemicals and material costs, disposal costs and miscellaneous costs for administration, insurance, discharge duty (if exists), external services etc..

There are many factors affecting operation costs [Bohn, 1993], accordingly operation costs may differ widely:

- Size and load of the plant
- Topography and geographical situation of the site (e.g. affecting pumping energy costs)
- Characteristics of wastewater and the discharge norm

- Technologies and the selected treatment process
- Type of sludge treatment and way of disposal
- Energy supply and energy recycling
- Degree of automation, measurement and process control
- Organization of the plant and its management

Figure 1 shows the composition of operation costs for a selected wastewater treatment plant of a capacity of 5,000 p.e. (population equivalent). It can be noticed, that the cost for personnel, maintenance, energy and sludge disposal are decisive categories as these account for most of the operation costs. In the following sections each single category of operation costs are discussed in more detail.

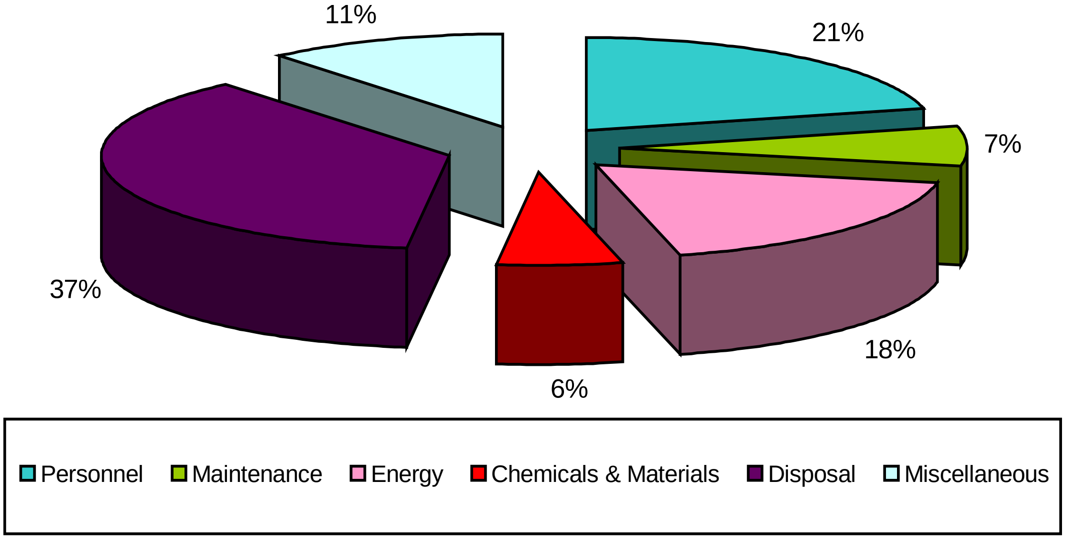

Figure 1: Composition of operation costs for a wastewater treatment plant of 5,000 p.e. in Germany [Halbach, 2003]

For rough calculation it can be assumed, that operation costs may amount up to 50% of the total costs for wastewater treatment. In average for wastewater treatment plants in Europe with more than 10,000 p.e., the specific operation costs will amount up to 25–35 €/p.e. and year. Smaller installations can achieve more than twice of that number.

As it has been the case in Europe, the more restrictive the discharge norms are – for example concerning nitrogen and phosphorous content –, the more demanding the treatment must be. That means that more technical requirements (like longer treatment times, conversion of existing structures or building of new ones) are needed to achieve the limit values. Such extra requirements represent more operational expenses as well.

2.2 Factors of Operation Costs

The figures 3 and 4 illustrate exemplarily the influence of the selected technology and the size of the plant on operation costs. In principle, low-tech systems as wetland systems or stabilization ponds with high land requirements have very low energy consumption and result in relatively low total operation costs. On the opposite, high-tech systems like activated sludge systems or chemical treatment can only be operated with high expenditures of energy and other operation costs. It can be noticed that the specific operation costs of small wastewater treatment plants are remarkably higher than of larger treatment plants. This is a result of economy of scale of all categories achieved in larger sizes of installations.

2.3 Operation Costs in Relation to total Costs of WWTP !

Regarding the total costs of a wastewater system operation costs play an important role. Operation costs are the expenses related to the operation, maintenance and monitoring of the plant, once it was constructed. These costs will be incurred in a regular basis along the service life. Exemplarily, figure 2 shows the cost composition of wastewater systems in Germany divided up in capital and operation costs [ATV, 2003]. Easily it can be seen, that operation costs can amount up to 50 % of the total annual costs. Therefore during the evaluation of process alternatives the consideration of operation costs is of crucial importance. Disregarding this conclusion will result in costs, which are neither adequate nor affordable for the customers. For example the treatment process may be interrupted or totally turned off due to e.g. high energy costs, which can not be paid to the local power authority.

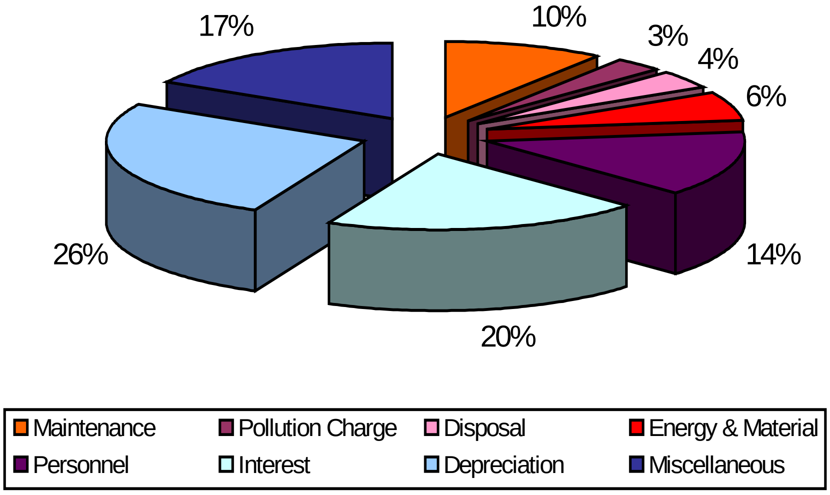

Figure 2: Composition of total annual costs for wastewater systems in Germany [ATV, 2003]

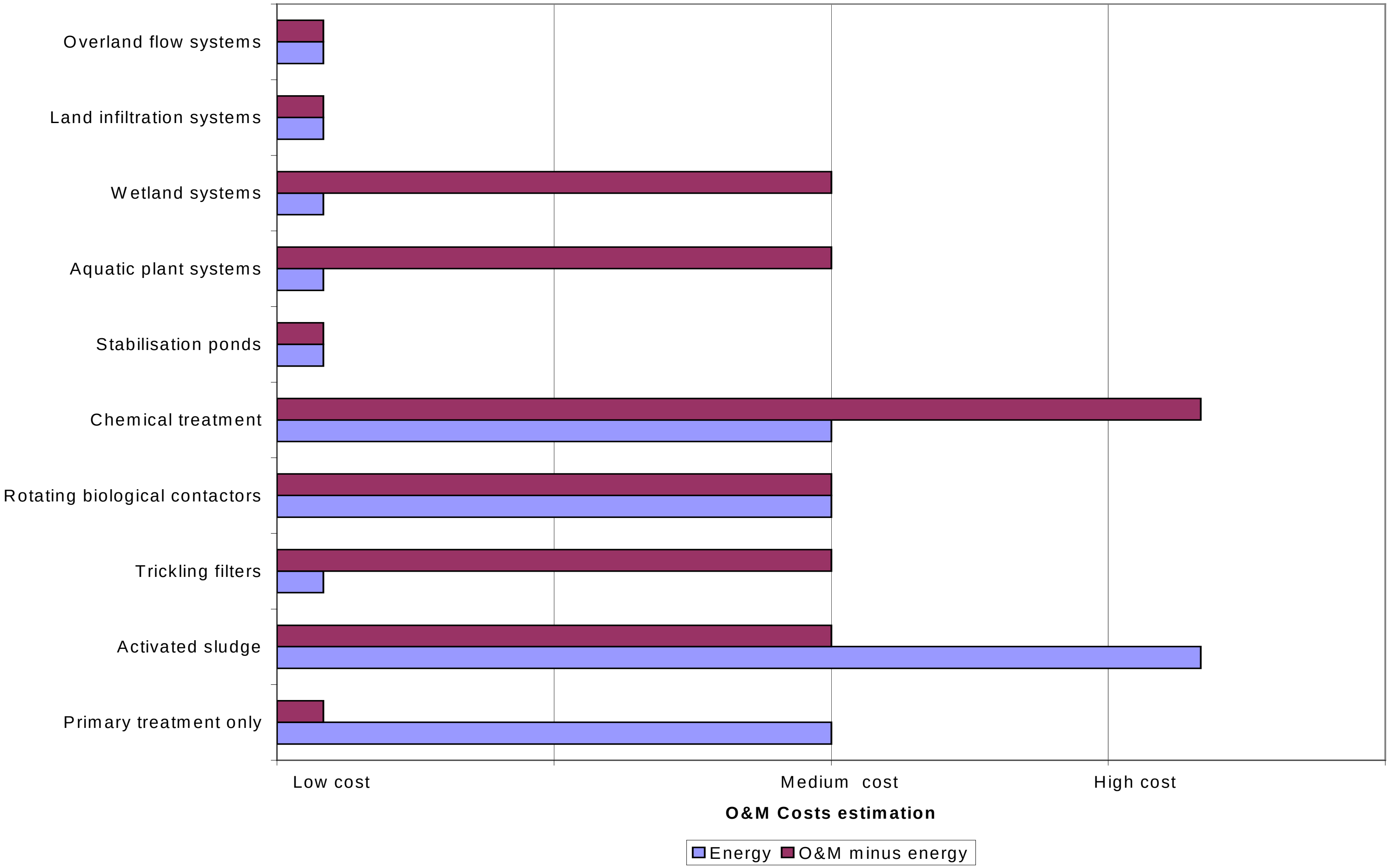

Figure 3: Comparison of operation costs operation (O&M) for different types of secondary treatment options [Kampet, 2000]

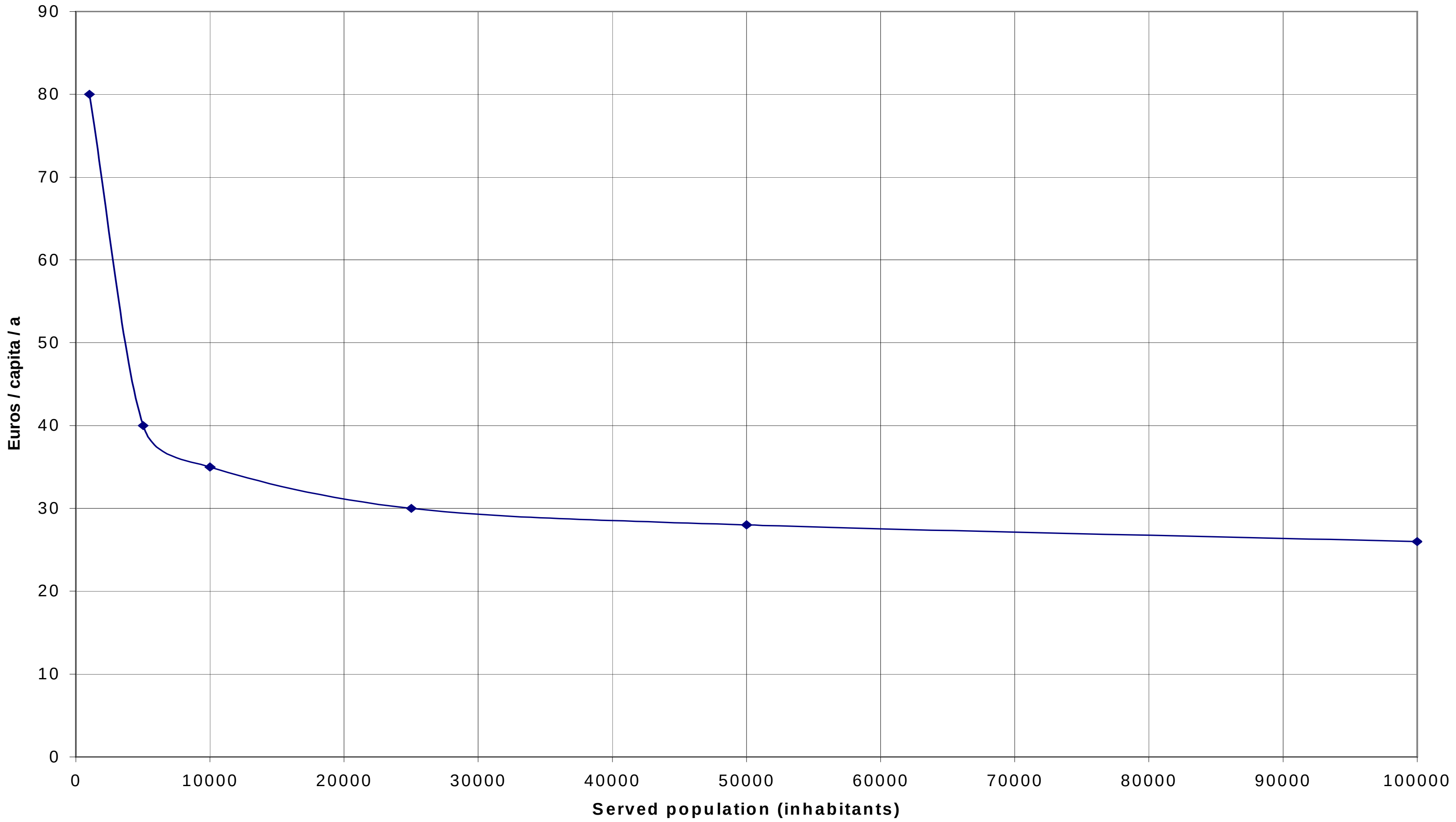

Figure 4: ***Operation costs for wastewater treatment plants related to the size of the plant [Kampet, 2000]***

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3. Personnel

The costs for personnel of wastewater treatment systems depend significantly on the size of the treatment plant, the selected technology and the level of automation. The table below shows the personnel costs subject to the treatment capacity of wastewater treatment plants [Reicherter, 2003].

< 10.000 p.e.	35 – 40 % of total operation costs
10.000 – 100.000 p.e.	25 % of total operation costs
> 100.000 p.e.	15 % of total operation costs

Costs for personnel normally comprises salaries/wages, pension and insurance costs. A typical working week consists of five working days per week, with a month’s leave over a year. Depending on a system’s requirements, there can be one, two or three eight-hour shifts for specific position. The operation personnel mainly is occupied with activities related to process control, in average 30 % of the working time is spend for maintenance activities. The cost to the employer of an annual salary including insurance depend on the wage level of each state or district, in which a treatment facility is located.

Kemper et al (1994) showed that in developing countries the cost of personnel in the wastewater treatment sector is proportionately higher than for developed countries. In average in Greece the cost of personnel is 48% of the total cost for operation of a treatment plant. For France the figure is 24 %, for Great Britain 38%. On the other hand, in Mexiko and Costa Rica, personnel costs are 68% of the total.

The qualification of operation staff is of crucial importance for an adequate and professional operation. There is a high need for a profound education and special training as a essential prerequisite. Plant operators can make a plant of poor and insufficient design perform well, conversely, they can cause the best design plant to perform poorly [Michel et al., 1969]. Smaller treatment plants employ fewer scientific personnel and fewer unskilled laborers, with higher number of technical personnel. There are likely to be two reasons for this: At first because small treatment plants are less complicated and easier to operate, secondly for small towns it is difficult to find higher educated personnel with scientific education, relying instead on local personnel.

Chemical engineers and chemists are the most dominant graduate employees in wastewater treatment plants. Chemical, electrical and mechanical engineers mainly work as control engineers, while technologists are in charge of the technical supervision. Technologists come from technical colleges which do not have university status. Ideally, a wastewater treatment plant would have an input from all kind of professionals. However, this is unfeasible for all but the very large installations and for centralized agencies with a number of plants under their jurisdiction.

3.1 Number of Employees

The major parameters that influence the number of operational staff employed are:

- the size of installation,
- the treatment processes and systems,
- the degree of automation,
- productivity efficiency of personnel,
- managerial efficiency and
- others.

In principle, it can be noticed that small wastewater treatment plants need more personnel per p.e. than larger ones. This is a result of economy of scale achieved in larger sizes of installations. In addition, in small and medium size plants, conventional systems are more costly in terms of personnel in comparison with extended aeration plants. An other factor that dominantly influences personnel costs is the degree of automation. Although automation requires considerable capital cost as well as specialized personnel to operate the plant, there is a concomitant reduction in the number of employees needed.

A good example is the analysis of economic data pertinent to existing municipal wastewater treatment plants (MWTP) in Greece, which has been carried out by Tsagirakis et al (2003). On the basis of data on personnel from 66 activated sludge systems the relationship between p.e. and t.p.e. and the number of personnel employed in MWTP has been analyzed (Figure 5). The figure shows the number of the p.e. equating to one person employed in a MWTP. It can be noticed that small installations need more personnel per p.e. than larger ones. This is a result of economy of scale achieved in larger plants. In addition, in small and medium size plants, conventional systems are more costly in terms of personnel in comparison with extended aeration plants.

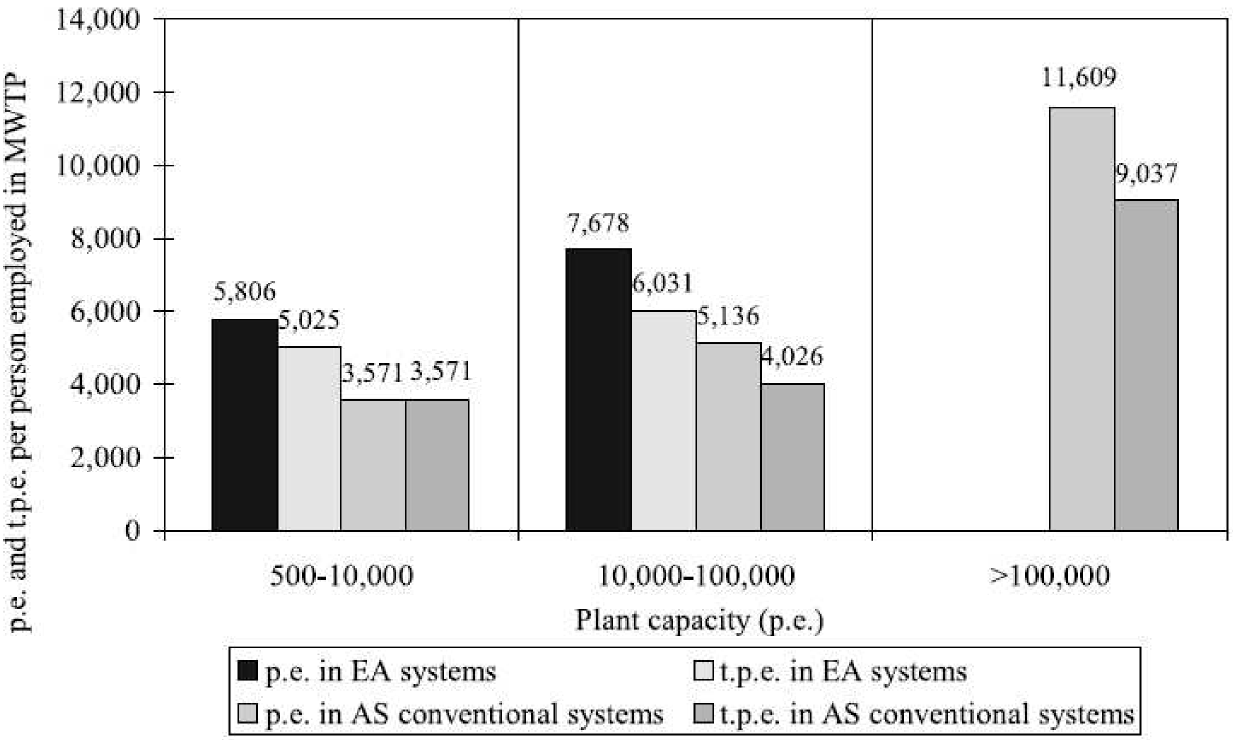

Figure 5: Employees per p.e. and t.p.e. in relation to their size; (EA = Extended Aeration; AS = Activated Sludge) [Tsagarakis et al, 2003]

4. Maintenance

The costs for maintenance of wastewater treatment plants usually amount up to 15–25 % of the total operation costs. Thus, the organization and strategy of maintenance activities play an important role for the agency.

Maintenance costs include the following: repairs on mechanical, electrical, electronic and civil parts and minor or major replacements like small or large parts for pumps, blowers or motors. They include internal personnel costs, material expenses and external services. Quantities of spare parts kept in stock and purchasing deals also influence the total maintenance costs.

For a first calculation maintenance costs can be derived from the investment costs as follows:

- Civil Constructions	0.5 – 2.0 % of investment costs per year
- Renovations of Civil Constructions	2.0 – 4.0 % of investment costs per year
- Mechanical Equipment	2.0 – 6.0 % of investment costs per year
- Electrical and Electronical Equipment	2.0 – 6.0 % of investment costs per year

The above given cost assumptions are very roughly and have to be specified for each particular project. They depend mainly on the chosen maintenance strategy of the agency.

Maintenance is an important activity that should be performed in any type of facility, thus it is necessary for proper functioning and prevents damages whose repairing can be very expensive. Even low-tech options demand maintenance activities. Maintenance should be considered in a regular time basis (semestral, annual) into the costing and budget of the project.

Wastewater systems often suffer from a history of inadequate investment in maintenance and repair often due to large part of “out-of-sight, out-of-mind” nature which poses an inherent problem. This stands for both sewer systems as well as treatment facilities. The lack of proper maintenance results in the deterioration of the installed equipment and the construction itself.

The purpose of maintenance programs is to maintain design functionality (capacity and integrity) and / or to restore the system components to the original condition and thus functionality. The ability to effectively operate and maintain a wastewater treatment system depends mainly on site conditions, proper design (including selection of appropriate materials and equipment), construction and inspection, testing and acceptance, and system start-up.

Operation staff should already be involved at the beginning of each project, including planning, design, construction, acceptance and start-up. When the system is designed with future maintenance considerations in mind, the result is a more effective program in terms of maintenance costs and performance.

4.1 Maintenance Strategy

Maintenance for wastewater systems can either be preventive/predictive or corrective activity. Effective maintenance programs are based on knowing what components make up the system, where they are located and the condition of the components. With that information, preventive/predictive maintenance can be planned and scheduled, rehabilitation needs identified, and long-term improvement programs planned and budgeted. High-performing agencies have all developed performance measurements of their maintenance program and track the information necessary to evaluate performance.

Commonly accepted types of maintenance include the following classification:

Corrective Maintenance (Those maintenance activities are also called reactive):

Maintenance classified as corrective, including emergency maintenance, is reactive. Only when equipment or system fails maintenance is performed. A corrective maintenance is characterized by the inability to plan and schedule work, the inability to budget adequately, the poor use of resources and a high incidence of equipment and system failures.

Preventive / Predictive Maintenance (Those maintenance activities are also called proactive):

Preventive Maintenance being defined by a programmed, systematic approach. This type of maintenance will always result in improved system performance except in the case where major chronic problems are result of design and/or construction flaws that can not be corrected by operation and maintenance activities. Major elements of preventive maintenance programs are planning and scheduling, records management, spare parts management, cost and budget control and training program for the involved personnel.

Predictive maintenance is a method of establishing baseline performance data and monitoring performance criteria over a period of time so that failure can be predicted and maintenance can be performed on a planned, scheduled basis.

In reality, every agency operates their system using a combination of corrective and emergency maintenance, preventive maintenance and predictive maintenance methods. The goal should be to reduce the corrective and emergency maintenance efforts by performing preventive maintenance that will minimize or even eliminate system failures and optimize operation cost.

Optimizing the operating costs, however, does not only mean having an optimum treatment process. Working effectively also means to optimize the operation of each individual part of the facility – for example, considering the cost of a measuring point is comprised of only 25% investment costs (planning, purchasing, commissioning) but 75% general operating costs, preventive and reactive maintenance costs: Obviously, there is great potential for cost reduction over the entire life cycle of the whole treatment system (see figure 6)

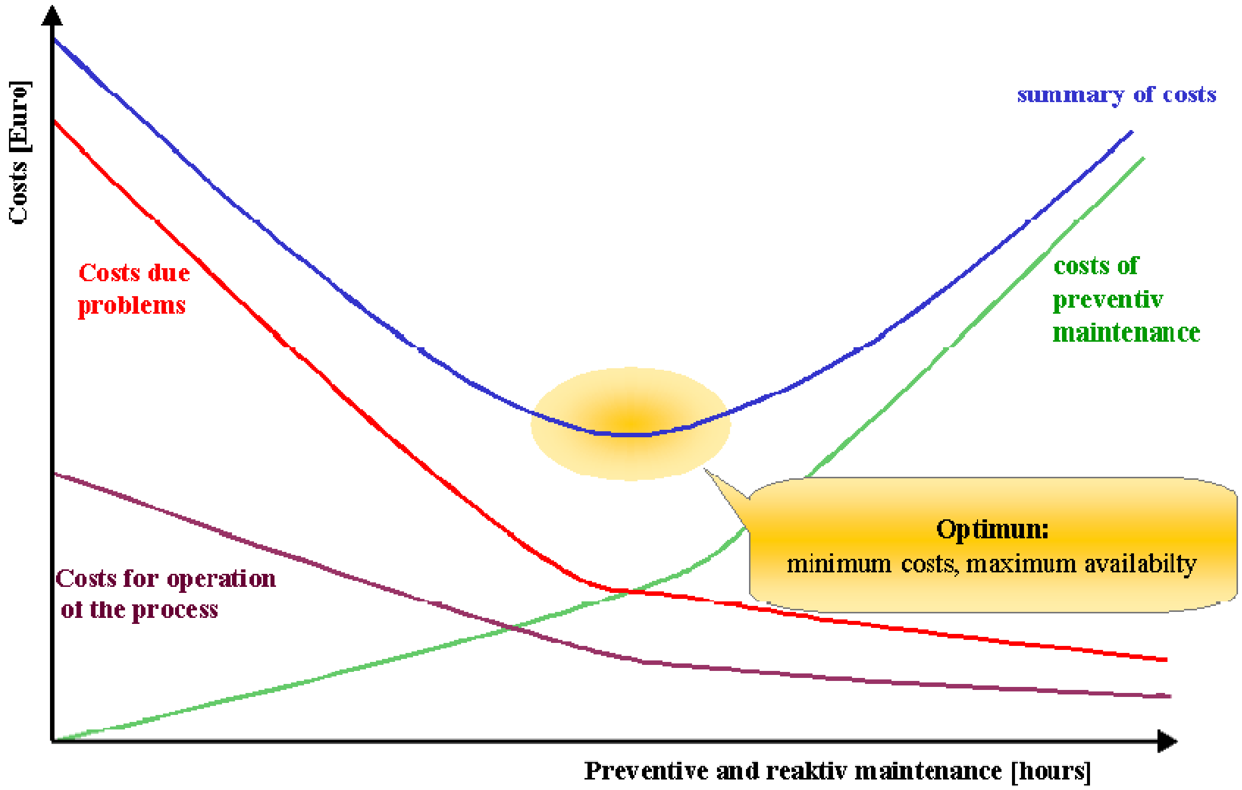

Figure 6: Costs and maintenance seen as a whole; the optimum is achieved from the best relationship between costs and availability [Müller, 2003]

5. Energy

Energy consumption is a major contributor to the operation cost of wastewater systems and therefore is an important parameter for choosing a treatment technology. The costs for energy usually amount up to 10–30 % of the total operation costs. Energy costs include the consumption (and internal production) of electricity, gas, oil and district heating. In sewer collection systems energy is used for transportation by pumping stations in case of a lack of sufficient hydraulic gradients. Aeration is considered to be the main energy consumer in the wastewater treatment process.

Due to different tariff structures all over the world, average costs for energy consumption of wastewater treatment systems can not be given. There are many different combinations of off-rates and peak-rates of the power utilities existing. For example in Israel the peak rates are fourth times the rates of off-peak rates, resulting in high incentive for energy consumption during off-peak period [Kadar and Siboni]

For a first calculation energy costs can be derived from the total amount of pumped wastewater and the population equivalent of the treated wastewater as follows [Bohn, 1993, NRW, 1999]:

- Pumping Stations[1]	10 – 15 Wh /m^3
- Screens	0.3 – 0.5 kWh / (p.e. &.a)
- Aerated Sand Traps	1.7 – 2.2 kWh / (p.e. &.a)
- Preliminary Sedimentation Tanks	0.4 – 0.6 kWh / (p.e. &.a)
- Aeration Tanks	17.2 – 25.8 kWh / (p.e. &.a)
- Secondary Sedimentation Tanks	1.2 – 2.3 kWh / (p.e. &.a)
- Thickener	0.7 – 1.1 kWh / (p.e. &.a)
- Sludge Dewatering Devices	3.0 – 4.0 kWh / (p.e. &.a)
- Digestion[2]	2.4 – 2.9 kWh / (p.e. &.a)

The above given assumptions for energy demand are very roughly and have to be specified for each particular project. They mainly depend on the size and the type of the chosen treatment process (possibly including digestion with the utilization of produced biogas). Target values for energy consumption are set up by Halbach (Figure 7), which demonstrates that the specific energy demand per p.e. remarkably declines from small to large treatment plants.

The operator has to challenge with energy as one of the main cost components of the treatment plant. Thus, for best results of energy cost reduction

- energy conservation,
- process efficiency,
- aeration devices and oxygen transfer,
- process flow configuration,
- bio-gas quantities,
- bio-gas utilization and
- time of day consumption of energy

should be optimized.
Modification of existing wastewater treatment plants can reduce the current energy costs remarkably. Optimization of oxygen transfer, primary sedimentation, utilization of bio-gas from the primary and secondary waste sludge, while considering in both cases the tariff of the power utilities, can reduce energy cost to a minimum. The self-produced electricity is best used during peak tariff hours. Because in a typical wastewater treatment plant there are other energy consumers such as pumps, electrical motors etc., the electricity produced can be used during peak time. In some nations e.g. in Germany or Israel it is also possible to sell electricity back to the power utilities.

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[1] Example for 3 m pressure head

[2] Gas utilization and energy production not included

Because gas production is some what regulated during the day, it seems a good idea to buffer bio-gas by the use of a gasholder. A multitude of energy efficient equipment, technologies and operating strategies like energy-efficient motors, variable frequency drivers or electrical load management systems are available to reduce energy costs in wastewater facilities.

Automation and control is an other important factor that influences the overall energy demand. On-line alterations to the aeration times according to the on-line requirements of the system can save a substantial amount of energy.

Firstly the implementation of measures and steps toward reduction of energy cost will generate investment costs, but those costs will likely be amortisised in a few years.

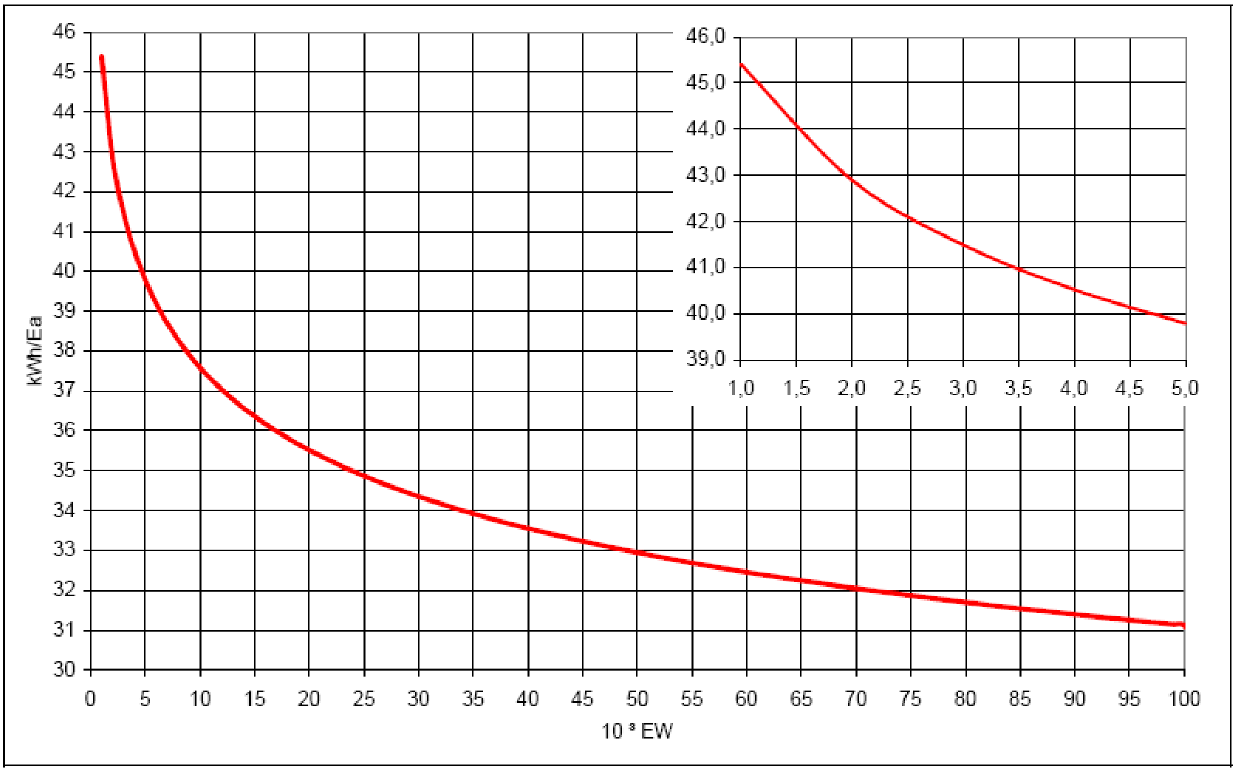


Figure 7: Target values for the specific energy demand subject to the treatment capacity (EW ~ E ~ p.e.) [Halbach, 2003]

5.1 Main Contributor to Energy Costs

Approximately 75% of the needed energy is consumed in the biological aerated reactor. Air or oxygen is introduced to the reactor to provide the inflow wastewater the oxygen to sustain the necessary level of biological activity. The demand of oxygen within a biological reactor can be met in various ways, but most aeration devices currently being used in activated sludge process may be classified as either diffused, dispersed, or surface aeration systems. Figure 8 shows the composition of energy demand of different components of the wastewater treatment process.

The treatment process produces effluents with low level of carbonaceous organic and low level of suspended solids. At the same time, however, excess sludge is being produced. Although excess sludge being a nuisance, bio-gas ($CH_4 + CO_2$) with a high energetic value might be generated under anaerobic digestion. The bio-gas may be used for heating the digester, to produce steam, to produce electricity, or to run direct drive equipment. By this up to 60 – 75 % of the total electrical energy demand and about 100 % of the thermal energy demand of the treatment plant can be covered.

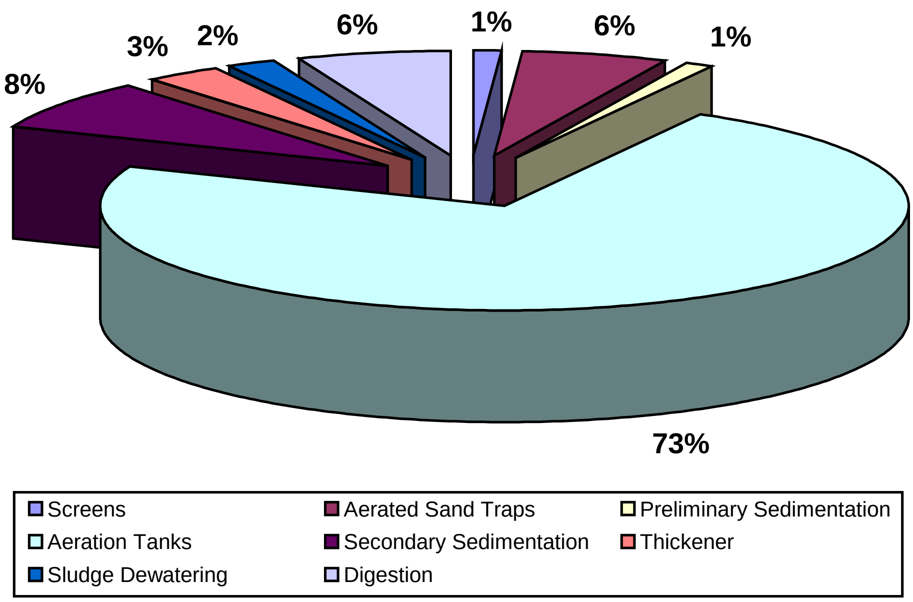


Figure 8: Composition of energy demand of different process components of wastewater treatment plants [Bohn, 1993]

5.2 Energy Analysis as a Tool for Energy Costs Reduction

To find out, which measures will be most favorable for the reduction of energy costs, an energy analysis can be carried out [NRW, 1999]. In Germany and in Swiss such analysis are successfully applied since many years on more than 100 wastewater treatment plants.

The energy analysis is carried out as a double-level analysis. In a first step, overall data of the plant as well as relevant energy consumption data of plant units like aeration step, sludge treatment etc. are recorded, evaluated and compared with best practice data from similar treatment plants. The aim of this first step is to find out in an “low-budget” way, whether there is some potential for energy saving existing. If so, the second step comprises the detailed analysis of each relevant electrical consumer of the plant and the sludge digestion, the gas utilization process (if existing) and the electrical power tariff system. The analysis will result in detailed recommendations for single optimization measures. The recommendations are divided up into short-termed measures, medium-termed measures and depending measures (measures which are connected e.g. to overall changes in process technology or renovation strategies).

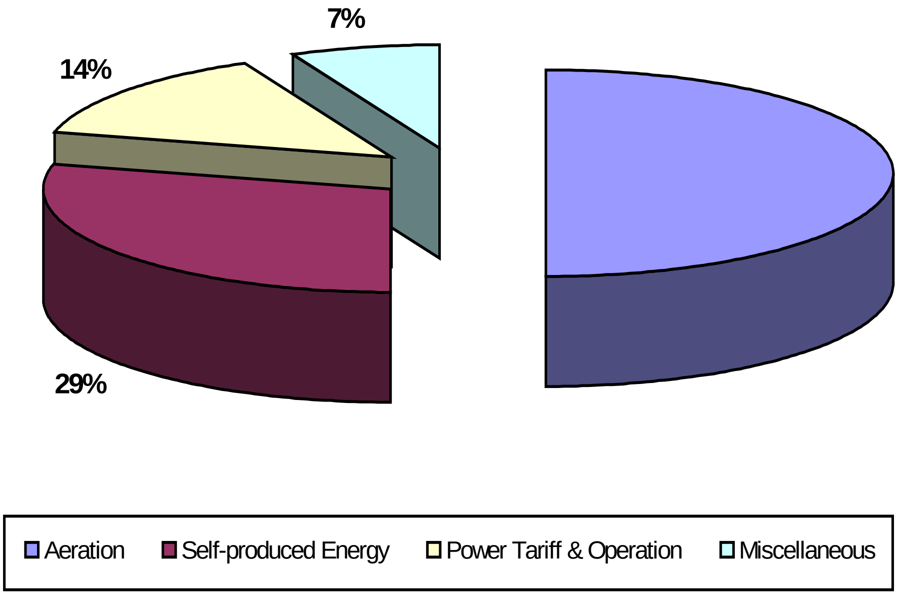


Figure 9: Energy savings related to proposed measures in 47 wastewater treatment plants in Germany [Kaste, 2003]

Detailed analysis of 47 wastewater treatment plants in Germany of 2,500 – 1,000,000 p.e. identified an energy cost saving potential between 5 and 100 % (average 34 %). Providing the realization of all proposed measures, about 2.3 m € could be saved per year [Kaste, 2003]. As expected, the main reduction in energy costs can be achieved by optimizing the aeration step (Figure 9) . Energy being produced of a renewable source or biological material like sewage sludge and being sold to the power utility is financially promoted by the state of Germany. Thus, in Germany all measures in this area will extremely contribute to the energy savings as to be seen in the figure. But also optimizing the operation of the electrical consumers under consideration of the tariff system and contract negotiations with the power utility can be very profitable.

6. Disposal

The costs for disposal consist of the disposal of sewage sludge, screenings, sand and municipal waste. The disposal costs can differ between 15 and 50 % of the total operation costs. Due to very low part on the total operation costs for screenings, sand and municipal waste, only sludge disposal will be discussed in the following.

Generally, disposal costs depend to a large degree on

- the size of the treatment plant,
- national regulations for the disposal of organic materials like sewage sludge,
- local conditions and market price conditions respectively.

Sludge originates from the process of treatment of waste water. Due to the physical-chemical processes involved in the treatment, the sludge tends to concentrate heavy metals and poorly biodegradable trace organic compounds as well as potentially pathogenic organisms (viruses, bacteria etc) present in waste waters. Sludge is, however, rich in nutrients such as nitrogen and phosphorous and contains valuable organic matter that is useful when soils are depleted or subject to erosion. In particularly the organic matter and nutrients are the two main elements that make the spreading of this kind of waste on land as a fertilizer or an organic soil improver suitable.

Sludge treatment and disposal operations on a local or regional basis need careful planning to ensure that the strategy undertaken is environmentally acceptable, reliable and cost-effective. Sludge quantities and quality have to be assessed now and into the future. Disposal options for sludge have to be analyzed by an environmental assessment approach which studies the accessibility of all outlets, environmental legislation and attitudes of collaborating agencies and the public at large. Other wastes which may compete with sludge for disposal outlets must be considered.

Outlets which involve recycling and beneficial use of sludge are advantageous but may not be practical. Sludge treatment must be evaluated in relation to the disposal options available. Sludge treatment centres, treating sludge from several surrounding wastewater plants, may be required especially if thermal drying or incineration are likely options. Economic evaluation has to consider capital and operating costs of sludge treatment and transport and other costs associated with disposal.

Practical experience with sludge disposal in different European countries (S, DK, G, F, CH) can be summarized as follows [EWA 2001, European Commission 2002]:

- Policy aspects as decision making procedures and continuity in political strategy play a key role in the different countries. There is a strong relation between these political factors and the costs for sludge disposal. Even very elaborated legal frameworks with very stringent quality criteria can have detrimental effects on the selection of sludge disposal routes.

- For large treatment plants in agglomerations sludge disposal after incineration can be an economically and ecologically sound solution. The development of low cost small incineration plants meeting advanced off gas standards is in progress.
- Co-incineration of sludge with cement and solid waste can result in economically sound solutions. In regard to P-recovery it does not represent a sustainable solution.
- Sludge disposal of dewatered sludge in landfills should be avoided as it results in long term monitoring requirements especially for ammonia leaching.
- For the very large number of small treatment plants (e.g. <20.000 PE) landspreading / agricultural use of sewage sludge seems to be the most economical and sustainable solutions as long as source abatement of possibly hazardous substances is successful. Landspreading of semi-solid and landspreading of solid sludge entail on average the lowest total cost (110 – 160 €/ton dry matter incl. external&internal costs).
- Landspreading of composted sludge, use of sludge in land reclamation and use of sludge in silviculture record intermediate total costs (210 – 250 €/ton dry matter).
- Landfilling, mono-incineration and co-incineration of sludge with other wastes entail the highest costs (260 – 350 €/ton dry matter).

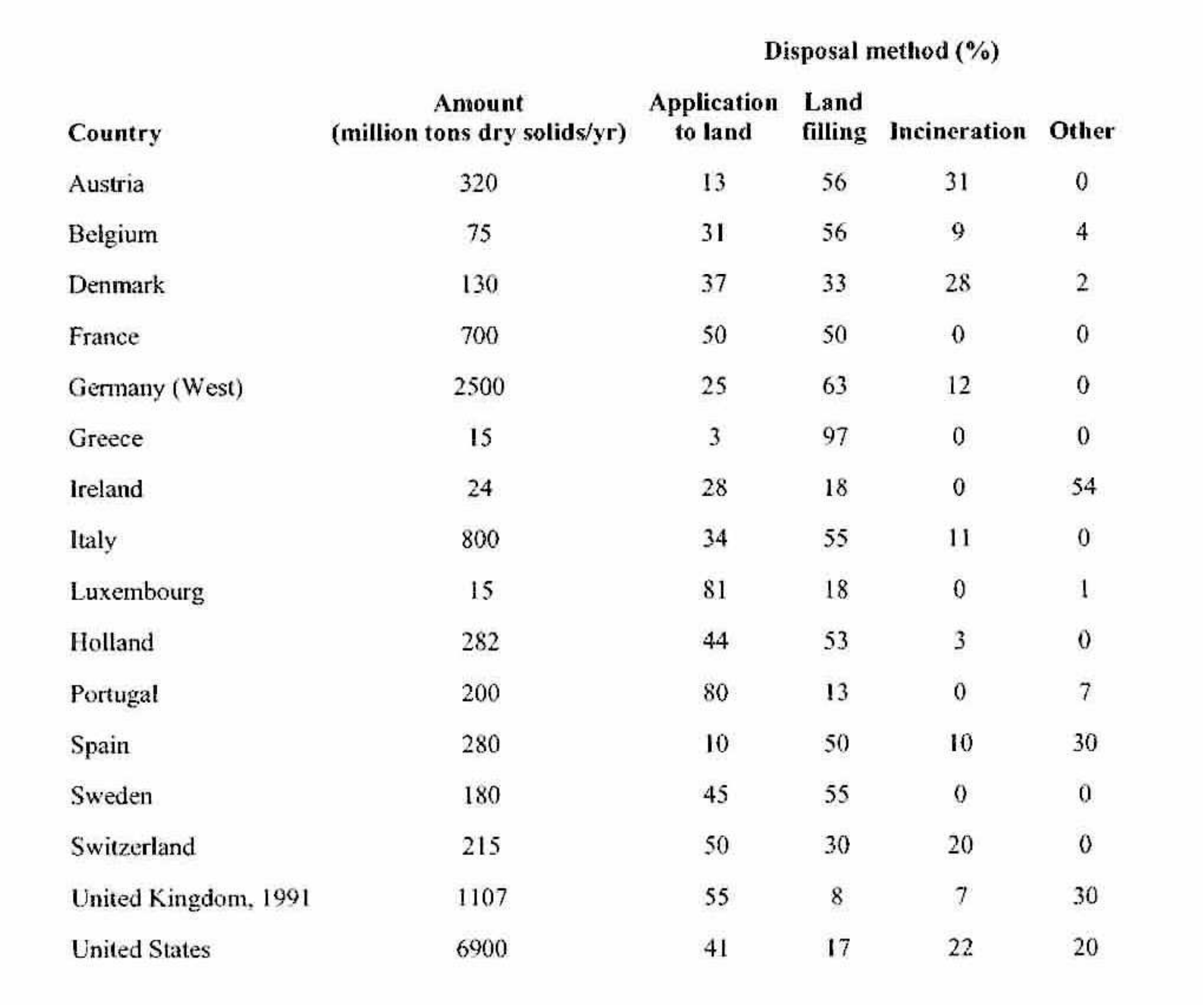
6.1 Sludge Disposal Regulations

Sewage sludge, also known as biosolids, is what is left behind after water is cleaned in waste treatment works. It is high in organic content and plant nutrients and, in theory, makes good fertilizer. However, most developed countries regulate its use because it also can contain a multitude of metals, organic pollutants, and pathogens. The application of sewage sludge to land, especially on agricultural lands, has been contentious since the late 1980s, when national and international clean water regulations prohibiting the ocean dumping of sludge were first enacted.

Millions of tons of sewage sludge generated each year must go somewhere. If not applied to land, most sludge would have to be burned in incinerators or landfilled. U.S. total annual production of sludge is stable or only growing slowly; however, in Western Europe, where tougher clean water laws are beginning to take effect, sludge production is growing significantly, as small communities build and improve waste treatment plants to comply. Although opponents of sludge use have many grievances, one of their main concerns is the long-term buildup of heavy metals in the soil. Over time, they argue, metals such as cadmium, zinc, and copper could build up to levels high enough to damage agricultural soils. Some opponents advocate a fullscale ban on the use of sludge as fertilizer. But for others, who acknowledge its benefits, the question is: At what levels do heavy metals cause harmful effects?

The European Union (EU) is beginning work on a new sludge directive that will lower permissible limits for heavy metals. Another EU directive, which sets absolute values for contaminants in food, could also drive down permitted levels of metals in sludges. Draft standards for some metals taken up by plants, in particular, cadmium in wheat, are set so low that to meet them, sludge cadmium levels would have to be significantly lower than current EU requirements. U.S. regulations for metals in sewage sludge are also slated for scrutiny. EPA is planning to commission a review of the science behind the regulations.

Table 1: Sewage sludge generation rates and disposal methods in different countries [EPA, 1999]



		Disposal method (%)			
Country	**Amount (million tons dry solids/yr)**	**Application to land**	**Land filling**	**Incineration**	**Other**
Austria	320	13	56	31	0
Belgium	75	31	56	9	4
Denmark	130	37	33	28	2
France	700	50	50	0	0
Germany (West)	2500	25	63	12	0
Greece	15	3	97	0	0
Ireland	24	28	18	0	54
Italy	800	34	55	11	0
Luxembourg	15	81	18	0	1
Holland	282	44	53	3	0
Portugal	200	80	13	0	7
Spain	280	10	50	10	30
Sweden	180	45	55	0	0
Switzerland	215	50	30	20	0
United Kingdom, 1991	1107	55	8	7	30
United States	6900	41	17	22	20

7. Chemicals and Materials

Costs for chemicals and material include the purchase costs of one or more of the following:

- Polymers, alum and lime for sludge conditioning
- NaCl, Cl_2, O_3 for disinfection
- $FeCl_2$, $FeCl_3$, AlCl for precipitation of phosphorous
- Methanol, ethanol for denitrification
- Reagents for laboratories
- Oil and gas for machinery and vehicles
- Others

The costs of chemicals and materials usually range between 5 – 7 % of the total operation costs. The costs mainly depend on the characteristics of wastewater and the discharge norm, the selected chemicals, correct dosing, quantities kept in stock and purchasing deals. The market situation and the price structure for chemicals differ strongly. Even in Germany there are different price structures due to transportation and availability. The total costs have to be specified for each particular project.

8. Miscellaneous

This type of costs comprise all costs, which can not be assigned to the other cost types:

- Internal laboratory services
  Self-monitoring and analysis of water authorities
- Pollution charges
- Pollution charges are often levied by local or national governments on the discharge of water into the environment, i.e. mostly into surface waters. They are usually imposed on operators of treatment plants and industrial dischargers. The charges are generally calculated based on actual quantities and/or pollution loads of the effluent. There is a variety of charging systems into place to determine the pollution charges on wastewater discharge. For treatment plants the pollution charge is often calculated based on the number of inhabitants served by the plant or the pollution load of specific chemical, biological and biochemical parameters. Additional information are given in Lesson D4.
- Administrative costs like insurances, office equipment etc.
  In some municipalities administrative costs are paid centrally, in some these costs are allocated to the wastewater treatment plant.

- Rents and tenancies
  Some municipality own their land and buildings and have theses costs on their capital budget. Others pay rents and tenancies.
- External costs for consultants, maintenance works, laboratory analysis

The miscellaneous costs can differ between 5 and 15 % of the total operation costs. If pollution charges have to be paid to the authorities, pollution charges are the main contributor to the total miscellaneous costs (4 - 8 %).

9. Exercise

As we have learned in this lesson, operation costs of wastewater treatment plants are influenced by many factors and can differ in a wide range. Accordingly, reliable cost calculations can only be worked out on the basis of detailed data from the plant.

Running through the whole of one particular wastewater treatment project as an exercise would go beyond the scope of this E-Learning course. That’s why the following exercise is based only on few data and shall mainly put you into the position to successfully deal with the relevant costs components and to investigate the most important influencing factors.

Please estimate the possible range of operation costs per year (€/a) of a new municipal wastewater treatment plant with a capacity of 10,000 p.e.. Discuss the main influencing factors on the operation costs.

The exercise should be carried out considering the following assumptions:

- The plant is located in southern Europe. It is operated as a conventional activated sludge system without sludge digestion. The produced sludge is utilized in agriculture as fertilizer.
- The costs to the employer of an annual salary, including insurance, is assumed to be 20,000 € per year.
- The investment costs amount to 2.7 m €. They are divided up into 50/35/15 % on construction/mechanical equipment/electrical equipment. Maintenance costs are assumed to amount up to 15 – 25 % of the total operation costs.
- The average energy tariff amounts up to 0,10 €/kWh.
- The daily volume of wastewater per p.e. is assumed to be 75 l.

Results

Unit	***Range of Operation Costs***
Personnel	*60,000 – 80,000 €/a*
Maintenance	*15,000 – 85,000 €/a*
Energy	*25,000 – 37,000 €/a*
Disposal	*35,000 – 70,000 €/a*
Chemicals & Materials	*14,000 – 17,500 €/a*
Miscellaneous	*3,500 – 25,000 €/a*
Total Operation Costs	***156,000 – 322,000 €/a***

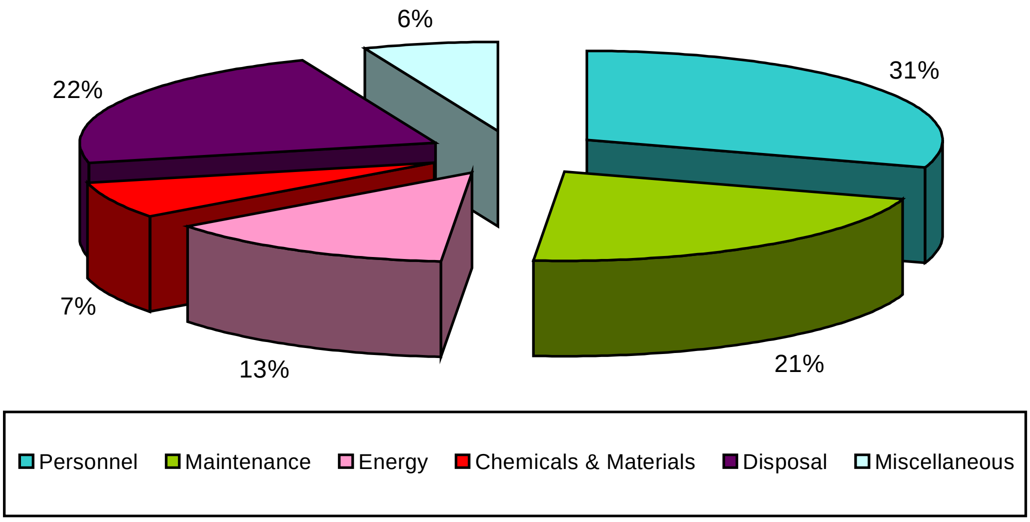


Figure 10: Results of exercise / Average composition of operation costs

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