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Research paper

Challenges of Energy Saving in the Wastewater System

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Abstract

The purpose of this study is to determine a number of energy-saving measures in the wastewater system. The methodological basis of this study is the General scientific dialectical method of cognition, under research which the object is studied as a dynamic system in the process of its development. Formation of the main water disposal system directions development was carried out on the basis of dialectical, historical, mathematical, statistical and systematic methods. Methods of comparison, analysis and synthesis, induction and deduction were used in the study and generalization of scientific and practical developments. Also, the study is based on legal and economic instruments, the development of research institutions and academic economists. The study identified the main components of the structure of the wastewater tariff. The structure of water utilities tariffs in 40 organizations of in different regions of Ukraine is analyzed. It is revealed that the specificity of pricing requires non-traditional approaches to the analysis and processing of primary statistics. That is why iterative approaches to tariff modeling have been applied. This made it possible to form a model of factors affecting the formation of the cost of wastewater disposal. Taking into account the constant tendency of increasing the cost of electricity, which is one of the components of the cost of services, the possibility of introducing energy-saving measures was considered. Thus, it was proposed to replace the old pumping stations with new more economical ones. A comparative analysis of the systems characteristics and calculating the planned savings from the reconstruction of the pumping station were presented. The scientific novelty of the results is in the development and calculation of the economic effect of the introduction of energy-efficient pumping stations, which will contribute to the preservation of tariffs for wastewater services.

Keywords: *energy, energy saving, drainage, housing and communal services, sewerage*

1. Introduction

Energy, namely electric power, is one of the most important products in an industrial society. It is investigated that the average income, duration and standard of living are important factors. They are related to electricity consumption per capita in a particular region or in the country as a whole. Like all natural resources, energy resources are being depleted. That is why it is important to save as much energy as possible. There is no alternative to the energy saving policy in Ukraine. Energy conservation should become a sub-sector of industrial energy and help to save a significant amount of energy. Under these conditions, the implementation of energy saving policy becomes a strategic line of economic and social development.

If we talk about an ordinary citizen of Ukraine, the largest share of energy used is due to the number of consumed housing and communal services. This is a huge segment where you can save a lot of resources. One of these areas is energy saving in the wastewater system. It is worth noting the negative combined effect of increasing the concentration of pollutants in wastewater. They are accepted into the Sewerage system, has an insufficient level of funding for repair and restoration work and maintenance of Sewerage networks and structures. Underfunding the planned replacement of depreciated networks, reducing the strength of the sewers due to gas corrosion contributes further to an increase of wear of networks and structures. All this already today leads to the destruction of sewers. In the future, this will lead to the need of increasing the cost of repairs by almost 2-3 times in comparison to the current cost of repair work. In fact, this will lead to the reconstruction of the Sewerage network and sewage treatment facilities.

2. Main body

The problems of energy saving in the wastewater system have a long history and are considered in many studies. The use of energy-saving technologies in the process of water disposal is reflected in the works [1 - 16, 19].

In particular, in [1] the author proves that the pump storage technique enables the using of cheap thermal electricity at periods of low demand to restore water resources that can be used to generate electricity at periods of peak demand. When the thermal plant and the hydro plant are managed by the same operator, the two plants are used in an efficient way to substitute low cost fuel for high cost fuel.

In [2], the author observed that to operate centrifugal pump against higher discharge pressure and to achieve specific speed for delivering the water, the level of irradiance required is quite high. Therefore, by knowing the operating pressure this problem may be minimized by using energy storage devices like battery or supercapacitor operated in parallel with the SPV module. Here is the need to select a proper configuration of solar PV water pumping system (SPVWPS) using energy storage devices for the economic application. Therefore, a new approach is made towards studying different configurations of 7SPVWPS with battery and supercapacitors under varying discharge pressure and evaluate the performance parameters.

Problems of management of water disposal systems were considered in [3], where the author highlights, the increasing penetration of fluctuating Renewable Energy Sources (RES), particularly in small isolated power systems. It is raising some problems in the operational management of the system. The simpler way to solve the problem is to perform RES curtailment, but this is not the right decision from an environmental point of view. In this context, the alternative storage is becoming more and more a cost-effective option.
The other essential problem of rehabilitation or expansion of their drainage systems was studied in [5], where the author proved that, increasing rainfall intensities related with climate change, uncontrolled growth and excessive waterproofing of cities causes that original drainage networks design have became insufficient. Inadequate drainage networks make it necessary to develop rehabilitation models of existing networks. This models should be compatible with them. This paper presents an optimization methodology to generate different solutions for the existing network improvement.
In [6], the author also paid attention to the problems of underground sewerage. Author of an improved subsurface drainage with characteristics of less land occupied and reasonable flow rate drained was presented to overcome the disadvantage of small flow rate of conventional subsurface pipe drainage and adapt to the new challenge of agricultural drainage. Based on soil column experiment, the performance of improved subsurface drainage was discussed in saturated and unsaturated soil. During the experiment, five factors of filter width, soil medium, surface ponding depth, outflow condition and groundwater depth were considered.
The experience of energy-saving water disposal systems implementation in different countries of the world is considered in the works of the authors [4, 7, 10, 11, 14]. According to the authors, it is a rational process of water distribution management that will contribute to the control of local interventions, monitoring of variables based on Scada technology, alerts and events in water supply and sanitation systems. In work [10] the analysis of 40 state municipal enterprises is carried out. Six explanatory factors (unprofitable water, population density, gross domestic product per capita, average maximum temperature, state mannequins and groundwater extraction) were chosen to explain the differences in the effect of technical inefficiency in public municipal waters in South-East Asia. The impact of water supply and sanitation on energy consumption in China is considered in [11]. The interdependence of environmental protection and economic development through energy consumption, emissions of pollutants and economic costs is established. In [14] administrative and legal mechanisms in Europe and the USA are considered. Comments are provided on the regulatory authorities and their responsibilities, including environmental management and pollution, as well as the experience of privatization of the UK water sector.
Water and energy are essential for human existence, and its rational use should be encouraged. According to the literature review, water consumption directly affects energy consumption and are inseparably linked resources. The energy to water part of the water/energy nexus, increasingly highlighted as an important issue for future planning and strategic policy considerations. Joint consideration of both water/energy domains can identify new options for increasing overall resource use efficiency. It is noted that they are an expensive source. This emphasis is made in [8, 9, 16].
Features of urban planning and construction of large technological networks are considered in [12]. They aim to integrate the urban region on the basis of circulating "modern ideals" of ubiquity and standardization of infrastructures. However, the centralized provision of infrastructure remains unstable and spatially uneven.
The main significance factors which affect the reliability of pipelines were detected and analyzed. The analyses of the pipelines' material as well as the operation of water networks on undermined territories were given in[13].
According to the author [15] the main goal is to minimize costs and maximize security of supply and sanitation. The latter is evaluated using reliability, maximum failure duration, maximum vulnerability, and reliability. Efficiency represents the performance of UWSS in various likely future scenarios, which includes the implementation of climate change and consumer demand. There are compensations between cost and security of supply for solutions that use desalination and garbage collection to increase water supply. However, the use of rainwater tanks is undesirable.
Energy saving in the drainage system is directly dependent on measures that reduce the consumption of electricity in the water intake, purification, processing, supply and distribution. Therefore, it is necessary to first consider the existing mechanism of tariffs formation for water disposal services and identify the dependence of the components cost.
It should be noted that new tariffs for centralized water supply and drainage have been established in Ukraine since December 17, 2017. This is stated in the resolution No. 1343 of the National Commission [17], which carries out state regulation in the fields of energy and utilities of November 2, 2017. Thus, the tariff structure for 40 water utilities in different regions of Ukraine was restored. Detailed information on the size and structure of the wastewater tariff is given in table 1 – 2.
Table 1 – 2 shows the main economic indicators used in the analysis of the structure and size of tariffs for wastewater services. It should be noted that pricing specifics require non-traditional approaches to the analysis and processing of primary statistics. As well as the use of an iterative approach to tariff modeling.
In particular, we consider it appropriate:
First, to conduct a detailed analysis of the components of "operating expenses", which represent the actual total cost. Thus it is necessary to allocate separately components of material and other expenses, namely: fuel, the electric power, purchased heat, purchased water, other material costs, and also "summary labor costs". It is also impossible to ignore the presence of the "financial and other operating expenses" article.
Secondly, to build a regression dependence of the resulting indicator (cost of services rendered – costs of operating activities per unit of service on its components). Third, to analyse the nature and dynamics of the ratio between the total cost and the actually established weighted average tariffs per unit of wastewater services. Fourth, to find out the pattern of changes in the ratio between the tariff and the total cost of services; to determine its expected dynamics for the future.

Table 1: Major economic indicators analysis of cost structure and tariffs size for services of water disposal and their symbols, 2018

№	Indicators / enterprises	Water is given, thousand m3	Average weighted tariff, UAH / m3	Total income, thousand UAH	Total cost, thousand UAH	Operating expenses, thousand UAH
1	2	3	4	5	6	7
	Legend	**V**	**t**	**INC**	**S**	**S1**
1	TOV "Infoks"	55568,7	4,5	311184,3	311184,3	292123,2
2	PAT "AK Kyyivvodokanal"	187900,0	4,2	1000711,3	974316,2	516000,2
3	KP "Irpinvodokanal"	3716,7	9,2	34087,1	33679,7	27318,6
4	KP "Vodokanal"	3088,0	7,8	24191,8	24191,8	19089,9
5	KP "Aul′s′kyy vodovid"	31,7	4,1	129,3	129,3	107,9
6	KP "Dniprovodokanal"	58015,0	3,5	242651,2	244540,0	225581,6
7	TOV "Bilotserkivvoda"	6916,4	9,8	67431302,0	63894,9	57553,5
8	KP "Berdyans′kvodokanal"	3501,4	9,3	32551,8	32551,8	27342,4

9	KVP "Mis′kvodokanal"	17612,3	5,0	88075,9	87825,7	57931,6
10	KP "Novomoskovsk Vodokanal"	1743,4	8,4	14619,4	14619,4	11895,0
11	KP "Umanvodokanal"	2002,6	8,9	17906,9	17998,5	14439,5
12	TOV "Taun servys"	3966,4	5,8	22843,3	22257,8	16938,8
13	KP "Brovaryteplovodoenerhiya"	4620,8	6,4	30 440,002	30440,0	27949,5
14	DMP VKH "Dnipro-Zakhidnyy Donbas"	12812,8	7,5	69461,1	69461,1	52401,2
15	KP "Kryvbasvodokanal"	51775,0	4,7	245165,8	245165,8	193089,8
16	KP "Pavlohrads′ke vyrobnyche up-ravlinnya vodoprovidno-kanalizatsiynoho hospodarstva"	3336,6	7,6	25345,3	25289,1	17428,0
17	KP "Chernihivvodokanal"	13540,5	6,8	91689,2	69189,6	60487,5
18	OKVP "Dnipro-Kirovohrad"	11 899,00	8,0	94611,3	92468,2	52895,3
19	KP "Zhytomyrvodokanal"	12763,9	6,1	77791,4	77492,4	59285,7
20	KP "Bakhmutvoda"	2574,6	6,0	16591,0	16591,0	13503,1
21	KP "Vyrobnyche upravlinnya vodoprovidno-kanalizatsiynoho hospo-darstva mista Uzhhoroda"	5669,6	5,4	30372,8	30331,4	22825,6
22	KP "Nikopol′s′ke vyrobnyche upravlinnya vodoprovidno-kanalizatsiynoho hospodarstva"	5093,3	8,0	40820,2	40820,2	25089,0
23	KP "Cherkasyvodokanal"	16987,1	3,7	83812,6	76833,7	70436,5
24	KP "Khmel′nnts′kvodokanal"	12465,0	5,5	68286,4	67405,9	44793,9
25	KP "Vinnntsyaoblvodokanal"	17500,0	3,8	66666,8	64307,8	44864,0
26	Kp "Luts′kvodokanal"	11477,8	4,6	52988,3	52768,2	34350,5
27	KP "Poltavavodokanal"	14897,5	5,0	74894,6	74894,6	55538,1
28	OVKP "Rivneoblvodokapal"	12314,9	3,7	65706,3	65706,3	41008,9
29	KP "Chernivtsivodokanal"	10 132,65	3,8	38285,6	38314,0	24225,3
30	KSP "Lysychans′kvodokanal"	3069,5	5,4	18190,8	17986,4	13791,3
31	KP "Kharkivvodokanal"	103800,0	3,1	412551,7	401194,5	209105,2
32	KP "Kremenchukvodokanal"	14025,0	5,8	80911,5	68883,0	48471,2
33	KP "VODOKANAL m. Zaporizhzhya"	45450,6	3,4	186501,0	187191,8	117102,5
34	KP "Mykolayivvodokanal"	21442,5	5,1	109431,3	107453,8	70534,2
35	KP "Mis′kvodokanal" m.Sumy	12024,8	5,0	59652,4	60596,6	45422,4
36	KVP "Kramators′kyy vodokanal"	5644,4	5,1	28868,6	28679,3	14054,8
37	KP "Mis′kteplovodenerhiya"m. Kam″yanets′-Podil′s′kny	5030,8	6,2	31222,5	30382,0	23076,6
38	KP "Ivano-Frankivskvodoekotekhprom"	12854,4	7,2	92949,0	72160,7	40755,0
39	KP "Lvovvodokanal"	45673,9	1,3	154481,3	138219,8	93980,6
40	KP "Drohobychvodokanal"	7053,0	2,7	24324,4	21773,3	13617,8

Table 2: Major economic indicators analysis of cost structure and tariffs size for services of water disposal and their symbols, 2018

№	Including				Amortization , UAH thousand	Other transaction costs, UAH thousand	Financial and other expenses, UAH thousand
	Electricity	Purchased water	Other material expenses	Consolidated labor costs, UAH thou-sand			
1	8	9	10	11	12	13	14
	x1	**x2**	**x3**	**x4**	**x5**	**x6**	**S2(x7)**
1	80456,5	0,0	63371,6	148295,1	6833,3	10974,2	1253,6
2	244173,2	0,0	98835,2	172991,8	404516,0	26115,3	27684,8
3	14584,5	0,0	9052,0	3682,1	4741,2	1086,5	533,4
4	8192,5	0,0	8082,5	2814,9	2662,7	1004,8	1434,5
5	40,0	0,0	43,0	25,0	16,9	4,0	0,5
6	98904,5	0,0	65778,9	60898,2	7177,7	11575,5	205,3
7	15474,1	0,0	12250,1	29829,3	2470,0	1596,1	2275,2
8	12770,7	0,0	9609,7	4962,0	3662,1	835,1	712,2
9	31109,0	0,0	19883,9	6938,7	22279,6	5330,7	2283,9
10	2622,4	0,0	6141,0	3131,6	1168,9	958,2	597,4
11	7373,9	0,0	4945,2	2120,4	2149,2	736,1	673,7
12	9477,3	0,0	4109,2	3352,3	2527,7	1096,7	1694,5
13	6789,7	0,0	15659,3	5500,4	865,1	1316,8	308,7
14	43652,3	0,0	5767,6	2981,3	15183,0	1410,9	465,9
15	115569,0	0,0	47031,7	30489,0	40201,8	6638,6	5235,7
16	7851,1	0,0	7032,4	2544,5	6197,2	846,9	817,0
17	14747,2	0,0	19648,3	26092,1	3111,7	2917,4	2673,0
18	30339,6	0,0	15547,4	7008,4	28939,4	5608,2	5025,2
19	33947,6	0,0	18683,7	6654,5	13300,8	3873,2	1032,6
20	4373,7	0,0	3089,9	6039,5	1781,9	802,8	503,2
21	13342,9	0,0	6267,0	3215,7	5020,5	959,7	1525,5
22	15600,5	0,0	7562,9	1925,6	10604,9	2078,3	3047,9
23	42145,1	0,0	11970,4	16321,0	3500,8	1609,2	1287,3
24	27784,7	0,0	11240,0	5769,2	17537,5	3752,9	1321,6
25	28715,7	0,0	11570,9	4577,5	14391,6	3821,1	1231,0
26	19493,8	0,0	9314,4	5542,4	14957,9	2347,3	1112,5
27	23085,8	0,0	18137,6	14314,7	15345,4	2348,9	1662,2
28	28854,5	0,0	8251,1	3903,3	18808,1	3767,1	2122,2
29	10204,6	0,0	9508,2	4512,4	11290,1	2103,4	695,2

30	2839,1	0,0	8180,5	2771,6	2928,4	759,4	507,4
31	127397,1	0,0	55915,8	25792,4	161976,1	14868,6	15244,6
32	18602,5	0,0	18237,5	11631,2	14811,1	2359,7	3241,1
33	61723,9	0,0	30525,9	24852,7	53922,4	7705,6	8461,3
34	31709,4	0,0	25241,8	13582,9	27393,0	5112,4	4414,2
35	24452,8	0,0	13028,1	7941,6	12067,9	1591,9	1514,4
36	6038,0	0,0	5776,0	2240,7	11178,1	1448,9	1997,4
37	6939,0	0,0	10641,0	5496,6	2052,8	562,4	4690,1
38	11331,8	0,0	8961,4	20461,9	21150,4	4448,8	5806,4
39	66268,6	0,0	18977,5	8734,5	33442,1	6581,1	4216,0
40	7542,3	0,0	4234,7	1840,8	6229,1	1310,6	615,7

Fifth, build a working model for forecasting the cost of services based on the possibility of adjusting the individual cost elements. Sixth, to determine the most realistic projected cost indicators using the above model, based on the expected changes in the cost (price) of the main cost components (energy, wages). Seventh, calculate the likely size of the tariff for services for sanitation and for future periods under the three scenarios: 1. On the basis of the actual ratio of the current tariff in the analysed period and the total cost. 2. Based on the dynamics of the previous years in the ratio of tariffs and total cost. 3. "Optimal" tariff for water disposal services, defined by the principle of regulatory profitability from 5 to 12 %. In this case, the tariff calculations are based on VAT. Operating expenses S is calculated by the formula:

$$S = s_1 + s_2 = (x_1 + x_2 + x_3 + x_4 + x_5 + x_6) + s_2, \quad (1)$$

The coefficient of inclusion of the total cost to the tariff in the reporting period k_t is calculated by the formula:

$$k_t = \frac{INC_t}{S_t}, \quad (2)$$

The weighted average tariff for water disposal services T_t is calculated by the formula:

$$T_t = \frac{INC_t}{S_t} = \frac{S_t}{V_t} \times k_t, \quad (3)$$

The forecast tariff for water disposal services, defined in the basis of the actual ratio of the current tariff and the total cost of T_1° is calculated by the formula:

$$T_1^{\circ} = S^{\circ} \times k_t, \quad (4)$$

The forecast tariff for water disposal services, determined on the basis of the dynamics of the previous years in the ratio of tariffs and the total cost of °T_2° is calculated by the formula:

$$T_2^{\circ} = S^{\circ} \times k_{t+1}, \quad (5)$$

The "optimal" tariff forecast for water disposal services is determined by the principle of ensuring the minimum standard profitability T_3° and is calculated by the formula:

$$T_3^{\circ} = S^{\circ} \times k_{r1} \times k_{tax}, \quad (6)$$

The forecast "optimal" tariff for water disposal services is determined by the principle of ensuring the maximum normative profitability T_4° and is calculated by the formula:

$$T_4^{\circ} = S^{\circ} \times k_{r2} \times k_{tax}, \quad (7)$$

In table 3-4, a model of factors influencing the formation of the cost price is formed. With the help of the data Analysis package Excel, we build a correlation table and determine the main factors (x_I) that affect the formation of the cost price (S). They are:

- x_1-electricity;
- x_2-purchase water;
- x_3-other material costs;
- x_4-summary of labour costs;
- x_5 – amortization;
- x_6 – other transaction costs;
- x_7 – financial and other expenses.

Thus the array formed includes 7 factors of influence for 40 enterprises of water supply and sanitation of Ukraine, presented in table 3. According to the results of the analysis, the regression line was built (table. 5). As a result of the calculations, the following regression formula was determined:

$$S^{\circ} = 1,26 + 0,000001x_1 + 1,29x_3 + 0,94x_4 + 1,23x_5 + 1.51x_6 + 0,79x_7$$

Thus the array formed includes 7 factors of influence for 40 water supply companies, and so the analysis was the dependence of the main factors influencing the cost of tariffs for services of water disposal. According to the data of the tariff structure of enterprises, about 16 % of the tariff consists of the cost of electricity. It should also be noted that since December 28, the wholesale market price for electricity has been increased [18]. The rise in the price of electricity will occur in two stages – from January 1, it increased by 9.5%, and from April – by another 6.1%. This indicates that tariffs for water disposal will definitely need to be increased.
That is why a number of energy-saving measures should be introduced to preserve the existing tariffs and modernize the wastewater disposal process. Taking into account the specifics of the water supply and sanitation enterprises, it can be noted that almost all of them use a complete separate water disposal system in their work. This process is carried out by means of pumps.

Table 3: The scheme of data representation of the correlation analysis

№	s=S/V	x1	x3	x4	x5	x6	x7
1	5,6	1,45	1,14	2,669	0,123	0,197	0,023
2	5,185	4,394	0,526	0,921	2,153	0,139	0,147
3	9,062	0,078	2,435	0,991	1,276	0,292	0,144
4	7,834	2,204	2,617	0,912	0,862	0,325	0,465
5	4,077	0,013	1,355	0,787	0,532	0,127	0,016
6	4,215	3120,015	1,134	1,05	0,124	0,2	0,004
7	9,238	0,267	1,771	4,313	0,357	0,231	0,329
8	9,297	1,846	2,745	1,417	1,046	0,238	0,203
9	4,987	8,885	1,129	0,394	1,265	0,303	0,13
10	8,385	0,149	3,522	1,796	0,67	0,55	0,343
11	8,988	4,23	2,469	1,059	1,073	0,368	0,336
12	5,612	4,733	1,036	0,845	0,637	0,277	0,427
13	6,588	1,712	3,389	1,19	0,187	0,285	0,067
14	5,421	9,447	0,45	0,233	1,185	0,11	0,036
15	4,735	9,02	0,908	0,589	0,776	0,128	0,101
16	7,579	0,152	2,108	0,763	1,857	0,254	0,245
17	5,11	4,42	1,451	1,927	0,23	0,215	0,197
18	7,77	2,241	1,307	0,589	2,432	0,471	0,422
19	6,071	2,853	1,464	0,521	1,042	0,303	0,081
20	6,444	0,343	1,2	2,346	0,692	0,312	0,195
21	5,35	5,183	1,105	0,567	0,886	0,169	0,269
22	8,014	2,752	1,485	0,378	2,082	0,408	0,598
23	4,523	8,275	0,705	0,961	0,206	0,095	0,076
24	5,408	1,636	0,902	0,463	1,407	0,301	0,106
25	3,675	2,304	0,661	0,262	0,822	0,218	0,07
26	4,597	1,114	0,812	0,483	1,303	0,205	0,097
27	5,027	2,011	1,217	0,961	1,03	0,158	0,112
28	5,336	1,937	0,67	0,317	1,527	0,306	0,172
29	3,78	0,829	0,938	0,445	1,114	0,208	0,069
30	5,86	0,28	2,665	0,903	0,954	0,247	0,165
31	3,865	41,504	0,539	0,248	1,56	0,143	0,147
32	4,911	0,179	1,3	0,829	1,056	0,168	0,231
33	4,119	4,401	0,672	0,547	1,186	0,17	0,186
34	5,011	0,698	1,177	0,633	1,278	0,238	0,206
35	5,039	1,14	1,083	0,66	1,004	0,132	0,126
36	5,081	0,502	1,023	0,397	1,98	0,257	0,354
37	6,039	1,229	2,115	1,093	0,408	0,112	0,932

38	5,614	2,252	0,697	1,592	1,645	0,346	0,452
39	3,026	5,155	0,416	0,191	0,732	0,144	0,092
40	3,087	0,165	0,6	0,261	0,883	0,186	0,087

Usually at the enterprises of water supply and drainage outdated equipment is used. Replacement of obsolete pumping stations with new and more economical ones will lead to a reduction in electricity consumption. Table 6.7 shows the design characteristics of the system and calculated the planned savings from the reconstruction of the pumping station. Under the condition of implementation of such reconstruction of pumping stations of the Sewerage we can receive the following economic effect, are given in table 8.

According to the results of the analysis, the following amounts of funding, the payback period of the project and planned energy costs were identified (table.9). Therefore, with the introduction of water supply and sanitation, energy saving measures and modernization of existing sewage pumping stations, it is possible to save from 64 to 80% of electricity. This will make it possible not only to increase the level of tariffs for these services, but also to reduce.

Table 4: Data set for correlation analysis of segments of the unit cost of water disposal services according to 2018

№	Unit costs UAH thousand / m3	Specific costs of operational activity thousand UAH / m3	Including				Amortization, UAH thousand	Oher transaction costs, UAH thousand	Financial and other expenses, UAH thousand
			Electricity	Purchased water	Other material expenses	Consolidated labor costs, UAH thousand			
1	3	4	5	6	7	8	9	10	11
	S/V	S1/v	x1/v	x2/v	x3/v	x4/v	x5/v	x6/v	S2/V
1	5,6	1,5	0,0	1,1	2,7	0,1	0,2	0,0	5,6
2	5,2	4,4	0,0	0,5	0,9	2,2	0,1	0,1	5,2
3	9,1	0,1	0,0	2,4	1,0	1,3	0,3	0,1	9,1
4	7,8	2,2	0,0	2,6	0,9	0,9	0,3	0,5	7,8
5	4,1	0,0	0,0	1,4	0,8	0,5	0,1	0,0	4,1
6	4,2	3120,0	0,0	1,1	1,1	0,1	0,2	0,0	4,2
7	9,2	0,3	0,0	1,8	4,3	0,4	0,2	0,3	9,2
8	9,3	1,8	0,0	2,7	1,4	1,0	0,2	0,2	9,3
9	5,0	8,9	0,0	1,1	0,4	1,3	0,3	0,1	5,0
10	8,4	0,1	0,0	3,5	1,8	0,7	0,6	0,3	8,4
11	9,0	4,2	0,0	2,5	1,1	1,1	0,4	0,3	9,0
12	5,6	4,7	0,0	1,0	0,8	0,6	0,3	0,4	5,6
13	6,6	1,7	0,0	3,4	1,2	0,2	0,3	0,1	6,6
14	5,4	9,4	0,0	0,5	0,2	1,2	0,1	0,0	5,4
15	4,7	9,0	0,0	0,9	0,6	0,8	0,1	0,1	4,7
16	7,6	0,2	0,0	2,1	0,8	1,9	0,3	0,2	7,6
17	5,1	4,4	0,0	1,5	1,9	0,2	0,2	0,2	5,1
18	7,8	2,2	0,0	1,3	0,6	2,4	0,5	0,4	7,8
19	6,1	2,9	0,0	1,5	0,5	1,0	0,3	0,1	6,1
20	6,4	0,3	0,0	1,2	2,3	0,7	0,3	0,2	6,4
21	5,4	5,2	0,0	1,1	0,6	0,9	0,2	0,3	5,4
22	8,0	2,8	0,0	1,5	0,4	2,1	0,4	0,6	8,0
23	4,5	8,3	0,0	0,7	1,0	0,2	0,1	0,1	4,5
24	5,4	1,6	0,0	0,9	0,5	1,4	0,3	0,1	5,4
25	3,7	2,3	0,0	0,7	0,3	0,8	0,2	0,1	3,7
26	4,6	1,1	0,0	0,8	0,5	1,3	0,2	0,1	4,6
27	5,0	2,0	0,0	1,2	1,0	1,0	0,2	0,1	5,0
28	5,3	1,9	0,0	0,7	0,3	1,5	0,3	0,2	5,3
29	3,8	0,8	0,0	0,9	0,4	1,1	0,2	0,1	3,8
30	5,9	0,3	0,0	2,7	0,9	1,0	0,2	0,2	5,9
31	3,9	41,5	0,0	0,5	0,2	1,6	0,1	0,1	3,9
32	4,9	0,2	0,0	1,3	0,8	1,1	0,2	0,2	4,9
33	4,1	4,4	0,0	0,7	0,5	1,2	0,2	0,2	4,1
34	5,0	0,7	0,0	1,2	0,6	1,3	0,2	0,2	5,0
35	5,0	1,1	0,0	1,1	0,7	1,0	0,1	0,1	5,0
36	5,1	0,5	0,0	1,0	0,4	2,0	0,3	0,4	5,1
37	6,0	1,2	0,0	2,1	1,1	0,4	0,1	0,9	6,0
38	5,6	2,3	0,0	0,7	1,6	1,6	0,3	0,5	5,6
39	3,0	5,2	0,0	0,4	0,2	0,7	0,1	0,1	3,0
40	3,1	0,2	0,0	0,6	0,3	0,9	0,2	0,1	3,1

Table 5: Layout of array data to determine the regression formula

	s=S/V	**x1**	**x2**	**x3**	**x4**	**x5**	**x6**	**x7**
1	5,6	1,45	0	1,14	2,669	0,123	0,197	0,023
2	5,185	4,394	0	0,526	0,921	2,153	0,139	0,147
3	9,062	0,078	0	2,43	0,99	1,27	0,29	0,14
4	7,834	2,204	0	2,61	0,91	0,86	0,32	0,46
5	4,077	0,013	0	1,35	0,78	0,53	0,12	0,01
6	4,215	3120,01	0	1,13	1,05	0,12	0,2	0,00
7	9,238	0,267	0	1,77	4,31	0,35	0,23	0,32
8	9,297	1,846	0	2,74	1,41	1,04	0,23	0,20
9	4,987	8,885	0	1,12	0,39	1,26	0,30	0,13
10	8,385	0,149	0	3,52	1,79	0,67	0,55	0,34
11	8,988	4,23	0	2,46	1,05	1,07	0,36	0,33
12	5,612	4,733	0	1,03	0,84	0,63	0,27	0,42
13	6,588	1,712	0	3,38	1,19	0,18	0,28	0,06
14	5,421	9,447	0	0,45	0,23	1,18	0,11	0,036

15	4,735	9,02	0	0,90	0,58	0,77	0,12	0,10
16	7,579	0,152	0	2,10	0,76	1,85	0,25	0,24
17	5,11	4,42	0	1,45	1,92	0,23	0,21	0,19
18	7,77	2,241	0	1,30	0,58	2,43	0,47	0,42
19	6,071	2,853	0	1,46	0,52	1,04	0,30	0,08
20	6,444	0,343	0	1,2	2,34	0,69	0,31	0,19
21	5,35	5,183	0	1,10	0,56	0,88	0,16	0,26
22	8,014	2,752	0	1,48	0,37	2,08	0,40	0,59
23	4,523	8,275	0	0,70	0,96	0,20	0,09	0,07
24	5,408	1,636	0	0,90	0,46	1,40	0,30	0,10
25	3,675	2,304	0	0,66	0,26	0,82	0,21	0,07
26	4,597	1,114	0	0,81	0,48	1,30	0,20	0,09
27	5,027	2,011	0	1,21	0,96	1,03	0,15	0,11
28	5,336	1,937	0	0,67	0,31	1,52	0,30	0,17
29	3,78	0,829	0	0,93	0,44	1,11	0,20	0,06
30	5,86	0,28	0	2,66	0,90	0,95	0,24	0,16
31	3,865	41,504	0	0,53	0,24	1,56	0,14	0,14
32	4,911	0,179	0	1,3	0,82	1,05	0,16	0,23
33	4,119	4,401	0	0,67	0,54	1,18	0,17	0,18
34	5,011	0,698	0	1,17	0,63	1,27	0,23	0,20
35	5,039	1,14	0	1,08	0,66	1,00	0,13	0,12
36	5,081	0,502	0	1,02	0,39	1,98	0,25	0,35
37	6,039	1,229	0	2,11	1,09	0,40	0,11	0,93
38	5,614	2,252	0	0,69	1,59	1,64	0,34	0,45
39	3,026	5,155	0	0,416	0,19	0,73	0,14	0,09
40	3,087	0,165	0	0,6	0,26	0,88	0,18	0,08

Table 6: Hydropower design characteristics of the system

Source	Specific energy consumption						
		New pump		The automatic control station "Cascade-GA PCH		Automatic control station +new pump	
	Power fact, kW/m3	The capacity of the new pump, kW/m3	Saving, %	Power +automatic control Station, kW / m3	Saving, %	Power +automatic control Station +new pump, kW / m3	Saving, %
1	0,8	0,144	82,1	0,142	82,3	0,103	87,1
2	0,64	0,129	79,9	0,165	74,2	0,129	79,8
3	0,68	0,129	81,3	0,149	78,4	0,112	83,7
4	0,52	0,378	27,2	0,553	-6,4	0,367	29,5
5	0,64	0,378	40,3	0,504	21,3	0,373	41,8

Table 7: Planned estimated savings after reconstruction

Source	Table of calculated energy savings					
	New pump		The automatic control station "Cascade-GA PCH		Automatic control station +new pump	
	Economy winter, kW / month	Economy summer, kW / month	Economy winter, kW / month	Economy summer, kW / month	Economy winter, kW / month	Economy summer, kW / month
1	3151	4726	3159	4739	3346	5019
2	6137	9206	5697	8545	6130	9195
3	4293	6439	4137	6206	4417	6626
4	1699	2549	-397	-595	1838	2757
5	3139	4709	1637	2456	3209	4814

Table 8: The estimated return on planned reconstruction of pumping stations in sewer system

Source	Table of calculated energy savings					
	New pump		The automatic control station "Cascade-GA PCH		Automatic control station +new pump	
	The amount of investment, UAH.	Payback, months	The amount of investment, UAH.	Payback, months	The amount of investment, UAH.	Payback, months
1	24660	5,7	39888	9,2	64548	14,0
2	22140	2,6	30996	4,0	53136	6,3
3	22140	3,8	30996	5,4	53136	8,7
4	55608	23,8	64068	-117,5	119676	47,3
5	55608	12,9	64068	28,5	119676	27,1

Table 9: Calculation of planned savings and investments

Figure	New pump L100-200/550	The automatic control station "Cascade-GA PCH 110 kW	Automatic control station +new pump 55 kW
$P_{indicator}$ kW /m3	0,162	0,160	0,133
Economy winter, kW / month	42637	50388	52524
Economy spring, кВТ/ month	36243	42853	44871
Saving summer, kW / month	23711	28099	30016
Economy autumn, kW / month	36239	42873	45114
Average economy, kW / month	34708	41053	43131
The amount of investment, UAH.	180000	460000	520000
Payback, months	2,9	6,3	6,8
Average annual economy, %	64,4	76,2	80,2

3. Conclusions

Thus, given the difficult situation in Ukraine and its regions with the payment of housing and communal services, there is an urgent need to change the situation. Therefore, the proposed energy-efficient measures of the wastewater disposal system can be one of the main methods of maintaining the existing tariffs for wastewater services. Nevertheless, it is necessary to create certain conditions for the implementation of energy-retaining measures. The size of the economic effect of replacing outdated pumping equipment with new ones indicates the reality and the possibility of implementing such an investment project. The calculations show a significant economic effect, which will contribute to the water supply companies of Ukraine to become powerful and independent in the future, and the citizens of our country to pay for the services received for sanitation.

The authors suggest implementing this development at 40 enterprises of Ukraine. This will save the existing tariff rates, save from 64 to 80 % of electricity and even reduce it in the future. The introduction of energy-saving measures will ensure the production of competitive services; strengthen the activities of companies engaged in water disposal, promote the introduction of innovative processes and effective mechanisms for coordination of government, business and education at the level of individual companies, and at the level of the region and the country.

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