Development status of global seawater desalination industry and dynamically comparative analysis of its production cost

Songhua Huan 1,3, Xiuli Liu 1,2,3,*
1 Academy of mathematics and systems science, Chinese Academy of Sciences, Beijing, China
2 Center for Forecasting Science, Chinese Academy of Sciences, Beijing, China
3 University of Chinese Academy of Sciences, Beijing, China

*Corresponding author e-mail: xiuli.liu@amss.ac.cn

Abstract. This paper summarizes seawater desalination's development status in China and abroad, then analyses its domestic development trend and attention through Baidu Index. Then compares the cost differences among RO, MED and other technologies in different scales and years and their change trend. Furthermore, the paper identifies the main impacting factors of production costs with RO and MED and evaluates their contributions to the cost through actual cases. The results show that: with the expansion of production scale and technological progress, the production cost of seawater desalination is gradually reduced, and the cost of RO and MED was reduced by 29.75% and 36.97% from 1999 to 2017, respectively. In the production cost of seawater desalination, power cost accounts for nearly 40%, and fixed asset investment accounts for about 20%. On a 100000 m$^3$/d scale, the production costs with RO or MED in China are 26.85% and 22.50% higher than those of foreign countries, respectively. The production cost of seawater desalination is about 1.28 times of tap water and 1.20 times of reclaimed water in China. In the future, reducing the production cost of seawater desalination in China can be promoted through scientific investment and operation, technological progress and innovation, improving the cost structure, making up for the shortage of talents, and government guidance and support mutually.

1. Introduction

Many countries and regions are facing water shortage problem. According to the prediction of relevant departments, the most serious Chinese water shortage problem will appear in 2030, when the population will reach the peak and effective measures are not taken in advance, the economic and social losses caused by water shortage will be even greater. With the rapid development of seawater desalination technology, seawater desalination is playing an important role in solving the water shortage problem[1]. The cost of seawater desalination is the main factor constrains its development.

This paper first summarizes the development status of seawater desalination at home and abroad, analyzes the trend and attention of seawater desalination related indicators through Baidu Index, and then dynamically compares and analyzes the cost differences and trends of RO and MED in different scales and years. Through domestic and foreign examples, we compare and analyze the main factors affecting the cost of desalination in China, and then carry out the desalination project cost comparison.
of desalinated water, tap water and reclaimed water. Finally, based on the analysis of the results, some suggestions are put forward to reduce the cost of seawater desalination in China.

2. Global status of seawater desalination

According to the international organization for desalination, in June 2018, there were more than 16000 desalination plants operating in the world, which produced 875 million cubic meters of fresh water every day and supplied nearly 300 million people \(^2\). Especially in Saudi Arabia, the United Arab Emirates and Kuwait in the Middle East, the desalination output of the three countries accounts for more than one third of the world. Due to the lack of local water resources, they started seawater desalination earlier and invested more funds in projects.

Chinese seawater desalination capacity has developed rapidly since 2005, the scale of desalination capacity increased year by year (Figure 1). By the end of 2018, 142 desalination projects had been established in China, with a daily output of 1201741 cubic meters of desalinated water. Most of China's desalination projects are distributed in Tianjin, Shandong, Hebei and other northern coastal provinces where water resources are scarce. By the end of 2018, the desalination capacity of Tianjin, Shandong and Hebei was 317245 m\(^3\)/d, 282625 m\(^3\)/d and 173500 m\(^3\)/d respectively. Civil desalination projects are mainly distributed in Zhejiang, Guangdong and other places. In 2018, the completed scale of desalination projects in Zhejiang was 232295 m\(^3\)/d, while that in Guangdong was 89296 m\(^3\)/d. In China, RO and MED are the main desalination technologies (Figure 2). With the deepening of belt strategy, the policy of water conservation and space management, the demand for seawater desalination is increasing.

3. People's attention to seawater desalination in China

This paper uses Python to capture the daily frequency of Baidu Index from 2011 to 2020, and draws the trend chart of every half year (Figure 3) and annual attention trend chart (Figure 4) after data sorting.

On the one hand, the seawater desalination related index had obvious fluctuation characteristics in the past 10 years, and tended to be stable from 2018. The volatility is reflected in the development of key words such as seawater desalination and seawater desalination companies, with the average daily search times of 422.82 and 45.29 respectively, and their value ranged in 159-2202 and 0-2173
respective, showing the strong concern of Chinese residents on seawater desalination. On the other hand, Chinese desalination industry is greatly affected by policies, media and other public opinions at home and abroad.

![Figure 3. Development trend of seawater desalination related indexes](image)

**Figure 3. Development trend of seawater desalination related indexes**

Data sources: Baidu index

Seawater desalination equipment accounts for more than 45%; the attention of seawater desalination cost fluctuates, about 30%; the attention of seawater desalination listed companies shows a downward trend, accounting for about 10%. From 2011 to 2020, the public's attention to seawater desalination indicates that the future development of seawater desalination in China had formed a good public foundation.

**4. Comparative analysis on production cost of seawater desalination**

Due to the large time span, the impact of price index on the cost cannot be ignored. Therefore, the comparable prices (2017 is the base year, use PPI and fixed asset investment price index) are adopted in the following chapters to make a dynamic comparison of the cost. The results are shown in Table 1.

| unit:(yuan / ton) | RO | MED |
|------------------|----|-----|
| time             | 1999 | 2006 | 2010 | 2017 | 1999 | 2006 | 2010 | 2017 |
| 10000t/day       | 6.67 | 5.95 |     |     | 6.67 | 5.95 |     |     |
| 30000t/day       | 6.28 | 5.25 | 5.03 |     | 7.71 |     |     |     |
| 60000t/day       |     | 5.19 |     |     |     | 6.65 |     |     |
| 100000t/day      | 6.01 | 4.50 |     | 7.07 |     | 5.40 | 4.50 |     |
| 250000t/day      |     | 4.52 |     | 4.92 |     | 6.52 | 4.93 | 4.90 |
| 500000t/day      |     |     |     | 4.40 |     | 6.33 | 4.81 |     |
| 1000000t/day     |     |     |     | 4.01 | 7.22 |     |     |     |
| Mean value       | 6.32 | 5.46 | 4.76 | 4.44 | 7.34 | 6.50 | 5.05 | 4.70 |

![Figure 4. Desalination concerns](image)

**Figure 4. Desalination concerns**

Data sources: Baidu index
Data sources: Collected from the desalination projects and literatures

Further explore the composition differences of desalination production costs under different production technologies and scales, based on the calculation results of relevant scholars and the collected production and operation data, and convert them into comparable prices. The comparison results are shown in Table 2 and 3.

### Table 2. Comparison of production cost components of RO

| Chemicals   | Material | Electricity | Salary | Maintenance | Depreciation | Financing | Others | Production costs |
|-------------|----------|-------------|--------|-------------|--------------|-----------|--------|-----------------|
| 0.49        | 0.21-0.35| 3.11        | 0.16   | 0.23        | 1.50         | 0.07      |        | 5.94            |
| 0.21-0.35   | 0.38-0.58| 1.55-1.77   | 0.15   | 0.14-0.28   | 0.63-0.85    | 0.07-0.28 |        | 3.86-6.63       |
| 0.29-0.78   | 0.38-0.58| 1.73-2.98   | 0.19-0.48| 0.17-0.23   | 0.87-1.25    | 0.19-0.24 |        | 4.36            |
| 0.39        | 0.55      | 2.31        | 0.17   | 0.46        | 1.07         | 0.34      |        | 4.56-5.11       |
| 0.38        | 0.87-1.05 | 1.43        | 0.17   | 0.23-0.26   | 1.48-1.76    | 1.46      | 0.27-0.45       | 4.41-6.88 |

1. LAVENDER Co.: http://www.docin.com/p-671787304.html (2013-06-28)
2. ZHEJIANG HUANENG Co.: https://wenku.baidu.com/view/44dcb3d2d2d233d4b14e852458fb770bf78a3bf3.html (2020-06-09)
3. Ashkelon Co.: https://xueqiu.com/9600279824/74147798 (2016-08-28)

Table 2 shows, to RO method, reasonable use of chemicals and desalination consumables, as far as possible to achieve large-scale electricity and water saving and constantly innovate technology, improve the level of desalination equipment localization and automation, and seek policy and technical support from the government and domestic universities and research institutes are of great benefit to the cost saving of desalination.

### Table 3. Comparison of production cost of MED

| Chemicals   | Material | Steam | Electricity | Salary | Maintenance | Depreciation | Financing | Others | Production costs |
|-------------|----------|------|-------------|--------|-------------|--------------|-----------|--------|-----------------|
| 0.17        |        |      |             |        |             |              |          |        | 4.92            |
| 0.19-0.49   |        |      |             |        |             |              |          |        | 5.29-7.14       |
| 0.19-0.48   |        |      |             |        |             |              |          |        | 5.57            |
| 0.29        |        |      |             |        |             |              |          |        | 4.70-8.56       |
|             |        |      |             |        |             |              |          |        | 5.51            |
|             |        |      |             |        |             |              |          |        | 6.75            |

1. Li (2010): http://www.docin.com/p-671787304.html (2013-06-28)
2. LAVENDER Co.: https://wenku.baidu.com/view/44dcb3d2d2d233d4b14e852458fb770bf78a3bf3.html (2020-06-09)
3. Ashkelon Co.: https://xueqiu.com/9600279824/74147798 (2016-08-28)
4. Li (2010): http://www.docin.com/p-671787304.html (2013-06-28)

Table 3 shows that for MED seawater desalination, speeding up the highly automated and intelligent construction of seawater desalination plant, realizing the desalination application of technology + new energy, and paying attention to reducing the desalination fees help to reduce the cost of desalination.
Figure 5. Cost components of RO (left) and MED (right) desalination

Data sources: Collected from Wang (2020) [6]

Conventional water and reclaimed water are two kinds of water sources that we frequently contact in our daily life. Only when the cost of desalination is close to or lower than their cost, people will consider gradually using desalinated seawater [12]. Table 4 compares the production costs of conventional water, reclaimed water and desalinated seawater under similar production scale.

Table 4. Comparison of production costs of three water supply sources

| Unit: (yuan/ton) | LAVENDER Co. (desalinated seawater) 2013, 10000 m³/d | SANYUAN Co. (conventional water) 2013, 12558 m³/d | DONGFENG Co. (reclaimed water) 2014, 15000-20000 m³/d |
|-----------------|----------------------------------------------------|-------------------------------------------------|------------------------------------------------------|
| Chemicals       | 0.21-0.49                                          | 0.77                                            | 0.35                                                 |
| Materials       | 0.21-0.49                                          | 0.65                                            | 0.80                                                 |
| Electricity     | 1.55-2.43                                          | 0.54                                            | 0.69                                                 |
| Salary          | 0.15-0.19                                          | 0.12                                            | 0.16-0.22                                           |
| Maintenance     | 0.14-0.39                                          | 0.82                                            | 0.96-1.27                                           |
| Depreciation    | 0.63-1.17                                          | 0.09                                            | 0.09                                                 |
| Financing       | 0.07-0.09                                          | 0.23                                            | 0.23                                                 |
| Others          | 0.07-0.09                                          | 0.23                                            | 0.23                                                 |
| Production costs| 4.10                                                | 3.21                                            | 3.41                                                 |

SANYUAN Co.: https://wenku.baidu.com/view/1b196525e418964be8b4b9d528a81c759f52e32.html (2018-12-18)

Table 4 shows that the unit water production cost of desalinated seawater is about 1.28 times of tap water and 1.20 times of reclaimed water. The main cost difference lies in energy and power cost and material consumption cost. The material consumption of desalinated seawater is significantly lower than that of conventional water and reclaimed water. The cost of energy, power and electricity for desalination is the key factor to improve the competitiveness in water market.

5. Conclusion

From the research, we can see that with the expansion of production scale and technological progress, the cost of RO and MED was reduced by 29.75% and 36.97%, respectively, from 1999 to 2017. The power cost accounts for nearly 40%, and fixed asset investment accounts for about 20% of the total cost of seawater desalination. On a 10000 m³/d scale, the production costs with RO or MED in China are 26.85% and 22.50% higher than those of foreign countries, respectively. The production cost of seawater desalination is about 1.28 times of tap water and 1.20 times of reclaimed water in China. In order to reduce the cost of seawater desalination, based on the results analysis, the following strategic suggestions are put forward.

First, scientific investment and operation should be realized. The water supply and minimum guarantee contracts should be signed according to the actual income situation, and agreements should be reached with power plants, heating companies and industrial enterprises as far as possible. Second, we should accelerate the innovation and progress of seawater desalination technology.
improvement and innovation of the basic engineering technology of seawater desalination, strive to enrich the relevant research of desalination. Third, we should improve the cost structure of desalination. We should try our best to use more new energy such as nuclear energy and wind energy, promote the "localization" and "unmanned" of technical facilities, and actively respond to the needs "Industry 4.0" to reduce labor costs and equipment maintenance costs. Fourth, we should actively make up for the shortage of talents. According to local conditions, efforts should be made to explore the personnel training mechanism of seawater desalination, and make targeted preparations for the establishment of desalination school enterprise research center. Fifth, government guidance and support should be strengthened. Governments need increase financial and tax policy support, regularly subsidize the enterprises with good performance and excellent achievements in desalination according to the scale of water production.

6. Acknowledgments
This work was financially supported by National Natural Science Foundation of China (71874184).

References
[1] Q.R. Zou, X.L. Liu, Economic effects analysis of seawater desalination in China with input-output technology, Desalination, 380(2016) 18-28.
[2] N. Voutchkov, Energy use for membrane seawater desalination – current status and trends. Desalination, 431(2018) 2-14.
[3] Q. Wang, G.J. Zheng, Y.W. Tan, Progress of desalination industry in China, Technol. Water Treat. 40(2014) 12–15. (in Chinese)
[4] Y.W. Tan, X.J. Zhang, W.S. Chen, et al. A pilot project for reverse osmosis seawater desalination at 10000 m³/d in Rongcheng, Technol. Water Treat. 3 (2004) 157–161 (in Chinese)
[5] Y.L. Yan, Y.Q. Wu, S.B. Wu, Analysis of cost advantage potential of seawater desalination in water supply industry. Journal of Salt Science and Chemical Industry, 47 (2018) 16-20. (in Chinese)
[6] R.H. Wang, P.F. Huang, X.J. Wang, et al. Study on cost structure and cost control of seawater desalination. Journal of Salt Science and Chemical Industry. 49(2020) 19-23. (in Chinese)
[7] Q.C. Meng, Total cost analysis of various water sources and optimization of water supply structure in Qingdao. Shandong University of science and technology, 2011. (in Chinese)
[8] X.M. Li, Techno-economic analysis and comparison of the main seawater desalination method, Enterprise 2 (2010)63–70. (in Chinese)
[9] K. Sadeghi, S. H. Ghazaie, E. Sokolova, E. Fedorovich, A. Shirani, Comprehensive techno-economic analysis of integrated nuclear power plant equipped with various hybrid desalination systems. Desalination,493(2020) 114623.
[10] A. Ophir, F. Lokiec, Advanced MED process for most economical sea water desalination. Desalination,182(2005) 187-198.
[11] L.L. Zhang, M.T. He, Z.Z. Wang, et al. Full cost analysis of seawater desalination in coastal water deficient cities--a case study of Huaneng Weihai Power Plant. Journal of Economics of Water Resources,39(2021) 31-35+80. (in Chinese)
[12] P. Du, L. Li, J. C. Wang, Methods and cost analysis of seawater desalination technology. Engineering Cost Management,2 (2018) 64-69. (in Chinese)
[13] Z. X. Zhang, Analysis on investment and operation cost of high-quality reclaimed water plant. Beijing Water,5 (2015) 49-52. (in Chinese)