VALUE ANALYSIS IN WATER SUPPLY

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Summary

The value analysis method has seemingly no role in water supply of national economy as this method was elaborated mainly for the enterprises producing products [1]. However, the final product, water can also be the subject of value analysis, especially if the technological process aimed at production is to be modernized or the costs of operation process realizing distribution are to be decreased. Besides operation investment decision is the field where costs decrease can be attempted. This paper shows it with some examples by the operation of the Waterworks of Budapest.

Waterwork's operation applications

Drinking water production

In order to determine the value of different drinking water producing sources, the costs of operation at certain establishments are to be known quite accurately.

The main task is the collection of the costs of technologies making water suitable for drinking and the determination of their specific values periodically.

An example is the gravel terrace of the Danube where the working costs from water producing wells, its quality corresponds with drinking water standard MSz 450/1, at the suction stub of pressure pump settlement is 0.5–0.7 Ft/m^3 including sterilizing javellization.

If at the same wells iron and manganese compounds appear in the water the costs of technological process necessary to remove them can be 0.6–1.2 Ft/m^3 that is the production cost of well water before pressure is between 1.1–1.9 Ft/m^3.

Drinking water can be produced from so-called day water taken directly from the Danube cleaning it by mechanical or chemical methods, and the cost is usually between 1–2 Ft/m^3 depending on the alluvial state of the Danube that naturally contains water producing costs, too.

As the yield of water of coastal filtration obtained from the gravel terrace of the Danube depends on the water level, the extent of escape among the gravel depends on the temperature of the water because of the viscosity change of the water, the cheap water produced from wells in summer or winter is not always in harmony with consumer demands, thus treated or cleaned water are also to be produced. On the other hand, the complicated cleaning process has a so-called setting up or running up time in course of which an active layer is formed on the filters and this time can be decreased only if the Company originally was operated with minimum costs because then it can reach full capacity in some hours. It is often necessary to substitute the water of groups of wells stopped because of absence of current. So it is expedient to operate the cleaning plant practically continuously with minimum capacity for safety reasons.

The problem surveyed schematically is to be solved daily because of the changes of weather and that of the water level of the Danube in order the costs of drinking water production should be minimum taking into consideration the cleaning surplus costs necessary because of safety reasons. The orders for the daily production of certain water sources are to be determined regularly on the basis of the evaluation of water quality costs.

Operation of distribution network

If the network costs are to be minimized the network pressure is to be kept at a necessary minimum value which means that the pressure level in front of the connection of buildings should be higher by 10–15 meters than the vent on the top floor of the building. This condition can be fulfilled neither in town nor in hilly region with similarly tall buildings, only if certain parts of the pressure region are operated with pressure reduction.

In the course of the solution of the functions we have to start from the fact that the feed engine compartment, return pressure basin of the region and the main or ridge mains connecting them are given. In this system minimum current resistance is to be achieved thus throttling is to be avoided. In branch mains, however, current resistance digests the energy contents of water so building in throttling can be useful.

If from among value analysis methods that of idea rush is used then a lot of ideas can be achieved for operation with minimum energy, and to a certain extent they can even contradict to each other. They are as follows: only water amount necessary as extinguisher water reserve is to be kept in the basin as higher water level digests superfluous energy;

— the water level fluctuation should be restricted so that the water of the basin could be exchanged in a week and the quality should not deteriorate;

— to avoid the fluctuation of the water level of the basin the pumps of the feed engine compartment is to be adjusted delicately which can be achieved with the change of revolution number if there is no throttling;

— the flap fittings rectifying current built into the closed chamber of the basin are to be substituted by locks operated with auxiliary energy, controlled by current direction sensor in order the current resistance of flaps could be eliminated;

— always the engine-pump combination of the best efficiency is to be operated and the efficiency of the machine is to be controlled at least once a year by measurement;

— the parts of the region where the pressure level is much higher than justified by the size of the buildings — either because of the current resistance of the mains or the given basin level — are to be separated and fed through pressure decreasing fittings controlled from lower pressure level; thus water consumption of the given region is also decreased as superfluos water courses also decrease influencing the energy consumption of the whole region [6].

The operation with minimum energy consumption does not mean that energy cost is minimal, as according to tariff 3 energy is the cheapest at night and the most expensive in the evening in peak consumption. Thus the following method is a conscious by energy wasting and at the same time cost saving one:

— at night the basin is to be filled up entirely at summer peak consumption or as necessary in the course of winter minimum consumption and in daytime the pressure is kept at such a level in the pump plant that the basin should not or only minimally empty and finally in the evening peak consumption period pumping energy consumption is decreased to the minimum pressure level, not emptying of the basin — leaving only extinguisher water reserve.

The enlisted operation procedure is difficult to be realized in every region of a big water company without computer methods so it is to be restricted to areas being the greatest energy consumers. Using the ABC method of value analysis the following order can be set up in Budapest [5]:

Name of region	% energy	Cumulative % consumption	Category
Basic zone in Pest	61.8	61.8	A
Basic zone in Buda	15.6	77.4	A
Upper zone in East Pest	3.8	81.2	B
Zone in Lipótmező	3.2	84.4	B
Zone in Diana	2.7	87.1	B
Zone in Castle	2.5	89.7	B
Further 14 zones	10.3	100.0	C

Thus 3–4 regions at the beginning of categories A and B can be chosen where examinations are worth performing because of the magnitude of the expectable result.

Table 1

Abridged table of the driving engines of drinking water pump at Budapest Waterworks for value analysing ABC analysis

pc	kW	Region	Total perf. kW	Cumulative		Categ.
2	1150	Pest basic	2300	2300	A	
6	1000	Pest basic	6000	8300	A	A total
8	800	Pest basic	6400	14700	A	25 pc.
6	800	Buda basic	4800	19500	A	
3	800	East Pest	2400	21900	A	
2	630	Pest basic	1260	23160	B	
1	600	Lipótmező	600	23760	B	
6	515	Pest basic	3090	26850	B	
2	500	Lipótmező	1000	27850	B	
1	480	Castle	480	28330	B	
2	480	Pest basic	960	29290	B	
2	400	Castle	800	30090	B	
2	400	Sas hill	800	30890	B	
3	400	Diana	1200	32090	B	
2	400	Budakeszi	800	32890	B	
2	320	East Pest	640	33530	B	
2	300	Buda basic	600	34130	B	
3	300	Csatárka	900	35030	B	
2	250	East Pest	500	35530	B	
6	250	Buda basic	1500	37030	B	B total
2	250	Ujpalota	500	37530	B	40 pc.
2	240	Buda basic	480	38010	C	
1	200	Felső Józsefhegy	200	38210	C	
3	200	Castle-Budaörs	600	38810	C	
2	200	Pest basic	400	39210	C	C total
52	100–200	different	6416	45625	C	507 pc
447	0–100	different	11093	56719	C	

Table 2
Abridged value analysing table of the drinking water basins of Budapest

Total volume name		308,036 100%				
		cubic cont. 1000 m³	total volume %	cumulative %	cat.	region
Sánc street		80	25.97	25.97	A	Pest
Kelenhegy st.		47.8	15.52	41.49	A	basic
Krisztina		23.67	7.68	49.17	B	Buda b.
Kőbánya old		22.2	7.21	56.38	B	Pest
Kőbánya new		20.	6.49	62.87	B	basic
Pestlőrinc		16.65	5.41	68.28	B	Pest b.
Castle+Dayka G. st.		16.53	5.37	73.65	C	Castle
Rákosszentmihály		10	3.25	76.9	C	Pest b.
Cinkota st.		10	3.25	80.15	C	East P.
Lipótmező		9	2.92	83.07	C	Lipót
All the other	33:	52,168	16.93	100.00	C	Different

As the efficiency examining capacity of the Waterworks is also restricted, the pumping machine groups and the frequency of their examination are also to be chosen by ABC method. If the performances of the engines driving the pumps are categorized according to size — Table 1 — it is evident that the machines in group A are to be examined every year, the ones in group B every 2–3 years and the examination of the ones in group C can be disregarded if it is not necessary because of some other problems.

When the energy cost saving considerations are examined by the electric peak consumption of water energy stored in the basin with cheap night current, then it is obvious that this problem should be examined not in the greatest energy consuming regions, but only in the ones having the greatest return pressure capacity.

If basin volumes are categorized by ABC method — Table 2 — the volume limit can be chosen above which this operation is worth organizing. It is clear that one has to make examinations only in the basic regions of Pest.

Waterworks development application

The place and method of water storage in the system

Water reserve is needed in water supply system as water producing systems are to be operated regularly because the clarification and filtration processes react to quick changes by the deterioration of water quality which is to be avoided. At the same time consumption is changing in time thus differences coming from it have to be equalized by storing.

Storing costs of one cubic meter water depend on

— the size of the container as the bigger one is specifically cheaper,

— on the height of storage above ground level, as the higher the container, the more expensive it is.

The investment costs of basin built on ground level are 4–8 thousand Ft/m^3. The specific costs of at most 600 m^3 steel water tower [4] with 24 m foot are 7,250–12,500 Ft/m^3. Specific investment costs of 3000 m^3 reinforced concrete water tower with 50 m foot are 40,000 Ft/m^3.

The water is most expediently stored in the centre of consumption field, as in this way the energy costs of transportation are minimum and if it is possible to store it in terrain high storage basin, the investment costs become the smallest. In this respect the situation is ideal in the greatest region of Budapest. as near to the consumption centre there is the Gellért Hill where big storage basins could be built. On a plain territory usually water tower is built instead which is, however, very expensive. When investment saving is necessary, the functions of the water tower are to be analyzed and probably look for a less expensive realization. The water tower fulfils the following functions:

— stores water; — stores energy; — restricts pressure level. These functions can be performed cheaper,

— if water is stored in terrain basin built in consumer centre for costs of about one fifth of a higher water tower. It is expedient if a system of lower pressure feeds the basin with water without energy loss. The pump plant feeding the network has to be settled in this territory, its capacity is to be chosen for local peak consumption, thus a little higher than with high storage basin. Its surplus cost is about one thousendth of the price of the water tower. Water distribution system has also to be dimensioned for peak consumption, but it is a prescribed because of extinguisher water demand, thus no surplus cost is to be calculated here.

Energy storing function — if the continuity of electric feeding is not reliable — can be substituted by reserve diesel motor generator set starting automatically operation during energy shortage. It is produced in Ganz Mávag (Hungary) built into the container. Its cost is about one twentieth–thirtieth of the cost of a water tower.

Nowadays maintaining the pressure level can be realized by tiristor speed governor by which the pressure level of the pump plant can be kept within 1 m level difference at any consumption. The cost of this equipment is also one twentieth–thirtieth of the cost of a water tower [2 and 7].

With these three solutions the water tower can be substituted by a cheaper solution, for 30–26% of its investment costs. In the case of energy shortage — if feeding in the suction basin was not cut simultaneously — it gives safety for a longer time than the water tower.

It is to be noted that the competence of the water tower cannot be disputed at a consumer requiring 100% safety like a hospital or a plant where water shortage can cause serious damage, but there a low cheap steel water tower gives the local solution and the town is not forced to build a very expensive — though many times representative — water tower.

At last, not disputing the necessity of storage, it is necessary to mention that to save energy in peak time storage basin is not suggested to be built as shown through a numerical example.

Problem of mains becoming restricted

An indispensable element of water supply system is the ridge or mains through which water gets from producing field to consumer centre. The town, however, outgrows the mains because of its development as a result of increasing water consumption. As the investment of pipe work among the investments of the waterworks is the greatest — in value of fixed assets surpasses 70% — building of mains, laying new mains are not possible because of financial reasons and thus cheaper though transient solutions are to be found that can be achieved by function analysis. The functions of the mains are: — carries water; — consumes energy in proportion to its current loss; — restricts pressure level as the pressure of the built in mains allowed nominally cannot be surpassed.

More water can be carried in the mains only by much more energy on the basis of relation $HV=BQ^2$. Here HV is the pressure level loss at passing through water current Q, and B is the constant. Because of the increasing HV the allowed nominal pressure would be surpassed at the initial point of the mains. Naturally, at every given case the relation of static delivery head HST and HV determine how far one can go at the initial point of the pipe. If pressure cannot be increased further, the solution is the intermediate pressure increase pump transfer.

The establishment costs of pump transfer is about one twentieth of the laying costs of a second mains of the same size but the energy consumption of pumping significantly increases the annual operation costs of the mains and if this annual increment is greater than the annual amortization of the costs and the interest of the credit — supposing credit was used to build the mains — for pipeworks then the investment of new mains would be more economical.

The restricted state of the existing mains in waterworks operation makes water restriction necessary for some weeks during summer peak consumption, this short period can be solved by pumping pressure increase more economically than by mains building. The operation is not economical if the intermediate transfer is to be operated continuously all year or if the pressure difference produced by pump change is also to be increased or further transfers are to be built in.

The second step is to divide the pipework divided originally into two parts to further two parts and the establishment of two new plants cannot be matched for the building of new mains economically.

The Basic region in Buda can be given as an example where the establishment of the III. mains could be postponed by 10 years [3] with the intermediate transfer established on the settlement in Budaújlak.

This problem is worth analyzing before the expansion of every mains with the economic data referring to the given field taking the fact that if it is laid today, it is done in agricultural uncovered territory but 10 years later topping is to be removed making construction disproportionally expensive into consideration. The cost effect of certain functions is to be calculated for 10 years in advance taking the gradual increase of water demand and pumping demand originating from it into account as well as costs and investment decision can be founded by the cost analysis of the possible variations.

At last it should be mentioned that the present economic practice unfortunately does not make possible to raise loan to finance such waterworks investments and everything is built from budget as it does not inspire to economize.

Conclusion

The enlisted operation and investment cases have shown how much reserve can be revealed by the value analyzing methods in the field of water supply thus they have to be applied consciously and to be spread.

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