RESEARCH FOR THE ESTABLISHMENT OF AN OPTIMUM WATER LOSS REDUCTION LEVEL FROM THE ECONOMIC POINT OF VIEW

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1. Introduction

Water supply systems in Romania are presently not in an appropriate condition:

- appreciatively 40% of the population does not have access to a controlled / supervised water supply system;
- in rural areas only 20% of the population has access to a water supply system;
- the existing systems are very old and a great part of the pipes are made from inadequate materials (asbestos cement, unprotected steel)
- in some cases the water losses are greater than 50%
- the rehabilitation process is very slow due to the insufficiency of funds and also to a low water tariff (0.2-0.7 Euro/m^3).

Since Romania has just joined the European Union, this means that during the next 10 years all water supply systems have to be rehabilitated and 100% of the population must have access to clean and safe water (drinking water by law 458/2002).

Network rehabilitation, especially in towns, is complicated and expensive. Investment needs have to be correctly identified as well as the mains to be renewed in order to ensure the maximum benefits. The target is to ensure that operational and maintenance policies are met while the operating costs are minimized. Therefore, the rehabilitation has to be done with precautions. The problem that arises is to identify the rational water loss reduction limit. This paper intends to find this limit starting from some real data collected.

2. Water loss. Dynamic of water loss phenomena

Water losses can be minimised by:

- a better structure of the water supply system that will help maintaining a minimum water pressure within the network;
- using good quality materials for the pipes and an appropriate and advanced execution technology;
- a continuous and good management.

Regardless of the precautions and the care that are taken in order to preserve the network at its best, the structure will still get old eventually. This will end up in an increased water loss and all the problems directly connected to this. In order to keep this loss under control some investments have to be made. Continuously the

remediation costs have to be compared with the lost water costs. When the expenses arisen from the water loss are bigger than the repairing costs, it is the time to take action. In the later stages of the pipe's life (usually due to the corrosion) the pipe can be deteriorated up to such a degree that when a pipe suffers the disturbance required for fixing (isolation, draining down and recharging), the pipe itself can initiate more leaks than previously existed. This is why the water loss needs to be kept under control by a permanent and continuous surveillance.

Water leakage is based on 2 major activities:

- identifying water losses (location and magnitude);
- repairing the defection that produces these losses.

In this situation there are 2 problems that need a decision:

(1) between what limits the losses have to be maintained rationally (see fig. 1, level A and B)

(2) what is the optimum period of time in which the rehabilitation has to be done (see fig. 1, values D and D1)

In the figure below (see fig. 1) it is represented the relation between the pipe aging (meaning increased water losses) and the investments made for the water loss reduction

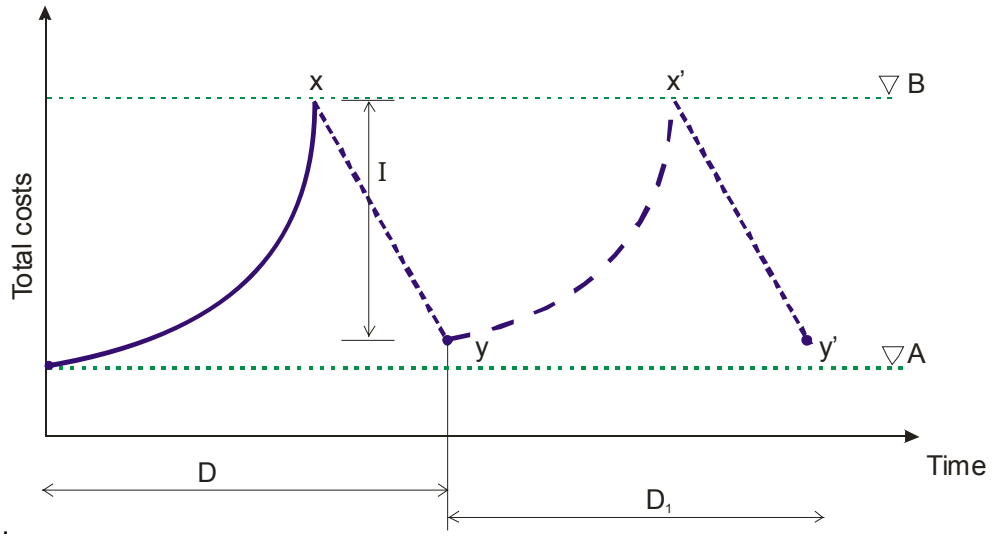


Figure 1: Cyclic rehabilitation of water distribution network

A = initial investment for the value of water loss technically accepted by standards; in Romania this value is set by standards at 10%;

B = exploitation costs level that the system reaches in time (point x, x');

I = the investment made for the water loss reduction up to the initial level or other level (A, y, y');

D = time period assigned for rehabilitation - "network rehabilitation cycle".

3. Case study

The losses are way above standard's requirements / acceptance but the problem is that due to the fact that the water tariff is very low the water providers cannot get the

funds necessary for the rehabilitation of the networks. Therefore, the repairing / replacing process is very slow and insufficient. The question that arises is "***Up to what limit the water losses must be reduced in order to get maximum results at a minimum financial input?***

3.1. Basic Data:

- Population number = 330000;
- Network length = 600 Km out of which 50% is made from unprotected steel;
- Average pipe diameter = 250 mm;
- The network is supplied through a direct one step pumping system, specific energy consumption - 0.26 kWh/m^3;
- Type of water = surface water, water from a river;
- Pumped water volume is 24 mil. m^3/year;
- Pipe material: 50% unprotected steel, 10% asbestos cement, 30% grey cast iron, 10% PEHD;
- Estimated water loss = 45%;
- The rate of repair = 30 defections / week; 5.2 km of network / year (usually PEHD);
- Network age: 35% has over 40 years; 65% has over 20 years;
- Water tariff = 0,22 EURO/m^3.

3.2 Helpful information:

- the network, having a specific length of 1.88 m/inhabitant, is intensely used;

- the network works with a reduced energy consumption, 0.26 kWh/m^3;

- the network is old; average pipe life is 27 years; having in mind that a steel pipe has an estimated life of 30 years, the iron – 100 years and PEHD – 50 years, it can be said that the average pipe life is around 55 years;

- water consumption is o.k., around 200 l/person and day; all water is metered;

- water intake is around 43.6 mil m^3/year;

- water supplied value is 0,22*24 mil. m^3/year = 5,28 mil. Euro/year, which means the average water intake cost is around 5.28 mil Euro divided by 43.6 mil m^3/year equals with 0.12 Euro / m^3;

- total investment cost for the network, with new cast iron pipe is of 280 mil. Euro;

- the volume of water loss is around 0,45 * 43,6 = 19,6 mil m^3/year;

- therefore the value of the water lost is of 19,6 mil m^3/year *0,12 euro/m^3 = 2,35 mil euro/year.

3.3. Hypothesis for calculations

- According to the effectual norms, initial water loss (as per the Romanian standard SR 1343-1/95)) is around 10% (for a new pipe);

- The water that is lost it is considered to be supplied through a “fictive system” who’s costs are similar to the one in case;
- Annual redemption rate is 168 mil EURO/ 55 years, resulting in 3.05 mil EURO / year.
- The cost for 1% water loss reduction is 3.05 mil EURO / year
- Water loss reduction is proportional with the necessary investment increased rate = 1.63% / year;
- Water tariff is constant in time (in reality it is constantly growing);

3.4. Determining the rational limit up to where the water loss has to be reduced

The values used for calculations are given in table 1 and are graphically represented in figure 2

There have been considered 6 levels of water losses reduction: zero, 10%, 20%, 30%, 40%, 45%.

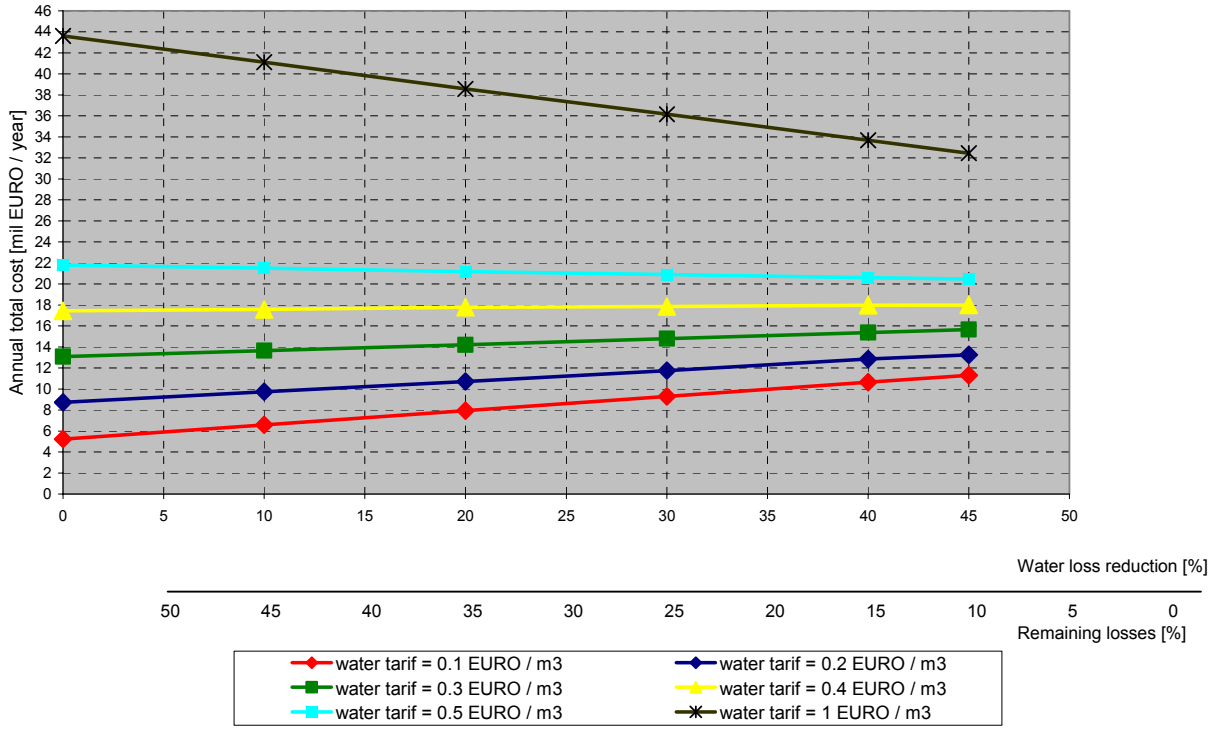
Making simplified calculations, the results indicate that in the case of a low water tariff, it is “*more economically advantageous”* to pay for the lost water instead of rehabilitating the network. In order to obtain a more rational solution (aiming to a more rational / responsible water use), water tariff has to be increased. Different water tariffs were used. The results show that when an intermediate solution is offered in the case of water tariff equal with 0,5 E/ m^3; here the rational solution has to be identified, see figure 2.

Table 1: Exploitation total cost at several water tariffs

Water loss reduction		**Amount of water supplied by the system**		**Annual investment**	**Water annual cost**
%	*Water volume [mil m^3/an]*	*Water volume [mil m^3/an]*	*Value [mil EURO/an]*	*Value [mil EURO/an]*	*Value [mil EURO/an]*
Water tariff 0.1 EURO / m^3					
0	0	43.6	5.23	0	5.23
10	4.36	39.24	4.71	1.88	6.59
20	8.64	34.88	4.18	3.76	7.94
30	13.08	30.52	3.66	5.64	9.3
40	17.44	26.2	3.13	7.52	10.65
45	19.6	24	2.88	8.46	11.3
Water tariff 0.2 EURO / m^3					
0	0	43.6	8.72	0	8.72
10	4.36	39.24	7.85	1.88	9.73
20	8.64	34.88	6.96	3.76	10.72
30	13.08	30.52	6.1	5.64	11.74
40	17,44	26.16	5.23	7.52	12.84
45	19.6	24	4.8	8.46	13.26
Water tariff 0.3 EURO / m^3					
0	0	43.6	18.8	0	13.08
10	4.36	39.24	11.78	1.88	13.65
20	8.64	34.88	10.44	3.76	14.2
30	13.08	30.52	9.5	5.64	14.79

40	17,44	26.16	7.84	7.52	15.36
45	19.6	24	7.2	8.46	15.66
***Water tariff* 0.4 EURO / m^3**					
0	0	43.6	17.44	0	17.44
10	4.36	39.24	15.7	1.88	17.58
20	8.64	34.88	13.95	3.76	17.79
30	13.08	30.52	12.21	5.64	17.85
40	17,44	26.16	10.46	7.52	17.98
45	19.6	24	9.6	8.46	18
***Water tariff* 0.5 EURO / m^3**					
0	0	43.6	21.8	0	21.8
10	4.36	39.24	19.62	1.88	21.5
20	8.64	34.88	17.61	3.76	21.17
30	13.08	30.52	15.26	5.64	20.9
40	17,44	26.16	13.08	7.52	20.6
45	19.6	24	12	8.46	20.46
***Water tariff* 1 EURO / m^3**					
0	0	43.6	43.6	0	43.6
10	4.36	39.24	39.34	1.88	41.12
20	8.64	34.88	36.18	3.76	38.58
30	13.08	30.52	36.16	5.64	36.16
40	17,44	26.16	33.68	7.52	33.68
45	19.6	24	32.46	8.46	32.46

Figure 2: Exploitation costs depending on the water loss reduction degree and water tariff



4.Conclusions

(1) WATER SUPPLY SYSTEMS ARE IN A DEEP NEED OF REHABILITATION DUE TO THE LARGE AMOUNT OF LOST WATER; SINCE IN ROMANIA THERE ARE ONLY FEW TOWNS THAT HAVE A MONITORING SYSTEM INSTALLED, THE REAL WATER LOSS LEVEL CANNOT BE PRECISELY ESTIMATED BUT THERE ARE INDICATIONS THAT THIS MIGHT BE AROUND 20-50%.

(2) Since a lot of water supply systems are old they have already reached a stage when they need to be rehabilitated. The aim is to establish the limit value of water losses in order to get maximum results at a minimum financial input.

(3) From the data that we used we can once again see the importance of having correct and accurate information:

a) a dynamics of water consumption;

b) accurate values of the costs for a good system exploitation (costs needed for a continuous leak detection, maintaining a database with the data from the rehabilitation of pipes, costs of rehabilitation, etc).

(4) Looking at the costs used for this simplified application (without taking into consideration the variation in time of all costs involved in network rehabilitation) it can be obtained a rational solution from the economical point of view. In order to get precise results, more accurate values need to be used. Also, since the water tariff is set for the entire water network, a direct connection is set between the rehabilitation of a particular water supply system and the whole network.

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