

# A Review of Industrial Water Resources Efficiency

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## Abstract

**With the acceleration of China 's industrialization process and industrial upgrading, the efficient use and fine management of industrial water resources have become an increasingly important issue of industrial development and environmental protection. Industrial production activities not only consume a large amount of water resources, but also may lead to water pollution. Improving the efficiency of industrial water resources not only helps to save the total amount of water resources, but also reduces the harm of pollution emissions to the natural environment. This paper summarizes the current situation of industrial water resources efficiency and effective management strategies, including policy support and technological innovation.**

## Keywords

**Industrial Water Resources Efficiency; Pollution Emissions; Management Strategy; Environmental Protection.**

## 1. Introduction

Industrial water accounts for a considerable part of China 's total water consumption. According to the data of China Water Resources Bulletin in 2023, the national industrial water consumption in 2023 is 97.02 billion m<sup>3</sup>, accounting for about 15.3 % of the total water consumption in China. However, compared with other production wastewater, the pollutants in industrial wastewater are complex, difficult to treat and costly [ 2 ]. Therefore, it is very important to improve the efficiency of industrial water resources from industrial sources and industrial production activities to solve the shortage of water resources quality and quantity. Although many industrial sectors and related enterprises have taken measures to improve water resources management, they still face many challenges. The purpose of this paper is to review the current situation of industrial water resources efficiency, explore the factors affecting efficiency, and put forward suggestions for improvement.

## 2. Usage Status of Industrial Water Resources

### 2.1. Overview of China 's Industrial Water

In 2023, China 's industrial added value was CNY 399.103 billion ( at the current price ), and the water consumption per 10,000 yuan of industrial added value was 24.3 m<sup>3</sup>, an increase of 0.83 % compared with the previous year. However, compared with high-income countries ( excluding the United States ), it is higher than its 6 % average level, and there is still room for improvement [ 3 ]. In addition, from the perspective of spatial distribution, the industrial water consumption in different regions is not the same. The industrial water consumption in the six northern regions ( Songhua River, Liaohe River, Haihe River, Yellow River, Huaihe River and Northwest Rivers ) is 20.57 billion m<sup>3</sup>, and the industrial water consumption in the four southern regions ( Yangtze River, Southeast Rivers, Pearl River and Southwest Rivers ) is 76.45 billion m<sup>3</sup>. The level of water resources endowment in the four southern regions is high, and the level of water resources endowment in the six northern regions is low. There are many industries with high water consumption intensity in the six northern regions, such as the source

base in Ningdong, the ' energy iron triangle ' in Ordos and northern Shaanxi. The rational distribution of resource-based industries and water resources is an important part of future development.

## 2.2. Main Water Industry

The high water consumption industries in China 's industrial industry are mainly concentrated in iron and steel, petrochemical, coal chemical, textile and other industries. According to relevant statistics, the annual water consumption of China 's iron and steel industry is about 4.2 billion m<sup>3</sup>, accounting for 3 % of industrial water consumption. The water consumption of petrochemical industry is about 7.2 billion m<sup>3</sup>, and the annual water consumption of modern coal chemical projects in the Yellow River Basin is about 530 million m<sup>3</sup>. The annual water consumption of the textile industry is about 3 billion m<sup>3</sup>, so the improvement of industrial water resource efficiency should be concerned from the above major industrial water consumption industries.

## 3. The Influencing Factors of Industrial Water Resources Efficiency

### 3.1. Technical Factors

The improvement of industrial water resources efficiency by water-saving technology is reflected in the development of high-efficiency energy-saving water-using equipment, green low-carbon sewage treatment technology and wastewater reuse system. For example, the use of reverse osmosis technology and membrane bioreactor can increase the amount of wastewater reuse [ 5 ]. Process optimization technology can reduce industrial water consumption by optimizing the production process, such as reducing the use of industrial cooling water or recycling water resources. From the technical dimension, the influencing factors of industrial water resources efficiency mainly include the following aspects :

1 ) Water treatment technology. Advanced water treatment technology can effectively treat and recycle wastewater, so that it can be reused and reduce the demand for fresh water. Membrane separation technology : such as reverse osmosis ( RO ), nanofiltration ( NF ), etc., these technologies can efficiently remove impurities in water [ 6 ], so that wastewater can be recycled. Biological treatment technology : such as activated sludge process, biofilm reactor, etc. These methods use microorganisms to degrade pollutants in water and improve water treatment efficiency.

2 ) Water-saving technology, such as the development of water-saving cooling system, low water consumption of production equipment, these equipment can reduce the consumption of water in the production process. In addition, accelerating the development of automatic control systems can monitor and regulate the use of water resources through sensors and control systems, and improve the level of intensive use of water resources.

3 ) Cooling system technology. In the industrial circulating cooling stage, the closed cooling system can be vigorously developed. Compared with the open cooling system, it can use circulating cooling water for many times, so it can reduce the consumption of water resources.

4 ) Process optimization. From the perspective of industrial production process, the demand for water can also be reduced by improving the production process. For example, in some fine chemical fields, the water demand of the production system can be reduced by optimizing the reaction conditions. In addition, multiple production steps can be combined by optimizing the composition of the production system or adjusting the process of the production system to reduce the water demand of different sections.

5 ) Monitoring and management technology, through real-time monitoring systems such as the use of sensors and monitoring systems to track the use of water, find and repair the leakage point, improve the efficiency of water resources use, but also use big data analysis and modern

modeling theory to predict and optimize the use of water resources system, thereby reducing the amount of loss.

6 ) Cleaner production technology, development and application of more environmentally friendly production processes and materials, reduce production system water demand and reduce pollution emissions. These technical means can effectively improve the efficiency of industrial water use, help enterprises reduce water consumption and wastewater discharge, and achieve sustainable development goals.

### **3.2. Economic Factors**

The investment of enterprises in water-saving technology needs to consider the rate of return, and the economy and long-term benefits of technology are the key factors. The impact of economic factors on the efficiency of industrial water resources is also crucial, mainly including the following aspects :

1 ) Water pricing. The price of water directly affects the water use behavior of enterprises. Higher water prices will force enterprises to adopt water-saving measures and water resource recovery technologies to reduce operating costs. The water price structure encourages conservation ( such as grading fees according to water consumption ). If ladder water prices are adopted, enterprises are more likely to pay attention to water conservation and efficiency improvement [ 7 ].

2 ) Investment costs, the introduction of advanced water treatment and water-saving technologies usually requires a higher initial investment. If enterprises can undertake such investment, they can obtain higher water use efficiency. From the perspective of operating costs, although high-efficiency water treatment and water-saving technologies may increase costs at an early stage, they can reduce water use and wastewater treatment costs in the long run, resulting in economic benefits.

3 ) Economic incentive policies. Subsidies, tax breaks or other economic incentives provided by the government can reduce the cost of water-saving and water treatment technology. Environmental regulation and fines : Strict environmental regulations and fines for excessive emissions can force companies to invest in more efficient water resources management technologies.

4 ) Market competition. In the industry with fierce market competition, enterprises usually take measures to improve the efficiency of water resources in order to reduce production costs and enhance competitiveness. Brand and reputation : Environmental protection and sustainable development have an important impact on brand image. Some companies may invest in water-saving technologies to enhance the brand 's green image and win market recognition.

5 ) Scarcity of resources. In areas where water resources are scarce, the cost of water resources acquisition is high. Enterprises must improve the efficiency of water resources use to cope with the challenges of resource shortage. In addition, the implementation of water rights and quota systems in some water-scarce areas can also affect the water use strategy of enterprises and encourage enterprises to optimize the use of water resources.

6 ) The level of economic development, the level of economic development in different regions, water resources management investment and technical level will be different. Developed regions usually can afford more investment in environmental protection and water-saving technologies, while developing regions may face greater economic pressure.

7 ) Financing and capital acquisition. The ability of enterprises to obtain funds determines whether they can invest in water-saving technologies and water treatment facilities. The diversity of financing channels and financing costs will affect the decision-making of enterprises. These economic factors work together to determine the strategy and efficiency of enterprises in water resources management. Through reasonable economic policies and

market mechanisms, enterprises can be encouraged to adopt more effective water resources management measures to achieve a win-win goal of economic development and environmental protection.

### 3.3. Policy Factors

The government promotes the efficiency of industrial water resources by formulating water resources management regulations and water standards. Such as the development of emission limits, water quotas and water efficiency standards. Incentive policies, including tax incentives, subsidies and reward and punishment mechanisms, encourage enterprises to adopt efficient water resources management measures. The impact of policy factors on industrial water resources efficiency is mainly reflected in the following aspects :

1 ) Regulations and standards. The wastewater discharge standards set by the government can encourage enterprises to adopt advanced water treatment technology to meet regulatory requirements. In addition, by stipulating the maximum limit of industrial water, enterprises are encouraged to reduce the use of water and promote the application of water-saving technologies.

2 ) Fiscal incentive policy. The government provides subsidies or financial support to enterprises adopting water-saving and water treatment technology to reduce the investment cost of enterprises. It can also provide tax relief for enterprises implementing water-saving and environmental protection measures to encourage enterprises to upgrade and improve technology.

3 ) water resources management policy, clear the ownership and use rights of water resources, to ensure the rational allocation and efficient use of resources. Implement the water use quota system, limit the water consumption of enterprises, and encourage enterprises to optimize water resources management.

4 ) Environmental policies, the development of environmental protection laws and regulations, requiring enterprises to reduce water pollution and wastewater discharge in the production process. Ecological protection measures : the implementation of policies to protect water and ecological environment, limiting the excessive exploitation of water resources.

5 ) Planning and coordination, formulate regional water resources planning and management measures, coordinate the use of water resources in different regions, and optimize the overall allocation of water resources. Cross-sectoral cooperation : Promote cooperation between government departments, enterprises and scientific research institutions to promote innovation and technological progress in water resources management.

6 ) Public participation and transparency, requiring enterprises to disclose water use and pollution data, improve transparency, and enhance public supervision. Encourage public participation in water resources management and protection, and increase social attention and participation in water resources issues.

These policy factors jointly affect the water resources management strategy of enterprises, promote their efficiency in the use of water resources, and support the sustainable development of industry in the new era.

## 4. Measures to Improve the Efficiency of Industrial Water Resources

1 ) Adopt advanced technologies, such as automatic water monitoring and control systems, water-saving equipment ( such as high-efficiency nozzles, low-flow valves ). Water reuse and recovery : the implementation of wastewater recycling system, the wastewater treatment and reuse in the production process.

2 ) Implement best practices and develop a comprehensive water resources management plan, including water audits, water-saving target setting and implementation details. Improve

employees' water-saving awareness and operational skills, and promote the establishment of water-saving culture within the enterprise.

3 ) Policy and regulatory support, formulate and improve regulations and standards for industrial water, and supervise enterprises to comply with relevant laws and regulations. Enterprises can also be encouraged to adopt water-saving technologies and management measures through financial subsidies and technical support. Measures to improve the efficiency of industrial water resources cover multiple levels of technology, management and policy. Here are some common measures :

4 ) Technical improvement, the introduction of advanced wastewater treatment technologies ( such as reverse osmosis, membrane bioreactor ) to recycle and reuse wastewater. Rainwater collection : Rainwater collection system is used to convert rainwater into industrial water and reduce the dependence on tap water ; vigorously develop water-saving technology, the use of low water consumption equipment, water-saving cooling system and cleaning equipment ; vigorously develop automatic control equipment : install intelligent sensors and control systems, monitor and regulate the use of water in real time, and avoid waste of water resources ; improve the production process : optimize the production process, reduce the demand for water, such as using less water in chemical reactions or using more efficient processes. Process integration : integrate multiple production steps to reduce the water demand of each step ; the development of closed circulating cooling system, the use of closed cooling system instead of open cooling system, can reduce the consumption of water. From the perspective of management measures, it is possible to scientifically formulate water use goals, set specific water-saving goals and indicators, regularly evaluate and improve the use of water resources, carry out water resources audits, regularly conduct water resources audits, and identify and repair leakage or waste. Carry out water-saving awareness training in the enterprise, carry out water-saving awareness training for employees, and enhance their understanding of the importance of water resources management ; increase the strength of employee operation norms, formulate and implement water-saving operation norms, and ensure that employees operate according to standard processes ; carry out real-time monitoring of relevant water consumption equipment, use sensors and data analysis tools to monitor the use of water in real time, find abnormalities and adjust them in time ; clarify the performance appraisal and evaluation of water resources, regularly evaluate the performance of water resources use, and analyze the effect of improvement measures.

From the perspective of enterprise development, relevant enterprises should follow wastewater discharge standards, ensure that wastewater discharge meets environmental regulations, and avoid fines and penalties. In addition, relevant water use standards and restrictions should be observed to promote the implementation of water-saving measures. Relevant enterprises should also apply for government subsidies to reduce the investment cost of water-saving technology and equipment by using the subsidies and tax incentives provided by the government; participate in environmental protection projects of government and industry organizations, and obtain technical and management support. Encourage and fund research and development of water treatment and water-saving technologies, promote technological progress in the industry, and share best practices and experiences in water conservation and water resources management through industry associations and platforms. Through the above comprehensive measures, enterprises can significantly improve the use efficiency of industrial water resources, and achieve a win-win situation of economic benefits and environmental protection.

## 5. Future Prospects and Conclusions

With the development of technology and the advancement of policies, the efficiency of industrial water resources is expected to be further improved. In the future, we need to pay attention to the following aspects : the application of innovative technologies, the continuous development and promotion of new technologies, and the improvement of water resources utilization efficiency. Comprehensive water resources management, combined with water resources, energy and environmental management, to promote sustainable development. Strengthen international information exchange and technical cooperation to jointly cope with global water resources challenges. Improving the efficiency of industrial water resources is an important part of achieving sustainable development. Through technological innovation, policy support and the promotion of best practices, the utilization of water resources can be effectively improved. Enterprises and governments need to work together to face the challenges of water resources management in order to achieve a win-win situation of economic benefits and environmental protection.

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