ECONOMIC TOOLS FOR MANAGING ENVIRONMENTAL ASPECTS OF WATER USE IN POWER PLANTS

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Abstract: *Water use in a power station is an irreplaceable resource due to its physical and chemical properties, good availability and abundance. That is why it is used in large volumes for many purposes. Despite the simplicity of water, it is very comprehensive in energy chemistry. Hence if you evaluate the variables in power plants, the second highest variable cost is water. All other types of variable costs are negligible against water. The largest portion of water in power plants is used for refilling cooling circuits. However the largest portion of water added to the cooling circuits (approximately two thirds) is lost to evaporation and is carried over in cooling towers. There is a concentration of water (evaporation) and carry over (drift of small droplets of cooling water in a stream of cooling air). The concentration of water leads to increased concentrations of impurities in the water. Effect of thickening and loss of water is one of the aspects that are discussed in this work.*

Keywords: *Economic tools, Demineralised Water, Power Plant, Water Management, Ion exchanger, Nuclear Power Plant (NPP).*

JEL Classification: *Q00, Q01.*

Introduction

Water is a common pool resource. As such, it has some specific attributes that make it susceptible to depletion. The overexploitation of a common pool resource leads to the "Tragedy of the Commons" a situation first described by Hardin [6] in 1968 [11]. Water use in the power station is an irreplaceable resource. Despite its simplicity the use of water is very comprehensive in Energy chemistry. This is due to its physical and chemical properties and availability in abundance. That is why it is used in large volumes for many purposes. If you evaluate the variable in power plants, the second highest variable cost is water. All other types of variable costs are negligible against water. The largest portion of this water is used for refilling cooling circuits. The biggest amount of water added to the cooling circuits - approximately two thirds are lost to evaporation and carry over on cooling towers. There is a concentration of water (evaporation) and carry over (drift of small droplets of cooling water in a stream of cooling air). Effect of thickening and loss of water is one of the aspects that are discussed in this work.

To reduce freshwater usage and wastewater discharge has become one of the main targets of design and optimization of process systems. Water system integration treats the water utilization processes in an enterprise as an organic whole, and considers how to allocate the water quantity and quality to each water-using unit, so that water reuse is maximized within the system and simultaneously the wastewater is minimized [1]. Water quality in the River is influenced by bedrock geology, industry on the river, time spent in containment or reservoirs, total flow (dilution waste water) and many other influences. By the necessity of water treatment it is important to know in detail the composition of water in order to design effective and economical method of treatment, from removal of different groups of materials contained in water, to the production of demineralised water, hence it is necessary to remove all dissolved and suspended substances and close to the ideal of pure H2O..

1 Statement of a problem

The methods of using raw water and water treatment technology leads to the water flow in the source river to:

- Reduce by water evaporation and carrying over in cooling towers. Approximately two thirds of the total water quantity is lost to evaporation or carry-over in power plants cooling towers.
- Thicken by water treatment agents dosed into the water and used in the process of demineralization and subsequently released into the source water. Increase salinity of discharged water and thus the salinity of water in the river due to the use of a number of chemicals for water treatment.

Problem 1

Evaporation and the carrying over of cooling water are given by the cooling tower design, flow and temperature of cooling water, for the most part is almost a linear function of output power. The water removes residual heat, which affects the efficiency of electricity generation process. With organizational arrangements are not solvable.

Problem 2

The second problem is determined by implemented technology of water conditioning and its implementation. It is very realistic reassessment of the deployment of necessary technology to reduce the intensification of waste water salinity and, consequently, the incoming water. It is necessary to create a system that would be able to track trends, values and the joint to eliminate the negative impact of the discharge of wastewater on the quality of raw water in the river. The combination of ecological and economic approach facilitates the creation of this system has not been applied elsewhere.

2 Methods

Objective Defining

The primary objective is to minimize the consumption of demineralised water and by the reduced consumption of demineralised water to optimize the consumption of chemical agents used in water treatment. Secondarily, to bring down the costs of production of demineralised water. It is necessary to elaborate a methodology for calculating the price of demineralised water, which will reflect the cost of raw water, operating materials, methods of operation and maintenance and other costs (as would water be sold). Further to develop a system to manage consumption of demineralised water so that the environmental impacts of manufacturing have been optimized. [5]

Defining the problem areas and necessary data, we must obtain the following information:

- Amount of demineralised water supplied to the production unit.
- Amount of produced electricity.
- Chemical agents used
- Life cycle of ion exchange filter cartridges.
- The effectiveness of ion exchange.
- Self-consumption of demineralised water (for demineralization lines use).

3 Optimization of the production method of demineralised water

3.1 Operating Expense (OPEX):

- The raw water costs are given by contract with the river-basin for the period.
- The cost of pumping energy is advantageous to convert for m^3 of water transported from the river to the deposit of demineralised water. (In case of NPP is in CZK per year = 41/60 kWh X house electricity price per m^3 consumed raw water).
- Operating chemicals needed to produce demineralised water. Here we count pre-treatment of water, regeneration and neutralizing of chemicals (H_2SO_4, HCl, NaOH, coagulants, flocculants,) and ion exchange materials. It should however be the actual count, not projected values. The value in the balance of the operating costs of the materials produced per 1 m^3 of demineralised water.
- Other operating expenses, which are hardly classifiable information, such as compressed air consumption, with operational materials handling, cleaning operations. Again, it is advantageous to find the coefficient of relative demineralised water produced, because these costs are stable, however, difficult to monitor.[7]

3.2 Capital Expenditure (CAPEX)

The larger part of fixed costs, where no matter the amount of demineralised water produced can be termed as a “capital”.

- Depreciation for the operating balance may not be consistent with the statutory depreciation for tax purposes because the objective is to cover as truthfully distribution of values in investment value over time. Depreciation is a function on 1 m^3 of raw water.
- The cost of maintenance, you can establish similar rules as in the previous section. Routine maintenance is included in a given year, but major maintenance interventions, such as replacement of piping, paint, etc. should be reflected in the estimated useful lives.
- Wages of employees involved in the production of demineralised water.
- Supply overhead and administrative overhead. This is the cost of the corporate infrastructure in the price of the product.

The resulting calculation procedure to calculate the price can be very different from case to case, but it must match the locations participating in the benchmarking. The biggest effects of these numbers are not in their absolute value, but in monitoring trends in their changes over time in comparison between the monitored sites and the correct evaluation of changes.

3.3 Optimising ion exchangers lifecycle

Ion exchangers' capacity for the calculations is determined by comparing the counted operating capacity in each cycle (mol trapped ions per liter of resin) with the capacity provided by the manufacturer. Cat ion exchangers Wofatit KPS-DS, followed by Lewatit S-100 have great durability. Since 1985 in the Dukovany NPP, cation was added only about 5% of its capacity annually to offset losses, the operational capacity does not decrease capacity, which would require a total replacement filter cartridges. For anion resins, Wofatit SBK-DS and AD-41 followed by Lewatit M-600 and MP-64 is a loss of strong basic capacity (Hoffman degradation of amines).

Exchangeable capacity of strong basic-anion form quaternary amines, which occur in time to the degradation of functional groups and conversion of lower amines. This reduces the capacity of strongly basic filter replacement for weakly basic. This leads to deterioration in overall employment and productive capacity anion resin. It was found the typical course of ion capacity exchange reduction; capacity-curve is variation in the acceptable tolerance. This data set was used to perform regression analysis and acquisition of capacity decline $y = -0.67x$, where x-axis is unit for the month and the unit on the y-axis (%) is operating capacity, where 100% capacity of the resin is given by the manufacturer. The annual average loss of total resin capacity is 8.04%. We consider the deployment of the anion filter cartridge in years 1, 2, ... n for any length of deployment enumerate costs and benefits that compare. We will use the following simplifying assumptions

- Production of demineralised water will be 700 000 m3 per year.
- Price of resin regeneration is 10,300CZK.
- Costs or revenues are not discounted.
- Prices of consumables will be considered as stable.
- The price of demineralised water is considered to be stable.

If this simplification is not accepted, each of the simplifying assumptions would change to the variable. The data indicate that the high cost of resin are moved to maximum effect between 8 and 9 year of operation, which decreases the operating capacity of about 50% against the new resin. [4, 8, 9, 10, 12]

4 Discussion

The efficient use and allocation of water is paramount to sustainable development hence Efficient and effective water resources management is as much a political as a scientific challenge, which not only requires a multidisciplinary approach, but also the integration of key stakeholders into multi-objective, multi-criteria decision making processes. The decision making process requires direct access to and ease of use of a shared information basis and decision making support tools that are intuitively understandable for a diverse user group, and that address not only hydrological and environmental engineering but also economic and social components direct.

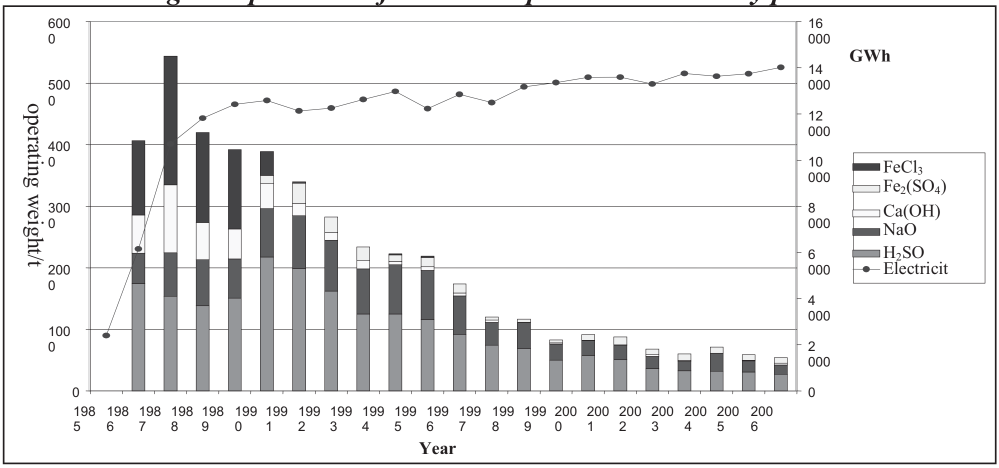
The aim of this work is to develop tools that can be used as economic indicators of the impacts of technology on the environment. If these instruments are defined, an equally important task is to master these tools and use them. This application requires some experience of the operations. When using these tools it is relatively easy to identify problem areas. Then follow a technical audit, which will propose concrete action in the field of technological discipline, work practices or suggestions to changing technology. There is scope for the use of benchmarking, or search for "best practices". This application part is specific to each plant and is outside the scope of this work. On the top of an imaginary pyramid of information are the following criteria:

4.1 Price of demineralised water

Price of demineralised water comprehensively describes the efficiency of production of demineralised water. It is divided into individual components, which can be individually monitored and evaluated. The largest influenced items in price of the demineralised water are operational chemicals.

These account for the major environmental impact. We get a real look at the effectiveness of the use of operational chemicals in a chart based on the production of electricity as the main product. Figure1is based on the production of electricity as the main product. In identifying the unacceptable trends in some of the observed values it is necessary to carry out detailed analysis of the situation and the local knowledge to be able to prepare an improvement.

Fig. 1: Operational fuel consumption and electricity production

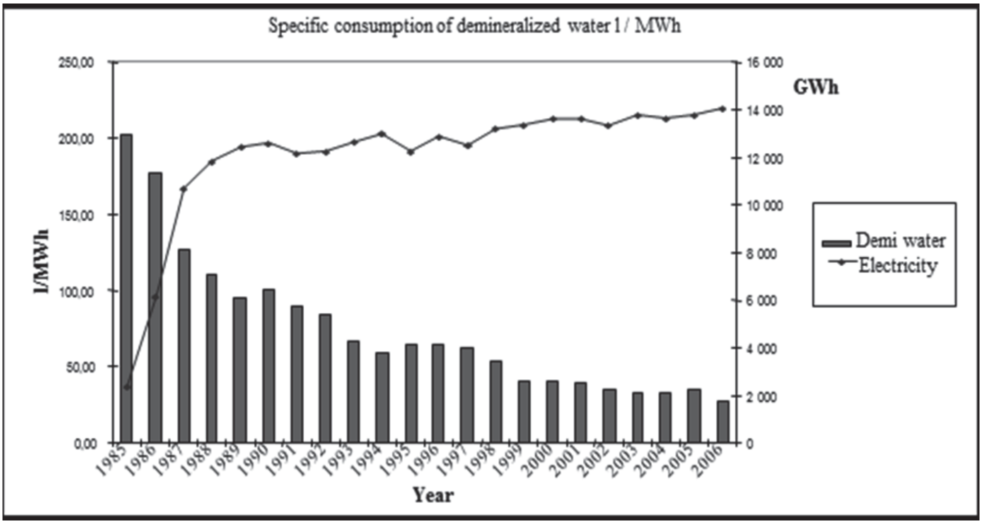


Source of data: author

4.2 Consumption of demineralised water

Is a comprehensive indicator which presents comparatively how economically produced demi water is used? As evidenced in the work, saved demineralised water presents an unused source of raw water, unused chemicals, which are then neutralized, salts discharged into the environment, and unused energy. It is a very convenient factor for benchmarking. To use a comparison of power plants and heating plants may be related to electric energy, but not the heat production. [2, 3] Trends in consumption of demineralised water as the aggregate carry more complex information than would be expected, as seen in figure 2 below. It is interesting to note the failed trend of decreasing consumption of demineralised water in 1990. There was significantly restructure in the organizational structure, and priorities were set into other areas. A similar effect was observed after 1995 when there was a major change in Dukovany NPP's organizational structure. This confirms that the movement of desired direction in any activity is subject to continuous pressure.

Fig. 2: Specific consumption of demineralized water l / MWh



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Conclusion

Effectiveness of this work's defined approach can be illustrated by the comparing data from Dukovany NPP with data which was obtained from plants that have not applied these methods. The origins of data used will not be registered. Company 1 of the figure 3 shows the trend of reporting period justifiable at high absolute demand of demineralised water against the firm 2 in the figure 4 showing an uneven trend and high consumption. This paper publishes a summary of instruments that can be used to manage the impact of chemical processes in water treatment to the environment not only in energy production plants.

Fig. 3: Comparison of consumption of demineralized water; company 1

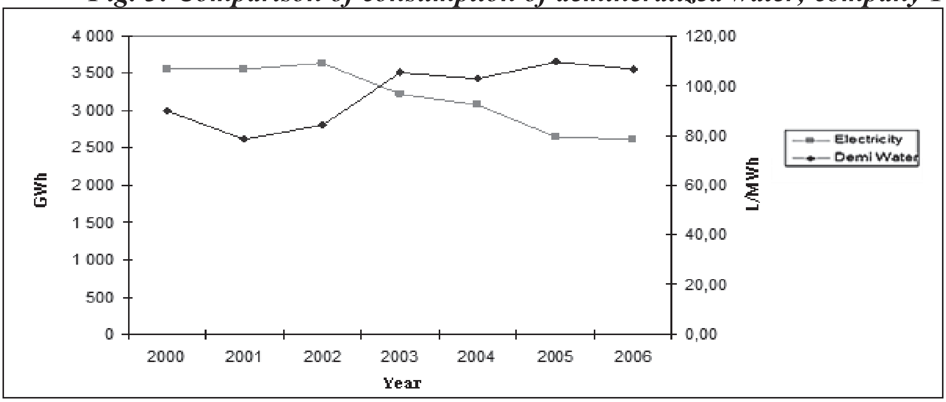

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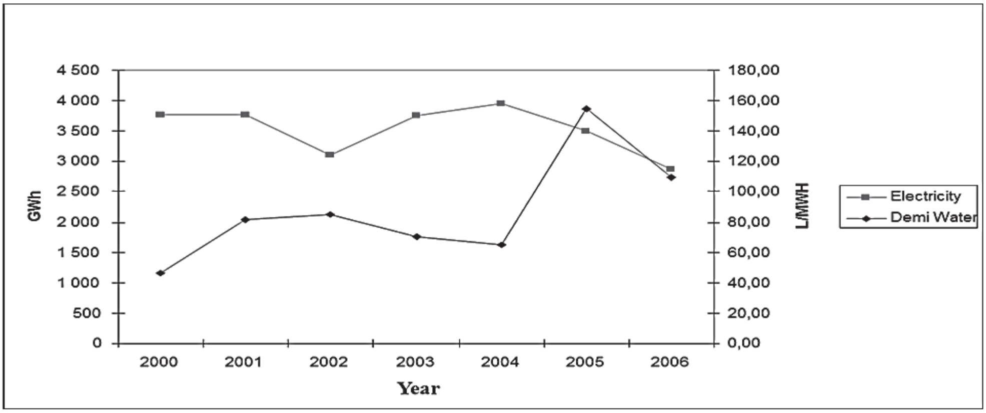
Figure 3 presents specific consumption of demineralised water just about 100 L/MWh. which shows negative dependence of electricity production and demineralised water consumption. It is reasonable, because higher electricity production means higher time share spent in optimal operation level. Trend is acceptable, but total specific consumption of demineralised water is unreasonably high. At present, this value is below 50 L/MWh at the Dukovany NPP. Figure 4 shows a different situation where high specific consumption of demineralised water leads to unreasonable trend, and there is no connection between electricity production and demineralised water consumption. Especially years 2005 and 2006 shows dramatically rising demi water consumption without any visible improvement steps. This gives evidence of profitability of tools described in this paper

Fig.4: Comparison of consumption of demineralized water; company 2



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However, limiting factors in the neighbourhood, in this case it was the assimilative capacity of environment, can over time cause the pressure in the continuity of production rearranging priorities. In addition, this work responds to the absence of an integrated process for monitoring and managing of the impact of chemical processes in relative frequent high volume water treatment. Indicated concentration of the economy and the environment provides for the use of this process good initial condition

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