Research Article

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The Need For Optimization of Water Supply Networks to Enable Rational Use of Water Supply Facilites

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Abstract

The need for water network optimization in recent times is increasingly being indispensable as a necessary measure for rational use of existing natural resources that are already experiencing the effects of climate change, reducing the water resources' savings. There are several methods for optimizing water supply networks, but as the most comprehensive way of optimizing this paper, the technical parameters of the main elements in each water supply system have been optimized. Pumping stations (installed capacity), supply pipelines (pipeline diameters) and reservoirs (volume of reservoirs) are optimized in the optimization of the water supply networks. The results clearly indicate the need to optimize the water supply networks.

Keywords: Pumped Stations, Pumped Stations, Inlet Pipes, Tanks, Operated Time of Pumped Stations.

Introduction To The Problem

Water supply systems have been increasingly affected by climate change impacts in recent years, which have a negative impact on the degree of savings in the source areas from which urban centers are supplied with water. Whether it is surface water or groundwater, the problem of reduced savings is the same and is constantly present.

One of the ways to successfully tackle water supply problems is to give greater emphasis to the rational use of existing source areas by protecting them from all kinds of pollution and by drastically reducing water losses in the distribution network of water supply systems. Reducing water losses is possible by strictly controlling the production (rational use) of water and the distribution of water to consumers in water supply systems.

One of the methods for rational use of available water sources is optimization of the operation of the water supply networks themselves, where the largest losses of water are actually recorded in the water supply systems.

The optimization of the water supply networks should contribute to the maximum utilization of the existing capacities of the water supply systems on the one hand, while the maximum utilization of the capacities of the water supply systems on the other hand should be achieved with minimal exploitation costs (depreciation of facilities and electricity consumption) [1].

There are several methods to optimize the operation of the water supply networks, but the most acceptable and technically sound solution is to optimize the technical parameters of the main elements of each water supply system, and these elements are:

1. Pumped Stations, whether they are pumped stations located on waterways or pumped stations located within the water supply network.
2. Pressure pipes located between water intakes and reservoirs inside the water supply networks.
3. Tanks for storing the water needed for 24-hour water level imbalances.

Using the most up-to-date software solutions, we obtain the required optimal values of the main elements of the water supply systems. Those optimal values are the following.

1. For Pumped Stations, the optimum value is the installed capacity of the N pumps themselves expressed in KW.
2. For Pressure Pipes, the optimum value is the diameter D of the cross-section of pipelines expressed in mm.
3. For Tanks, the optimum value is the volume W of the useful tank space expressed in m3.

The optimization of the water supply networks is possible only with the help of software packages that can simultaneously optimize a number of parameters in different operating conditions of the water supply networks.

By applying the Optimal Zone software package developed in the Visial Fox Pro 6 software as part of the overall Visial Studio 6 software package, the optimal values of the main elements of the water supply networks are obtained at various operating conditions (timing and end of pumping station operation).) and in different field configurations of the water supply networks [2]. The optimization of the technical parameters of the main elements of the water supply systems depends on several inputs, which can generally be divided into two parts. These data are as follows:

Data to be provided in advance such as [1].

- Number of inhabitants Nk in the settlement being analyzed.
- Water supply standard Qo (l / day / h), which actually determines the required water consumption in the settlements.
- The volume of water W (m3), which should be distributed 24 hours a day in the settlement and 365 days a year.
- High and low tariff electricity prices (expensive and cheap electricity daily and annually).

Data to be determined by SEO itself such as [1].

- The coefficients of daily and hour inequalities a1 and a2.
- Optimal installed power of the pumped stations in the water supply network.
- Optimal size of the transverse section of the diameters of the ducts.
- Optimum tank volume volumes in the water supply network.
- Optimal operation time of the water supply networks.

Optimizing the technical parameters of the main elements in the water supply systems is only possible by precisely defining the time range of start of pumping stations and defining the end point of pumping stations.

The software package determines the time range of operation during the 24-hour operation ie the operation of the main elements in the water supply systems. The time range of the operation of the water supply networks actually determines the optimal values that are interdependent, because in which time the main elements of the water supply system will operate, the success and comprehensiveness of the optimization of the technical parameters of the main parameters will depend (, drainage pipes and tanks) in a water supply system.

Research Methods And Materials

To analyze the adopted method of optimization of water supply networks, it is necessary to define the technical conditions through which the optimization will be performed. The technical conditions need to be compared to each other in order to obtain reliable results from the performed optimization of the water supply networks.

When designing and optimizing the values of the technical parameters of the main elements of the water supply systems, various schemes of the water supply networks are provided with the layouts of the main elements of the water supply systems. The schemas given are identical, which enables the comparison of the results obtained.

When developing hydraulic simulations to calculate the optimum values of the technical parameters of the main elements in the water supply systems disposition of tanks behind the settlement. Also, the most striking way of optimizing the operation of the water supply networks is the zoning of the water supply networks according to the height criterion, ie zoning according to the geodetic difference between individual points in the water supply networks.

The optimization of the water supply networks is equally applicable for branch water supply and circulation water networks.

By applying the Zone Optimizer software package, results are obtained that treat water supply in zoned water supply networks in the time range of 24 hours to 1 hour over a 24-hour period. The software package itself also optimizes the installed power of the pumped stations, the diameters of the pressure pipelines and the volumes of the tanks. The results of three schemes for water network optimization will be presented in the continuation of this research paper. The schemes considered for the water supply systems are a one-zone zoned system, a two-zone zoned system and a three-zone zoned system.

Figures 1 and 2 show the baseline and longitudinal profile of a single-zone water supply scheme analyzed for optimization.

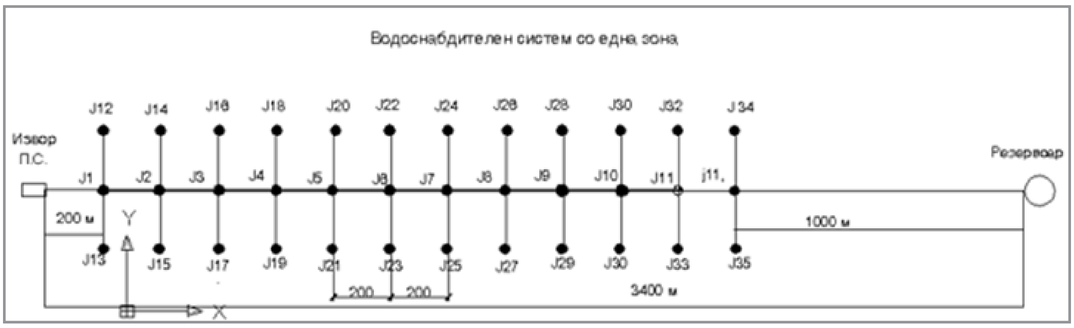


Figure 1: Single zone water supply scheme scheme [1]

Figure 2: Single zone water supply scheme, longitudinal profile

Table 1 presents the spreadsheet of the optimization results obtained for a single-zone water supply scheme. From the table 1 itself, one can immediately see the difference in the diameters of the discharge pipes, depending on the time range of operation of the pumped station in the water supply network from 24 hours to 1 hour. Other values relate to total rearmosting costs and electricity costs. The last one a column is the sum of the depreciation and the cost of electricity consumed.

Table 1:

	Zones	Hours	Q	dh	D	kt	ke_e	k
1	1	1	0,71	38,70028	600	7856257,16	271777,32	8128034,48
1	1	2	0,355	25,91119	500	5822592,23	245780,49	6068372,72
1	1	3	0,23667	38,66481	400	4799780,12	271705,23	5071485,35
1	1	4	0,1775	45,02785	350	4252662,61	284639,6	4537302,21
1	1	5	0,142	28,81782	350	3935331,77	251688,9	4187020,67
1	1	6	0,11833	46,48776	300	3579941,51	287607,21	3867548,72
1	1	7	0,10143	34,15427	300	3337915,33	522656,52	3860571,85
1	1	8	0,08875	26,14936	300	3137380,93	490262,57	3627643,5
1	1	9	0,07889	20,66122	300	2960806,61	468053,39	3428860
1	1	10	0,071	45,52353	250	2660294,42	568665,22	3228959,64
1	1	11	0,06455	37,62276	250	2505969,74	536692,65	3042662,39
1	1	12	0,05917	31,61357	250	2345174,42	512374,89	2857549,31
1	1	13	0,05462	26,937	250	2192010,29	493449,96	2685460,25
1	1	14	0,05071	23,22629	250	2024712,21	240322,8	2265035,01
1	1	15	0,04733	20,23268	250	1879717,11	234237,58	2113954,69
1	1	16	0,04438	60,8628	200	1630820,64	316827,88	1947648,52
1	1	17	0,04176	15,75209	250	1635772,61	448187,28	2083959,89
1	1	18	0,03944	14,05047	250	1556716,72	441301,25	1998017,97
1	1	19	0,03737	43,16032	200	1358776,34	559101,87	1917878,21
1	1	20	0,0355	38,95219	200	1315955,57	542072,57	1858028,14
1	1	21	0,03381	35,33079	200	1316728,26	527417,6	1844145,86
1	1	22	0,03227	32,19189	200	1360299,17	258547,5	1618846,67
1	1	23	0,03087	29,45345	200	1385167,58	252980,98	1638148,56
1	1	24	0,02958	27,05013	200	1411414,71	248095,66	1659510,37

The difference in the diameters of the pressure pipes is from the initial D = 200 mm for 24 hour pump operation to the final D = 600 mm for 1 hour pump operation, with the water volume being constant indicating that no matter the time range of pump operation required volume of water for 24 hours will be distributed to consumers. Figures 3 and 4 show a schematic overview of a two-elevation water supply network.

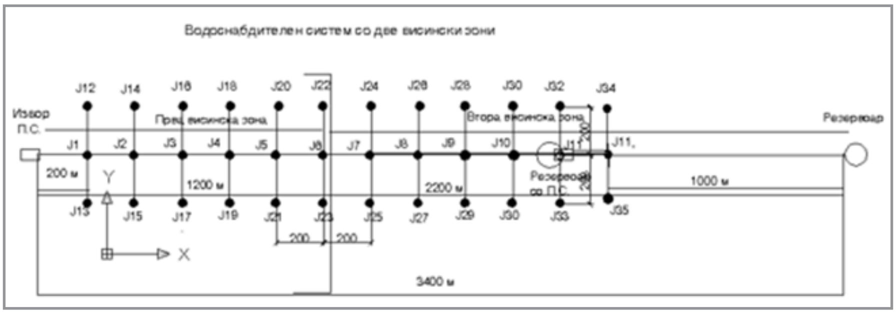


Figure 3: Scheme of two-zone water supply network, basis

Figure 4: Two-zone water supply scheme, longitudinal profile

Table 2 presents the spreadsheet of the optimization results obtained for a two-zone water supply scheme. From Table 2 itself, one can immediately see the difference in the diameters of the pressure pipes, depending on the time range of operation of the pumped station in the water supply network from 24 hours to 1 hour. Other values relate to total rearmosting costs and costs of electricity consumed. The last column is the sum of the depreciation charges and the costs of electricity consumed. For a two-zone water supply scheme the difference in the diameters of the pressure piping ranges from the initial D = 150 mm for 24-hour pump operation to D = 500 mm for one-hour pump operation, with the volume of water distributed constant indicating that , regardless of the pump's running time, the required volume of water for 24 hours will be distributed to consumers.

Table 2

Case	Zones	Hours	Q	dh	D	kt	ke_e	k
2	2	1	0,36	9,40455	500	6695434,8	139068,87	6834503,69
2	2	2	0,18	16,343	350	4992802	160454,21	5153256,21
2	2	3	0,12	16,87288	300	4299051,3	162087,37	4461138,64
2	2	4	0,09	9,49099	300	3925973,4	139335,31	4065308,7
2	2	5	0,072	16,52291	250	3571413,3	161008,72	3732422,04
2	2	6	0,06	11,47424	250	3344406,9	145447,98	3489854,87
2	2	7	0,0514	8,43006	250	3131317,8	270878,3	3402196,05
2	2	8	0,045	6,45426	250	2946199,4	258754,97	3204954,35
2	2	9	0,04	17,4541	200	2668490,8	326249,18	2994740,01
2	2	10	0,036	14,13782	200	2487945,4	305900,73	2793846,15
2	2	11	0,0327	11,68415	200	2340707,2	290845,18	2631552,37
2	2	12	0,03	9,81793	200	2183074,9	279394,2	2462469,06
2	2	13	0,0277	8,36558	200	2031711	270482,64	2302193,62
2	2	14	0,0257	7,21317	200	1864570,4	132314,73	1996885,16
2	2	15	0,024	6,28348	200	1720533,3	129449,27	1849982,6
2	2	16	0,0225	5,52259	200	1531982,6	171632,34	1703614,93
2	2	17	0,0212	4,89198	200	1479666,6	249168,91	1728835,55
2	2	18	0,02	4,36353	200	1402942,6	245926,36	1648868,93
2	2	19	0,019	19,30862	150	1241319,7	337628,36	1578948,07

2	2	20	0,018	17,42603	150	1200069,4	326076,93	1526146,32
2	2	21	0,0171	15,80592	150	1202890,3	316136,07	1519026,32
2	2	22	0,0164	14,40168	150	1249176,2	154470,76	1403646,98
2	2	23	0,0157	13,17658	150	1276381,8	150694,83	1427076,59
2	2	24	0,015	12,10141	150	1304961	147380,99	1452341,94

Figures 5 and 6 show a schematic overview of the three height zones.

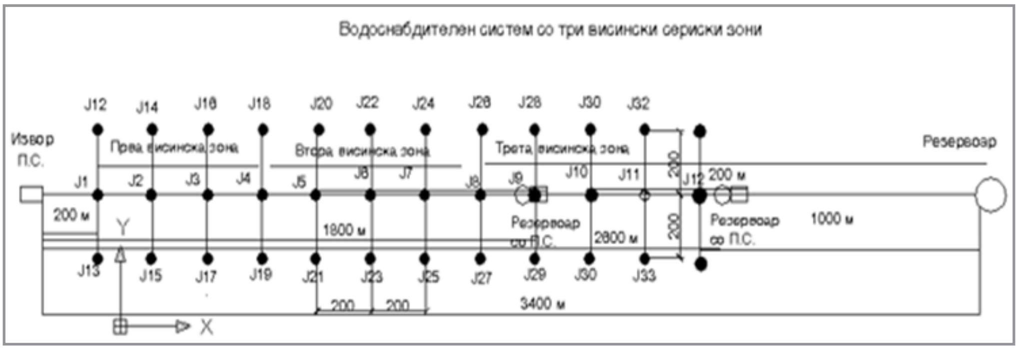


Figure 5: Scheme of three-zone water supply network, basis

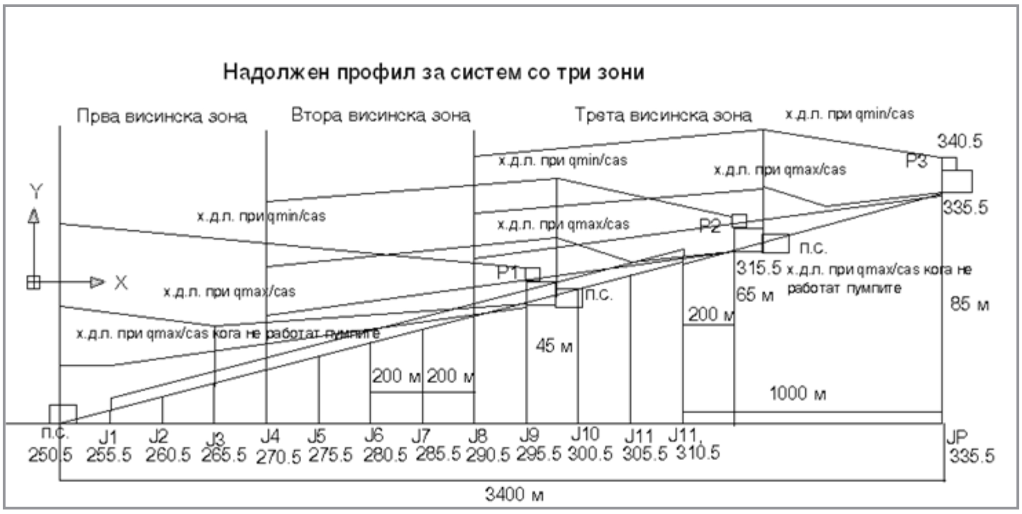


Figure 6: Three-zone water supply scheme, longitudinal profile

Table 3 shows the spreadsheet of the optimization results for a three-zone water supply scheme. From the table 3 itself, one can immediately see the difference in the diameters of the pressure pipelines, depending on the time range of operation of the pumped station in the water supply network from 24 hours to 1 hour. Other values relate to total rearmosting costs and electricity costs. The last column is the sum of the depreciation charges and the costs of electricity consumed. For a two-zone water supply scheme the difference in the diameters of the discharge piping ranges from the initial D = 125 mm for 24-hour pump operation to D = 400 mm for one-hour pump operation, with the volume of water distributed constant indicating that , regardless of the pump's running time, the required volume of water for 24 hours will be distributed to consumers.

Table 3

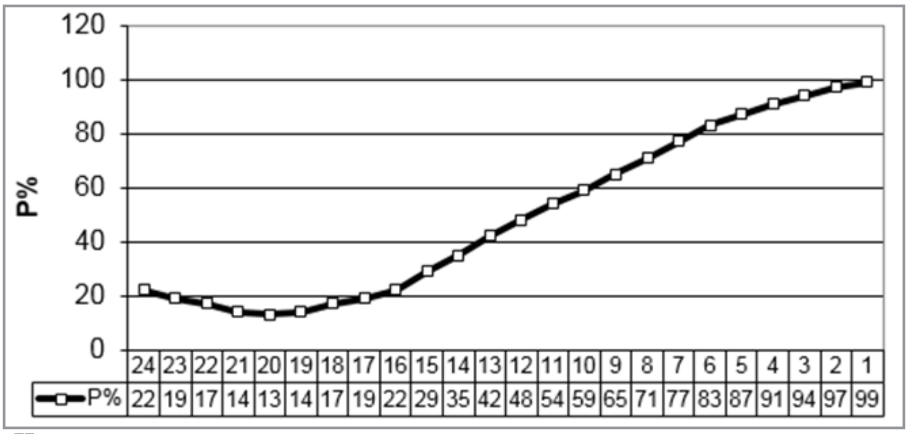
Case	Zones	Hours	Q	dh	D	kt	ke_e	k
3	3	1	0,24333	9,61736	400	6243144,95	117491,57	6360636,52
3	3	2	0,12167	11,56322	300	4830194,38	124242,6	4954436,98
3	3	3	0,08111	13,97948	250	4228112,14	125676,05	4353788,19
3	3	4	0,06083	7,86346	250	3839976,36	111406,52	3951382,88
3	3	5	0,04867	5,03261	250	3591553,58	101585,07	3693138,65
3	3	6	0,04056	11,96154	200	3321317,8	125624,56	3446942,36
3	3	7	0,03476	8,78807	200	3091715,83	228173,84	3319889,67
3	3	8	0,03042	6,72836	200	2895823,65	213947,58	3109771,23
3	3	9	0,02704	5,31624	200	2719788,14	204194,11	2923982,25

3	3	10	0,02433	4,30615	200	2556258,19	197217,49	2753475,68
3	3	11	0,02212	3,5588	200	2421131,02	192055,6	2613186,62
3	3	12	0,02028	14,74358	150	2253148,07	204430,26	2457578,33
3	3	13	0,01872	12,56258	150	2030773,24	254244,15	2285017,39
3	3	14	0,01738	10,83202	150	1853465,6	121705,75	1975171,35
3	3	15	0,01622	9,43589	150	1701763,34	116861,97	1818625,31
3	3	16	0,01521	8,29326	150	1553934,01	112897,69	1666831,7
3	3	17	0,01431	7,34628	150	1450507,01	218215,5	1668722,51
3	3	18	0,01352	6,5527	150	1370396,52	212734,28	1583130,8
3	3	19	0,01281	5,88109	150	1313221,18	208095,52	1521316,7
3	3	20	0,01217	5,30769	150	1278676,36	204135,04	1482811,4
3	3	21	0,01159	4,81423	150	1287341,67	200726,75	1488068,42
3	3	22	0,01106	12,12075	125	1303979,37	126176,94	1430156,31
3	3	23	0,01058	11,08969	125	1330926,16	122599,72	1453525,88
3	3	24	0,01014	10,1848	125	1359377,69	119460,26	1478837,95

From the three table views, it can be seen that the zoned water networks fully correspond to the proposed concept of optimization, where different zoning schemes obtain different diameters of the transverse sections of the pressure pipelines.

In addition to the optimization of the pressure pipelines, the optimization is also done for the volumes of the tanks analyzed in the software package optimization. Figure 7 gives a graph of the change in the percentage of coverage of maximum daily water consumption.

Percentage of maximum coverage daily water consumer



Hours

Figure 7: Percentage of coverage of daily water consumption

The optimization gives the percentages of coverage of maximum daily water consumption, by which the tanks in the water networks are dimensioned. The optimum percentages are directly dependent on the time range of operation of the pumped stations.

By processing the data obtained from the software, it is concluded that the optimum percentages of maximum daily consumption coverage are obtained when the pumping stations stop operating at midnight, ie 0.0 pm.

For every other time slot in the operation of pumped stations, much greater values of coverage of maximum daily consumption are obtained, thereby obtaining much larger volumes of reservoirs in the water supply networks, which only burden the operation of the water supply networks. [3].

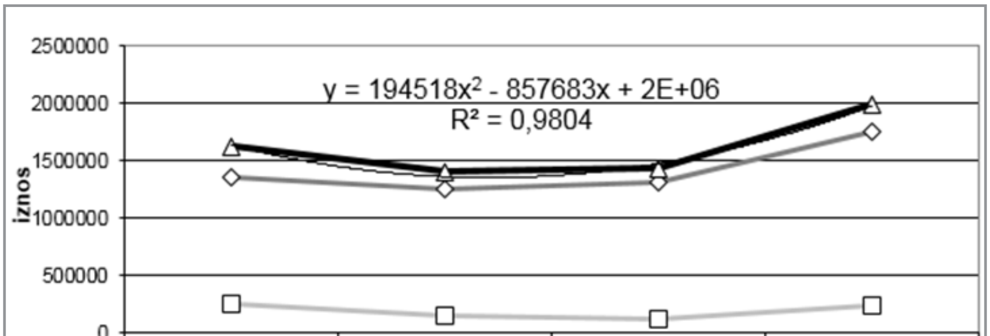
From the graphical representation of Figure 7, it can be seen that for the pump operating time range from 24 hours to 16 hours the percentage of maximum daily consumption coverage is symmetrical and ranges from 22% for 24 hours to 22% for 16 hours with Minimum value of 13% for 20 hours pump operation. For pumps with a running time of less than 16 hours the percentage of coverage of maximum daily consumption increases dramatically reaching the maximum value of 99% for 1 hour pump operation. [4].

The installed power of the pumping stations is also directly correlated with the duration of pump operation, but also with the time range in which the pumps operate.

When operating the pumps at 04 o'clock in the morning, the lowest values of the installed capacity of the pumps are obtained, which directly affects the reduced consumption of electricity in the water supply networks[5].

Optimization of pumping stations, ducted pipelines and reservoirs in zoned water supply networks gives optimum result for zoning of two-zone water supply networks and pump operation of 22 hours starting pump operation at 02 hours. Figure 8 gives a graphical interpretation of the total costs of the optimized water network [6].

Optimization by heights for 22 hours



	1	2	3	4
Kt	1360299,17	1249176,22	1303979,37	1758168,98
Ke_e	258547,5	154470,76	126176,94	234857,67
K	1618846,67	1403646,98	1430156,31	1993026,65

Zones

Figure 8: Height optimization for 22 hour pump operation

The following conclusions can be drawn from a comprehensive analysis.

Conclusions from the Implemented Analysis

By applying the Optimized Zone software package developed in Visial Fox Pro 6 as part of the overall Visial Studio 6 software package, the following results are obtained from the analyzed zoning schemes.

1. The analysis of the optimization of the water supply networks is performed on the zoning of the water supply networks through three cases of one-zone water supply system, two-zone water supply network and three-zone water supply network.
2. The optimization of the water supply networks is carried out on the main elements of the water supply systems (pumping stations, supply pipelines and reservoirs).
3. The optimization refers to the technical characteristics of the main elements of the water supply systems, such that the pumped stations optimize the installed capacity N (Kw), the intake pipelines cross section D (mm) and the tanks volume W (m3).
4. Optimizing precisely determines the time range of operation of pumped stations. The overall optimization of the water supply networks depends on the length of operation and the time of day the pumps operate.
5. The zoning of the water mains results in much smaller dimensions of the diameters of the inlet ducts and the volumes of the tanks.
6. The installed capacity of pumping stations is also much lower in zoned water networks than in non-zoned water networks.

The optimization of the water supply networks results in maximum utilization of the water supply capacities, with minimal operational costs such as depreciation and electricity costs.

References

1. Srbinoski, S. (2005). Optimal zoning of water supply networks (Master's thesis). Skopje.
2. Suvag Waterworks. (2006). Presentation. Tivat, Germany.
3. Srbinoski, S. (2014). Production, consumption and water losses in the Skopje water supply system. Macedonian Committee for Large Dams, Struga.
4. Srbinoski, S. (2014). Water supply norm Qo (l/day/h) in the Skopje water supply system. Macedonian Committee for Large Dams, Struga.
5. Srbinoski, S. (2015). Modern methods in the maintenance of water supply networks. Macedonian Committee for Large Dams, Skopje.
6. JP Vodovod i Kanalizacija Skopje. (2012). Development strategy of JP Vodovod i Kanalizacija Skopje for the period 2012–2042. Skopje.