Prospects of innovative development of water supply and sewerage enterprises as one of the Sustainable Development Goals

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Suhak T. M. [a1], Chimyshenko S. M. [a]

[a] *Kyiv Institute of Business and Technology, Ukraine*

Abstract

The article points to the need for innovative development of water supply and sewerage due to the content of the sixth Sustainable Development Goal (SDG 6), established by the UN General As-sembly – affordable clean water and proper sanitation for all inhabitants of the planet. Sustainable development as a holistic set of guidelines and directions for developing national development pro-grams allows building a strategy for the country's development under the generally accepted needs of humanity. The issue of access to water resources is relevant for Ukraine, especially in insufficient funding for water supply and sewerage in recent decades. The authors analyzed the current state of water supply and sewerage in Ukraine to meet the objectives and achievements of SDG 6. In particular, following the first task – the market of drinking water supply, availability and quality of drinking water for residents of settlements of the country, including according to the type of set-tlement and region. The technical condition of water supply networks is analyzed, the issue of un-controlled water losses due to the unauthorized abstraction of drinking water from centralized net-works and leaks is studied, the technical condition of centralized drainage networks under tasks 2 and 3 of SDG 6. The issues of water use efficiency, in particular, the water intensity of Ukraine's GDP and the importance and expediency of implementing integrated water resources management systems, have been studied. This analysis aimed to identify the main reasons that hinder the innova-tive development of water supply and sewerage, highlighting the main problems in the field of wa-ter supply and sewerage. The authors have developed recommendations and a set of measures to correct negative trends in the field of water supply and solve problems that meet the Sustainable Development Goals.

Keywords: *centralized water supply and drainage, quality and affordable drinking water, water efficiency, water intensity of GDP, SDG 6.*

Перспективи інноваційного розвитку підприємств сфери водопостачання та водовідведення як одна із цілей сталого розвитку

Сугак Т. М. [a1], Чімишенко С. М. [a]

[a] *Київський інститут бізнесу та технологій, Україна*

Анотація

У статті вказується на необхідність інноваційного розвитку сфери водопостачання та водовідведення, що обумовлено змістом шостої Цілі сталого розвитку, встановленої Гене-ральною Асамблеєю ООН — доступна чиста вода та належні санітарні умови для всіх мешканців планети. Сталий розвиток, як цілісний комплекс орієнтирів та напрямків для роз-робки національних програм розвитку, дозволяє будувати стратегію розвитку країни відповідно до загальноприйнятих потреб людства. Питання доступності водних ресурсів є актуальним для України, особливо в умовах недостатнього фінансування сфери водопоста-чання та водовідведення протягом останніх десятиліть. Автори провели аналіз поточного стану сфери водопостачання та водовідведення в Україні в розрізі виконання завдань та до-сягнень шостої глобальної Цілі сталого розвитку. Зокрема, відповідно до першого завдання - розглянуто ринок питного водопостачання, доступність та якість питної води для мешканців населених пунктів країни, в тому числі відповідно до типу населеного пункту та регіону. Проаналізовано технічний стан водопровідних мереж, вивчено питання неконтрольованих втрат води внаслідок несанкціонованого забору питної води з централізованих мереж та протікань, технічний стан мереж централізованого водовідведення відповідно до завдання 2 та 3 шостої Цілі сталого розвитку. Досліджено питання ефективності водокористування, зок-рема водоємність ВВП України та важливість і доцільність впровадження систем інтегрованого управління водними ресурсами. Результатом такого аналізу стало визначення основних причин, що гальмують інноваційний розвиток сфери водопостачання та водовідведення, висвітлення головних проблем сфери водопостачання та водовідведення. Автори розробили рекомендації та комплекс заходів, що покликані виправити негативні тенденції в сфері водопостачання та вирішити завдання, що відповідають Цілям сталого роз-витку.

Ключові слова: *централізоване водопостачання та водовідведення, якісна та доступна питна вода, ефективність водокористування, водоємність ВВП, ЦСР 6.*

[1] Corresponding author.
E-mail address: suhak.t@kibit.edu.ua

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Introduction

The Sustainable Development Goals (SDGs) are a call to action by the entire world community to address pressing social, economic, and environmental issues. SDGs contain clear guidelines and targets that countries worldwide should prioritize and develop programs to achieve. SDGs unite the efforts of all countries to improve the quality of life of present and future generations.

There are currently seventeen SDGs critical to all of humanity and 169 goals that have been developed according to the set goals and will determine the policies and directions of UNDP funding until 2030.

Today, almost 40% of people do not have constant access to clean drinking water (The Protocol on Water and Health, 2006). Thus, 41 countries have shortages of drinking water, and 10 of them have almost depleted their freshwater drinking water reserves and are now looking for alternative sources. According to the UN, due to climate change and increasing drought by 2050, water short-ages will affect every fourth inhabitant of the planet.

During the period from 2000 to 2015 in Ukraine, due to urbanization and dense settlement of suburban areas, uncontrolled groundwater production, increasing the number of private unregistered wells and discharge of untreated sewage about 70% of surface water and a significant share of groundwater reserves as a source of drinking water supply. However, issues of waste management and provision of centralized water supply to the rural population remain problematic.

The UN General Assembly has determined SDG 6 as clean water and good sanitation. In order to achieve this goal, five tasks have been formulated to ensure its implementation:

Task 1. Ensure the availability of quality services of drinking water supply.

Task 2. Ensure the availability of modern drainage systems.

Task 3. Reduce the amount of untreated wastewater discharged at the state and individual levels.

Task 4. To increase the efficiency of water use (water capacity of GDP).

Task 5. Ensure the implementation of integrated water resources management.

Methods and Materials

Before developing an action program to solve the tasks, it is necessary to analyze the current state of water supply and sewerage, identify problems in this area, assess the prospects for the development and implementation of modern innovations. When implementing innovations, it is essential to adapt them to the specifics of enterprises in this field, to regional characteristics, technical characteristics, and environmental problems of the area in which they are located. It is important to remember that blindly borrowing or copying an example of a successful innovation strategy for businesses in different regions and countries is unacceptable. All innovative trends must be carried out through the prism of the relevant conditions of individual enterprises and the economy as a whole. For our country to achieve SDGs is an acute problem.

To perform the tasks in the study used the following methods: abstract-logical, tabular to display analytical information, and scientific methods: analysis and synthesis, induction and deduction, classification, systematization. In addition, the study used laws and regulations of Ukraine, official statistical materials of the State Statistics Service of Ukraine, works of Ukrainian and foreign au-thors. The results of the study were formed based on analysis of statistical data, analytical materials of periodicals.

Results and Discussion

Firstly, we will consider the current state of centralized drinking water supply and sewerage in Ukraine because of SDG 6. The Law of Ukraine «On Drinking Water, Drinking Water Supply and Sewerage» (2020) defines the subjects of the water supply market as such enterprises that «produce drinking water, provide cities, other settlements, separately located drinking water facilities through the centralized drinking water supply or other means of decentralized water supply, sewerage services»; public authorities and local governments responsible for «regulation, supervision, and control of drinking water quality and/or sewerage services, condition of sources, drinking water supply and sewerage systems», as well as water consumers and sewerage services. Therefore, the water supply market structure in Ukraine consists of a centralized and decentralized water supply.

Centralized water supply determines the economic activity of enterprises of various forms of own-ership, the purpose of which is to meet the needs of end consumers in drinking water. Such enter-prise functions are realized through the corresponding infrastructure, i.e., special objects, distributive water supply networks connected by the uniform technological process of extraction, preparation, and water transportation.

Decentralized water supply is the process of meeting the needs of consumers in water using appro-priate sources of drinking water through the operation of special water bottling points (mobile tank-ers, wells, etc.), the use of the individual or joint production and production of bottled drinking wa-ter and bottled drinking water, which may come from different sources of water supply and does not contain food or food additives.

Thus, there is an effective alternative to a centralized drinking water supply that helps ensure sus-tainable development.

According to the State Statistics Service of Ukraine, the provision of settlements in Ukraine

with a centralized drinking water supply in 2019 was: 99.1% in cities, 91.22% in urban settlements, 26.91% in rural areas (Table 1).

Analyzing the statistics presented in Table 1, we see that over the past 30 years in rural areas, access to centralized water supply has increased by 11.04 percent. However, rural settlements usually do not have access to a centralized water supply and use water from mine wells or catchments filled from surface water sources, respectively, without special

Table 1

Provision of settlements with centralized water supply

	Number of administrative-territorial units				Water supply, interest			
	1991	2000	2013	2019	1991	2000	2013	2019
Cities	437	451	460	406	99,3%	99,3%	99,3%	99,1%
Urban-type set-tlements	925	893	885	683	88,2%	89,1%	85,6%	91,22%
Rural settlements	28845	28651	28397	26076	15,87%	23,2%	22,16%	26,91%

Table 2

The length of dilapidated and emergency water supply networks

Total urban and rural population	2009			2019		
	Length of the entire water supply system, km	The length of dilapidated and emergency water supply networks, km	% all to до dilapidated	Length of the entire water supply system, km	The length of dilapidated and emergency water supply networks, km	% all to до dilapidated
Ukraine	181209,6	67161,4	37,1	120320,5	46060,5	38,3
Autonomous Republic of Crimea	14194,7	7162,9	50,5	No information		
Vinnytsia region	4035,7	1234	30,6	3146	936,5	29,8
Volyn region	2715,9	437	16,1	672,67	387,22	57,6
Dnipropetrovsk region	15382,7	6545,2	42,5	14796	5538,8	37,4
Donetsk region	24747	11786,1	47,6	15300	9429,93	61,6
Zhytomyr region	4024,4	1017,6	25,3	3818,91	1201,48	31,5
Transcarpathian region	1180,5	297,2	25,2	2577,7	313,2	12,2
Zaporozhye region	9997,4	3785,7	37,9	9290,3	3171,2	34,1
Ivano-Frankivsk region.	1614,4	463,7	28,7	1622	390,8	24,1
Kyiv region	9152,1	2034,4	22,2	5291,06	749,9	14,2
Kirovograd region	5297,1	2037,7	38,5	3253,91	1514,8	46,6
Luhansk region	11662,1	7008,5	60,1	2334,02	1426,28	61,1
Lviv region.	4990,3	2288,7	45,9	4750,72	2183,64	46,0
Mykolaiv region	7046,1	2165,4	30,7	7136	1949	27,3
Odessa region	11576	3806,6	32,9	9179,9	3450,5	37,6
Poltava region	6599,8	1109,4	16,8	2603	760	29,2
Rivne region	2764,8	532,2	19,2	2003,47	458,15	22,9
Sumy region	3370,9	748,8	22,2	4175	1014	24,3
Ternopil region	2577,7	515,4	20,0	1290	452	35,0
Kharkiv region	8305,5	2495,3	30,0	6577,1	3168,5	48,2
Kherson region	12122,4	4898,3	40,4	7049,6	2596,1	36,8
Khmelnytsky region	4066	1232,5	30,3	3310,4	1167,7	35,3
Cherkasy region	4034,3	955,6	23,7	2769,87	779,43	28,1
Chernivtsi region	803,6	289,3	36,0	924,4	252,9	27,4
Chernihiv region	3717,1	827	22,2	2148,1	801,4	37,3
Kyiv	4116,3	859,2	20,9	4299,41	1967,08	45,8

Table 3

Uncontrolled water losses in centralized networks

	Uncontrolled water losses, in %		
Total urban and rural population	2009	2013	2019
Autonomous Republic of Crimea	36,1	34,8	-
Vinnytsia region	29,1	28,8	38,3
Volyn region	21,5	26,5	35,8
Dnipropetrovsk region	24,1	21,0	32,8
Donetsk region	26,9	30,9	49,5
Zhytomyr region	44,1	43,0	49,8
Transcarpathian region	37,3	38,3	50,7
Zaporozhye region	32,7	32,9	34,9
Ivano-Frankivsk region.	30,5	38,9	43,6
Kyiv region	15,3	16,6	16,6
Kirovograd region	28,3	24,7	42,2
Luhansk region	36,6	38,7	30,1
Lviv region.	40,2	47,1	42,5
Mykolaiv region	33,5	29,7	41
Odessa region	32,6	28,3	35,2
Poltava region	22,9	22,0	38,6
Rivne region	17,3	18,5	27,7
Sumy region	27,3	26,7	27,5
Ternopil region	30,2	27,7	26,6
Kharkiv region	37,5	38,8	42,1
Kherson region	25,7	22,9	24,8
Khmelnytsky region	26,9	28,5	28,2
Cherkasy region	23,4	24,9	30,3
Chernivtsi region	44,1	42,8	61,8
Chernihiv region	21,2	21,3	19,4
Kyiv	16,6	21,8	28,9

water treatment and purification. Therefore such water may be of inadequate quality. Poor water quality is often caused by industrial enterprises and agriculture and is also affected by the lack of efficient wastewater and sewage treatment systems (Dmitrieva et al., 2018). Proper preparation of drinking water from wells is quite expensive for private households, so an alternative source of drinking water is artesian wells. Individual households or communities extract artesian water from a depth of 25-200 meters. It is more reliably protected from external pollution than surface water (Bondar et al., 2016).

Although the provision of cities with centralized water supply reaches almost 100%, it should be taken into account that part of the water supply networks is dilapidated, in disrepair, and needs major repairs. Table 2 shows that the most complex emergency networks in 2019 were networks in Donetsk (61.6%), Luhansk region (61.1%), Volyn (57.6%), and Kharkiv (48.2%) regions.

Respectively, emergency and dilapidated networks need significant repairs or replacement. In addi-tion, such networks have more significant uncontrolled water leaks (Table 3), which increase the use of water resources and increase the price of drinking water for the final consumer.

Thus, the **first task** is to ensure the availability of quality water supply services performed in cities and to a greater extent in rural settlements through the centralized and decentralized water supply. Although many unresolved issues with an emergency, dilapidated networks, and water losses, many water companies need to modernize their

water supply networks; thus, the population has free access to drinking water (Babych, 2016).

The provision of the population with sewerage in 2019 is 95.5% in cities, 63.7% in urban-type settlements, and 1.8% in rural settlements. According to the State Statistics Service, there is currently no drainage in 14 cities, 248 urban-type settlements, and 25,611 rural settlements (Lototska et al., 2020). This situation is quite ambiguous, as settlements that do not use centralized drainage have to drain their effluents through other utilities, so it is necessary to investigate how well such effluents are treated and where they end up. High-quality wastewater treatment requires the use of special treatment facilities and mechanisms that emit or neutralize contaminants. Domestic wastewater is usually treated mechanically or biologically. The choice of a particular method depends on the composition and intensity of pollution in the water and its further use. However, the use of such treatment is a legal and moral obligation of every business entity (Khomko & Ruda, 2018; Kozak & Kozlyuk, 2019).

The second task is half completed, the urban population is 99% equipped with sewerage systems, but rural settlements are less than 2%. This task is more challenging to solve, and it is related to **task three** – to reduce the discharge of untreated wastewater. Therefore, by 2030, water quality needs to be improved by reducing pollution, eliminating waste disposal, minimizing emissions of hazardous chemicals and materials, halving the share of untreated wastewater, and significantly increasing the recycling and safe reuse of wastewater. In our opinion, this is an important task and requires an appropriate development strategy.

The fourth task concerns the water capacity of GDP, which is determined in cubic meters of water used per 1000 UAH ($36.7) of GDP. The capacity of GDP is the ratio of total annual volumes of both fresh water and circulating and re-water supply to GDP at current prices. The numerator is the volume of used fresh water per year and the circulating and repeated water supply per year (data from the State Water Agency). The denominator is the GDP for the year in the current year's prices (according to the State Statistics Service).

The water intensity of GDP is one of the indicators of the level of nature intensity of production, or nature efficiency – the efficiency of the country's natural resources. The total level of water intensity of Ukraine's GDP in 2014 was more than two times higher than the world average. Today this level is close to the world average. The level of water capacity indicates how a country saves its water resources. Ukraine has traditionally had high consumption rates of natural resources, which have developed historically, and the situation has not changed fundamentally since the nineteenth century. Inefficient use of water resources has been a major cause of drinking water problems.

The amount of water that must be used to produce a certain amount of product is called the water capacity. For example, for the production of 1 ton of pig iron in total, it is necessary to spend about 200 m3 of water and obtain 1 ton of steel – up to 300 m3. Thermal power plants with a capacity of up to 1 million kW consume 1.2-1.6 km3 of water per year, and nuclear power plants – up to 3.5 km3.

Water consumption for the production of 1 kg of plant food is about 2 thousand liters of water, and 1 kg of meat – 20 thousand liters. Positioning Ukraine as a country with a robust agro-industrial complex, it should be understood that due to lack of water, black earth is degrading. 80% of arable land today is deficient in moisture, and the resource of soil fertility is rapidly declining. Therefore, no matter how effective the measures to stimulate the economy, the country's economy itself can rest on the water «ceiling», which will be quickly overcome by administrative or financial mechanisms (Boreyko, 2018; Kichko & Kholodnytska, 2021).

The fifth task is to ensure the application of specific integrated water resources management based on the «basin» principle, which must be done by developing and implementing appropriate algorithms for river basin management. Achieving this is possible through the development of the National Water Strategy, which will aim to ensure a satisfactory state of the country's water resources (Ryabets, 2018; Klimchik et al., 2018; Golikov et al., 2018).

The main activities that should ensure the implementation of the tasks are, in particular, the deep modernization of water supply and sewerage systems. This will reduce the water consumption of industrial and agricultural products and help save electricity spent on collecting, preparing, and supplying water to end-users (Golyan & Androschuk, 2016). Improving the efficiency of wastewater treatment networks and eliminating leaks in sewage networks will help affect the state of the environment, especially the availability and quality of drinking water, and therefore the health of the country's population. Progressive improvement of relevant production processes and the construction of special systems to ensure circulating and reusing water will help reduce water consumption, increase the competitiveness of domestic products, and reduce the artificial environmental impact. Creating a reliable monitoring system to ensure the prevention and prevention of natural disasters will protect the population, reduce the destructive effects of the disaster, and reduce the amount of damage (Cherkashina, 2020).

Obstacles hindering the development of water supply and sewerage:

In Ukraine, many companies do not issue permits for particular water use, i.e., such use occurs in the «shadow», without proper accounting and statutory fees. This is one of the most significant water issues

in the country because it is not known precisely how end-users use much water. In addition, it is not possible to predict the consequences of such water use.

Typically, «shadow» water users gain access to better groundwater while discharging untreated wastewater. This creates the following problem: the transfer of groundwater to surface water, which ultimately significantly worsens the state of the river basin and groundwater-dependent territory. As a result, we receive a severe environmental threat on a national scale.

At present, there is no focus of economic entities and regulators on rational water use and following the economic principle: if an economic entity pollutes water resources, it must compensate for this, and the funds received by the relevant administrator will be spent on water replenishment, replenishment (Hbur & Krylova, 2019).

From 2011 to 2020, the national target program «Drinking Water of Ukraine» operated, but its actual funding was at the level of 13% of the significant amount, so this program was actually failed.

About 80% of industrial enterprises in Ukraine do not own local treatment plants. Also, many companies have not created an effective environmental safety system, do not have environmental certificates, often dump into the public sewer petroleum products and their processing, fats, various garbage, including household, various chemicals. This leads to deterioration of the sewage network, sometimes even to an emergency shutdown of sewage pumping stations. At the same time, the biggest threat is volley dumps, which quickly destroy the drainage system. Such discharges usually occur at night, as they are challenging to track and quick response is impossible. In addition, due to the clogging of unauthorized emission

Conclusion

After conducting a study of the state of water supply and sewerage, we concluded that Ukraine had made some progress in achieving the appropriate indicators of SDG 6. However, due to the lack of funding at both the state and local levels and the insufficient use of regulatory mechanisms by regulators, further efforts are still needed to achieve these goals.

In particular, it is estimated that the process of restoring emergency networks through depreciation in the current approaches to tariff formation will take 250 years. Therefore, it is necessary to take a comprehensive approach to solve all problems of centralized water supply, develop modernization projects and implement new modern technologies of drinking water treatment, look for ways to attract the necessary investments, actively participate in international sectoral programs.

Requiring consumer access to safe and inexpensive drinking water by 2030 requires appropriate investment in infrastructure, ensuring the creation and modernization of sanitary facilities, and pro-moting hygiene at all levels. In addition, the protection and restoration of aquatic ecosystems, in-cluding forests, mountains, swamps, and rivers, is also essential to prevent water scarcity. Finally, targeted international cooperation is essential to achieve an efficient level of water consumption and introduce the latest water treatment technologies.

One of the effective ways to improve the organization of water supply and sewerage enterprises is the introduction of automation of technological process management, which is designed to solve the following main tasks:

- calculation of optimal modes of operation of infrastructure facilities;
- forecasting the needs of end-users in water, as well as an accurate accounting of sales vo-lumes;
- remote control of water treatment and water supply systems;
- optimization of water treatment and water supply systems;
- formation the operational information on the emergencies occurrence at facilities with accu-rate time and area determination of such situations;
- formation of the necessary reporting;
- calculation and analysis of technical and economic performance of facilities and mechan-isms.

Automation of production processes provides an opportunity to significantly increase the reliability and technical and economic performance of the water supplier, allows to obtain a tangible economic effect through proper organization of control over the main mechanisms and structures, optimizing their use, reducing costs of water resources, prepared water, energy, chemical reagents, and labor costs.

Also, we identified the reasons that led to the deterioration of the situation in the centralized drink-ing water supply sector. The main ones are the insufficient length of water supply systems, lack of round-the-clock water supply in some places, non-standard quality of drinking water, significant losses of drinking water due to worn-out, and often emergency centralized water supply networks.

These reasons, underfunding and careless management of water supply companies, significant overall depreciation of their fixed assets, the use of outdated water treatment technologies, and other factors, as a result, worsen the situation with centralized supply. Indirectly, this situation leads to an increase in unauthorized water abstraction from centralized water supply networks, mass transfer of consumers to private water sources, which are often created without proper permits and, consequently, harm the environment and negatively affect water resources.

We believe that the following measures should be taken to address negative water supply situations:

1. The National Commission to form a package of investment programs that will be able to en-sure the necessary modernization of water supply companies, actively introduce the latest technologies of high energy efficiency, apply modern methods of water purification and wa-ter treatment;
2. The State Sanitary and Epidemiological Service to implement the necessary and effective control over the quality of drinking water at centralized water supply enterprises;
3. Local state administrations and local self-government bodies should actively implement the practice of informing the population about the condition and quality of local water supply and regularly carry out explanatory work on the conservation and rational use of drinking water.

The main obstacle to the reconstruction of water supply companies is the lack of financial resources, as tariffs do not cover all costs of enterprises for treatment and preparation of drinking water for consumers. Development and modernization of the drinking water supply system includes construction and repair of water supply facilities, restoration of water supply networks, adjustment of water supply systems of residential buildings, provision of energy-saving technologies, updating the accident prevention system at drinking water supply enterprises. Although financing the development and reconstruction of centralized water supply companies is carried out not only through tariffs but through:

- funds of water supply enterprises in accordance with their development programs;
- funds of district and local budgets;
- funds from the State Budget of Ukraine;
- international financial organizations.

The main ways to solve the main tasks at the local level are full implementation of regional and local program actions on the proper provision of the population with drinking water of sufficient quality; regular and extensive audit of water use and resource efficiency; direct application of modern energy-saving technologies and equipment at public utilities; ensuring full-fledged (round-the-clock) water supply to the population; establishment, within the powers granted by law, of tariffs for centralized water supply services, taking into account all economic factors; implementation of necessary measures to ensure maximum payment by consumers for consumed water resources and repayment of actual debt; active attraction of private, including foreign, investments in the renewal and modernization of water supply systems; protection and prudent use of available sources of drinking water supply, as well as their restoration.

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