Benchmarking as a tool for the development of "green" technologies in the water supply and sanitation enterprise

Marina Treyman[1*], *Anna* Nazarova[1], and *Daria* Ignatova[2]

[1] St. Petersburg State University of Industrial Technologies and Design, 198095 Ivan Chernykh str. 4, St. Petersburg, Russia
[2] St. Petersburg State University of Economics, 191023 Griboedov Canal Embankment 30-32, St. Petersburg, Russia

Abstract. The study presents the features and principles specific to the implementation of benchmarking for water supply and sewerage enterprises. Benchmarking is an assessment and control tool that allows enterprises to improve their activities in the field of environmental management, which will make it possible to reduce the environmental burden on the region and increase the environmental safety indicators of the region. The authors of the article developed an algorithm for implementing the principles of benchmarking in the activities of enterprises, which will improve both the quality of services and increase the efficiency of its work. The principles and technologies of water supply used in St. Petersburg and the Sultanate of Oman identifying problematic aspects of water management and key indicators that reflect the effectiveness of processes are presented. A comparative analysis of the key indicators of water supply in the Russian Federation (on the example of the city of St. Petersburg) and the Sultanate of Oman (on the example of the capital city of Muscat) was carried out. The key areas for improving activities were identified.

1 Introduction

At present, the development of resource-supplying enterprises is relevant and significant in modern reality, because at the level of the formation of the region, it is these enterprises that ensure environmental safety and allow maintaining a high level of public health and environmental safety. Water and sewer companies need up-to-date management tools and benchmarking is one of them.

Benchmarking is a set of techniques that allows identifying the best practices in the field of resource supply and subsequently apply this experience in the enterprise. Benchmarking methods allow comparing companies in the same industry and adopt best practices to improve the activities of the enterprise. For water supply and sewerage enterprises intra-industry benchmarking is used [1].

* Corresponding author: britva-69@yandex.ru

Benchmarking combines different comparative approaches, but they can be combined into 4 main principles [2]:

- Mutual agreement in the implementation of benchmarking elements - all departments and employees must come to mutual agreement on the criteria for evaluating benchmarking and setting achievable goals.
- Drawing an analogy between the business processes of companies in the same industry.
- All the indicators studied in the framework of benchmarking should be measurable, which will make it possible to carry out an assessment, and on the basis of this analysis, and the subsequent assessment, the improvement of the enterprise's activities will be carried out.
- Reliability of the data is mandatory, since factual information will allow to give objective assessments for further improvement of the organization's activities.

Integrated benchmarking approaches are aimed at improving the efficiency of managing the activities of a water supply and sewer enterprise. Benchmarking also affects the quality-of-service provision, and in the case of a water and sewer enterprise, this affects production processes to a greater extent. Benchmarking allows the company to adapt for itself more modern technologies that will increase the efficiency of enterprise development. Benchmarking can further contribute to strategic planning.

2 Water supply in the city of St. Petersburg

Currently, St. Petersburg is one of the largest cities in the Russian Federation, as well as an industrial centre. Over its long history, the city has developed an industrial complex: at present, machine-building, metallurgical, automotive, food and other branches of the national economy operate in the city. Due to the fact that St. Petersburg has historically been an industrial centre, it is now a natural environment, including water. heavily polluted and in need of restoration measures.

It should be noted that St. Petersburg is a city on the water and has a significant amount of water resources, since the city is located on the Neva River and has access to the Baltic Sea. The city is fully provided with water resources, and they come to consumers after treatment at "Vodokanal of St. Petersburg resource supplying enterprise.

Currently, the city is provided with modern water treatment and wastewater treatment systems, which, on the one hand, allow maintaining the necessary state of the natural environment and reduce the environmental burden on the natural environment, and, on the other hand, will allow providing quality services to subscribers. The main technology of water treatment is carried out as follows: initially, the water taken from the Neva River is purified from suspended particles, then water hardness is adjusted by filtration methods using sodium cation exchange filters, and then ultraviolet treatment is used to disinfect water [3].

For the development of St. Petersburg Vodokanal, benchmarking tools are important and relevant in today's reality, as they will improve the efficiency of operations and the quality of maintenance of existing systems.

The quality indicators include the state of drinking water in St. Petersburg, a comparative analysis of these values is presented in Table 1.

Table 1. Comparative analysis of drinking water quality indicators at St. Petersburg waterworks with indicators of other countries of the world, mg/dm^3[4].

Indicators, units	**St. Petersburg waterworks**	**France**	**Germany**	**Japan**	**South Afrika**	**Brazil**	**China**	**Finland**	**Sweden**	**Australia**	**USA**
Fluorine	0.15	1.5		0.8	1	1.7	1.0	1.5		1.5	4.0
Chromium (gen.)	0.0005	0.05	0.10	0.05	0.1	0.05	0.05	0.05	0.05		0.1
Zinc	0.0044		0.20		1.0		1.0			0.05	
Cyanides, incl. cyanogen chloride (according to CN^-)		0.05	0.5	–	0.2	0.1	0.05	0.05	0.05	0.08	0.2
Aluminum	0.164	0.2		0.2	0.15	0.2		0.2		0.2	
Ammonia and ammonium (by NH^{4-})	0.114	1.5	0.2	–	1.0			0.5		0.5	
Bicarbonates (according to HCO^{3-})		100		–							
Iron	0.03	0.2		0.3	0.3	0.3	0.3	0.2	0.1	0.3	
Copper	0.0066	1.0		1.0	0.5	1.0	1.0	2.0		2.0	1.3
Manganese	0.0048	0.05		0.01	0.05	0.1	0.1	0.05	0.05	0.5	
Sulphates (according to SO_4^{2-})	25.6	250		–	200	400	250	250	100	500	
Chlorides	7.8	200		200	250	250	250	250	100	250	

In this case it should be noted that the State Unitary Enterprise "Vodokanal of St. Petersburg" shows a fairly high level of water treatment quality, from which we can conclude that this makes it possible to reduce the incidence of the population, since providing the population with high-quality drinking water makes it possible to improve the social component of the region. Data analysis showed that the enterprise maintains low levels of heavy metals and nutrients in water. High-quality drinking water meets sanitary standards, and technologies related to water supply are environmentally friendly and allow maintaining the principles of sustainable development in the North-West region. Treatment technologies can be classified as “green”, as the company has a two-stage system for complex water disinfection (using the ultraviolet method), a water quality control system based on biomonitoring has been installed (the use of crayfish to control water quality, since crayfish are indicators of pollution and may exist only in pure water without contamination by impurities). Crayfish are used in this technology, because their sensitivity has long been known, males aged 3-5 years are selected for the technology. 6 crayfish go out per shift to control water quality and their condition will be constantly monitored with the help of sensors and abnormal pollution of water resources will be detected. This technology is innovative [5].

The water treatment technologies used at Vodokanal of St. Petersburg are innovative and provide the region with high-quality drinking water.

3 Water supply in the Sultanate of Oman

We will consider foreign experience in the development of water supply and sanitation systems on the example of the sovereign country of Oman. Oman is located in Southwest Asia and borders on the Arab Emirates, more precisely located in the Southeast of the Arabian Peninsula. The permanent population is about 4 million people, of which 57.4% are local residents. One of the tasks of the Sultanate of Oman is to improve climatic conditions by reducing the impact of greenhouse gases on the atmosphere. The decline in climate impact should change from 50 ºC to 17 ºC by 2040. The total area is 309 thousand km [6, 7]. The population density is 18.2 people/km2. Projected volumes of water use in Oman are shown in Figure 1.

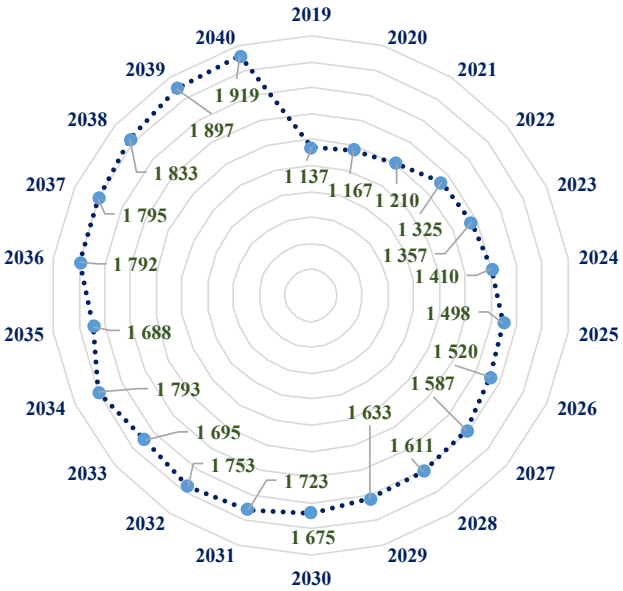

Fig. 1. Long-term forecast of the average water consumption of the Sultanate of Oman, m^3/day.

Most of Oman's water resources - 90% - are spent on agriculture. In this state, there is a significant lack of fresh water, therefore, it was decided to implement a project for the desalination of sea water, and a program is also being implemented to economically use water resources for domestic purposes. 13,000 km of networks have been laid in the city [8, 9, 10]. In the last year, the Omani authorities planned to intensify the processes of water desalination, but an environmental problem intervened in this activity: sea poisonous algae began to multiply in the sea, so the desalination process had to be stopped, which led to a shortage of fresh water (Figure 2).

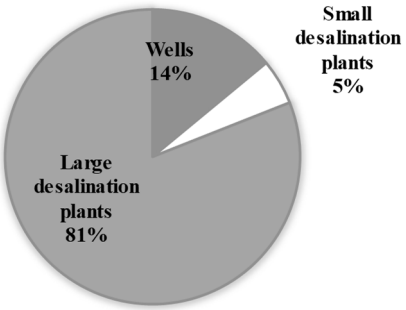

Fig. 2. Breakdown of water supply systems for the Sultanate of Oman.

The capacity of the desalination plant is 1,254 thousand m3/day. The main cities, fully provided with water supply: Muscat, Raysut, Salalya. In waterless areas, water is delivered in tank trucks. On average, the growth rate of water demand is 6% per year. At present, control over water use is carried out - this is the responsibility of the Ministry of Natural Resources of the Sultanate, the activity of drilling water wells is licensed [11].

Thus, the Sultanate of Oman is currently not fully provided with water resources and this desalination technology does not fully provide the state with fresh water, in this case, innovations and "green" technologies are used, but they are not fully implemented and regional water use needs to be adjusted in connection with the shortage of water resources in certain areas of the state.

4 Conclusion

A comparative analysis of practices was carried out and the applied benchmarking tools made it possible to build a benchmarking system suitable for any resource supplying enterprises. The algorithm for implementing the benchmarking functions will allow you to create an effective change management system at the enterprise (Figure 3).

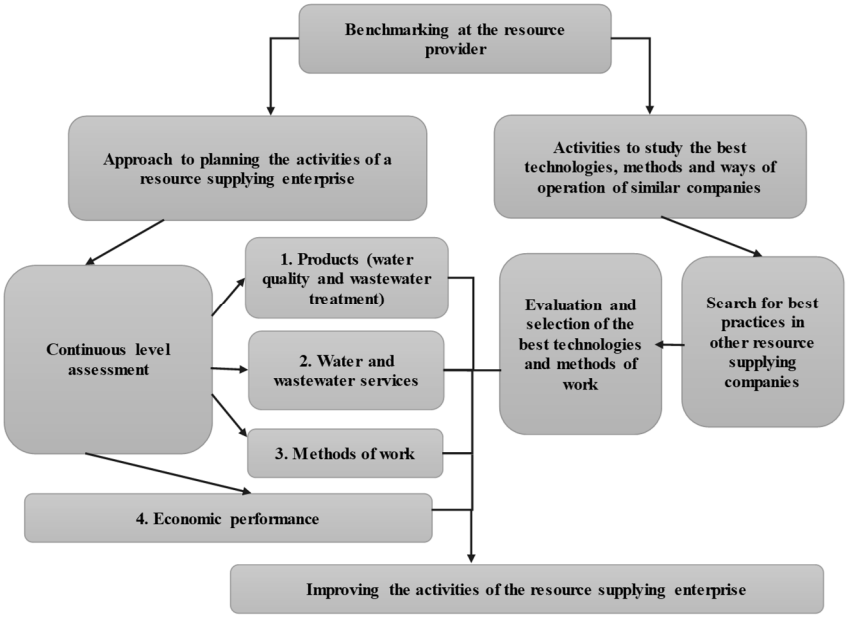

Fig. 3. Algorithm for managing the benchmarking process at a resource-supplying enterprise.

In this case, for resource-supplying enterprises it is necessary to determine the best practices both in the technical sphere and in the financial sphere and in the direction of working with subscribers, a separate area is continuous improvement and constant assessment of the quality of services both by the enterprise and by the subscriber, determining methods of work and management tools and their economic results.

To carry out continuous assessment and control of activities, it is necessary to take into account key indicator indicators, which may include: production, quality and reliability indicators, financial, economic and environmental indicators. All these parameters reflect the efficiency of the water supply and sewerage enterprise. Let's take 4 main indicators for the water supply of large countries and conduct a comparative analysis based on benchmarking of the data obtained (Table 2). The comparison made between St. Petersburg and the Sultanate of Oman can be considered corrective and convergent, since the objects under study have approximately equal volumes of water use and the need of the population for water resources.

Table 2. Comparative analysis of key indicators for water supply for water supply and sewerage enterprises in the world [12].

City	Total population, thousand people	Volume of produced water, thousand m^3/day	Water consumption, l/person per day	Unaccounted for water losses during transportation, % of supply
Australia, Sydney	4 841	1 448	198	7.2
Armenia, Yerevan	1 123	399	120	63.7
Bangladesh, Dhaka	6 970	2 250	97	22
Bulgaria, Sofia	1 350	253	126	52
Great Britain, London	9 000	2 600	137	25
Germany, Hamburg	2 000	313	111	4
Norway, Oslo	634	276	160	41
Poland Warsaw	1 811	335	115	12.9
Russia, Saint-Petersburg	**5 398**	**1 480**	**127**	**10,3**
Sultanate of Oman, Muscat	**4 321**	**1 325**	**135**	**12.8**
Czech Republic, Prague	1 260	261	108	14

According to the data obtained, St. Petersburg is one of the most densely populated cities and is the leader in terms of the “volumes of supplied water”, but at the same time, the indicators for consumption per person per day are average, which indicates economical water use, the indicator of unaccounted losses is low compared to the considered world practices. The Sultanate of Oman shows less stable results, but in addition to the problem of fresh water

shortage, we note that water management is carried out competently and activities are aimed at continuous improvement.

The use of benchmarking elements allows water supply and sewerage enterprises to carry out constant accounting and control of their activities, and also contributes to the continuous improvement of the management system for all types of activities and positively affects the efficiency and quality of services provided.

References

1. L. M. Naumova, Sboeva I. A., *Benchmarking tools in the technology of competitive positioning of a manufacturing organization* (PSTU, Yoshkar-Ola, 2017)
2. A. A. Chalova, I. A. Belozerova, *Benchmarking in the management system of a modern enterprise* (Fabula, Stavropol, 2018)
3. E. D. Shchetinina, K. I. Logachev, T. V. Saprykina, *Improving the efficiency of managing industrial enterprises based on benchmarking* (Publishing House of BSTU, Belgorod, 2011)
4. S. G. Zyukin, R. R. Tolstyakov, *Competitive intelligence as a marketing tool* (Tambov, 2013), 152-158
5. G. G. Onishchenko, Yu. Rakhmanin, F. V. Karmazinov, *Benchmarking of drinking water quality* (New Journal, St. Petersburg, 2010)
6. A. V. Zimovets, Ya. A. Nalesnaya, S. V. Stash, L. V. Sharonina, *The system for monitoring the effectiveness of activities (benchmarking) of housing and communal services as a factor in the socio-economic development of the region* (Aeterna, Ufa, 2018)
7. K. Doppler, C. Lauterburg, *Change Management* (Campus, New York, 2014)
8. A. B. Bakhmat, *Analysis of foreign experience in reforming the management system of water supply and sewerage* (Minsk, 2010), 286-299
9. T. Schmitz, *Benchmark: Dutch Water Companies* [Electronic resource] Theo Schmitz www.iwahq.org.IWA%20conference%20on%20benchmarking%202006_04_Theo%20Schmitz
10. R. Cunha Marques, Towards a benchmarking paradigm in the European public water and sewerage services https://www.econ.kuleuven.be/ew/academic/econover/Papers/Benchmarking%20paradigm%2023-03.pdf.
11. K. K. Sadangi, S. Mohapatra, *Managing organizational change: lessons from political upheavals in India* (Emerald, Bingley, 2017)
12. A. A. Kovalchik, D. G. Vysokinskiy, A. V. Kiselev, *The system of strategic management of a water supply and sewerage enterprise* (Publishing House of the Ural Federal University, Yekaterinburg, 2013)