Research on Operational Performance Evaluation System of Urban Waste Treatment PPP Project Based on AHP

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Abstract. Based on the research status of the operational performance indicators of waste treatment projects, according to the relevant standard specifications and accounting the actual operability, this paper established an operational performance evaluation system for waste treatment projects. The constructed evaluation system covers indicators such as economic benefit, social benefit, satisfaction, ecological benefit and project sustainability. The initial data are obtained through questionnaire survey. The weight of each index is determined by AHP, combining the individual indicator status values to obtain the operational performance evaluation criteria. The established indicator system can help managers to provide project management direction, promote the optimization of funding allocation, and improve the operational efficiency of waste treatment projects.

1. Introduction
With the continuous advancement of industrialization and urbanization, China has achieved remarkable achievements in economic construction, and the environment has also faced enormous challenges. According to the China Environmental Report, the economic losses caused by environmental pollution have reached 54 billion US dollars, of which urban domestic waste accounts for 51%, and the treatment of urban domestic waste has become an urgent matter. With the gradual exposure to the shortcomings in the traditional garbage disposal mode, the public's requirements for urban infrastructure construction are getting higher and higher, and the government's financial pressure is increasing. The PPP model has won the favor of the government by virtue of its own efforts to alleviate financial pressure and make full use of the professional and technical advantages of social capital. In the process of introducing the PPP model, in order to ensure the efficient operation of the garbage disposal project, how to evaluate the operational performance has become a focus of strengthening project management and promoting the development of the PPP model.

In view of this, this paper takes the garbage disposal PPP project as the research object, builds the operational performance evaluation index system based on the previous research, and uses the AHP to carry out the weight analysis. Finally, the specific operational performance is obtained through the analysis of the operational performance evaluation standard value. The evaluation indicators are intended to provide an accurate means of performance evaluation for waste disposal projects.

2. Construction of evaluation index system

2.1. Determination of primary indicators
To build a reasonable operational performance evaluation index system, the first step is to set the appropriate first-level indicators. Whether the first-level indicator setting is reasonable is related to the
accuracy of the second- and third-level indicators. The primary indicators can be determined by the opinion documents issued by relevant national government departments on performance evaluation and the common methods in the literature combined with the characteristics of the garbage disposal PPP project.

According to the *Ministry of Finance's Instructions on Conducting Budget Evaluation of Central Government Investment Projects* (Cai Jian [2004] No. 729), the performance evaluation is carried out in three stages: Performance evaluation of pre-project, construction period and operation period. The *Instructions* proposed that the project operation performance evaluation is mainly to evaluate the economic, social and environmental impacts of the projects being used. The evaluation content may include the degree of completion of the target, cost analysis and evaluation, economic and social actual impact, and project sustainability.

As the garbage disposal PPP project has more attention to social and ecological benefits, this paper will also refer to the “5E” principle. The “5E” principle is based on the “3E” principle. The “3E” principle is a commonly used method for traditional public project performance evaluation index system, referring to "Economy," "Efficiency," and "Effectiveness". As society continues to develop, people are paying more and more attention to the impact of public projects on society and the environment, thus evolving the “5E” principle. The “5E” principle adds “Equity” and “Ecology” to highlight the social and environmental performance of public projects.

The content of the *Instructions* is combined with the “5E” principle to determine the primary indicators. This paper sets the primary indicators as: economic benefits, social benefits, satisfaction, ecological benefits and project sustainability.

### 2.2. Determination of the second and third level indicators

In order to more clearly find the operational performance indicators of urban garbage disposal PPP projects, this paper will determine the secondary and tertiary indicators by dividing general and specific indicators. The general indicators are mainly determined based on the literature, mainly from the aspects of project economics, social benefits, project operation management, and satisfaction. Special indicators refer to specific indicators in garbage disposal projects, such as garbage pollutants. The special indicators here are mainly ecological benefits, which are determined according to the relevant policy documents on waste disposal and waste incineration. According to the relevant literature [1-2] and the documents, eight secondary indicators and 23 third-level indicators are compiled, as shown in Table 1.

| Primary indicator | Secondary indicators | Three-level indicator |
|-------------------|----------------------|-----------------------|
| Economic benefits | Financial benefit     | Operating cost control rate |
|                   |                      | Own capital in place rate |
|                   |                      | Economic internal rate of return |
| Social benefits   | Impact on the people | Increase in average income of residents in the project area |
|                   |                      | Increase in employment opportunities in the project area |
|                   | Impact on industry development | Promote industry innovation and fair competition |
| Satisfaction      | Public service satisfaction | Government satisfaction |
|                   |                      | Public satisfaction |
| Ecological benefits | Sustainable development | Safe operating rate |
3. Evaluation of operational performance evaluation indicators

3.1. Judgment matrix construction.
This article mainly through the questionnaire survey method. The five experts in the PPP project area of the quasi-operating infrastructure scored the importance of the 23 indicators obtained in Table 1. After obtaining the specific data, the AHP was used for further calculation. Matrix (1) is a judgment matrix based on an expert's scoring of the primary indicators of the garbage disposal PPP project.

\[
A_1 = \begin{bmatrix}
1 & 1/3 & 1/2 & 1/2 & 1/3 \\
3 & 1 & 1 & 1 & 1/2 \\
2 & 1 & 1 & 1/2 & 1/3 \\
2 & 1 & 2 & 1 & 1 \\
3 & 2 & 3 & 1 & 1
\end{bmatrix}
\]

(1)

3.2. Hierarchical ordering and consistency check
After the single-layer judgment matrix is constructed, the maximum eigenvalue \( \lambda_{\text{max}} \) of the judgment matrix \( A_n \) and its corresponding feature vector are calculated, and then the feature vector is normalized to obtain the ranking weights of the evaluation indexes of the same layer relative to the importance of an upper index. This process is a hierarchical ordering. The constructed judgment matrix should be tested for consistency.

The consistency ratio C.R. of the judgment matrix is determined by the ratio of the consistency index C.I. to the average random consistency index RI, and the R.I. can obtain the value, C.I. = \( (\lambda_{\text{max}} - n)/(n-1) \), where n is the order of the judgment matrix. When C.R. < 0.1, the consistency of the judgment matrix is recognized, otherwise the judgment matrix needs to be corrected.

In order to obtain the ranking weights of the lowest level indicators for the total target, the total ordering of the levels should also be calculated. The total sorting weights should be combined from top to bottom. The total ranking of the hierarchy also needs to be consistent, and the test method is the same as above.

Calculate according to the above steps, first use the data given by the experts to calculate the weights of the first, second and third level indicators, and then calculate the average value. Finally, the operational performance index weights of the urban waste disposal PPP project can be obtained, as shown in Table 2.
| Primary indicator | Secondary indicators | Three-level indicator | Index Weight |
|-------------------|----------------------|-----------------------|--------------|
| Economic benefits | Financial benefit    | Operating cost control rate | 1.94%        |
|                   |                      | Own capital in place rate | 2.35%        |
|                   |                      | Economic internal rate of return | 3.98%        |
| Social benefits   | Impact on the people | Increase in average income of residents in the project area | 3.38%        |
|                   |                      | Increase in employment opportunities in the project area | 10.13%       |
| Impact on industry development | Promote industry innovation and fair competition | 2.71%        |
| Satisfaction      | Public service satisfaction | Government satisfaction | 3.56%        |
|                   |                      | Public satisfaction | 10.67%       |
|                    |                      | Safe operating rate | 6.31%        |
|                   |                      | Operational technical reliability | 3.13%        |
|                   |                      | Treatment plant operating load rate | 5.87%        |
|                   |                      | Staff training rate | 1.07%        |
|                   |                      | Management technology innovation | 2.31%        |
| Ecological benefits | Sustainable development | Annual garbage disposal rate | 5.45%        |
| Pollutant treatment | Acid gas emissions | Soot emissions | 4.50%        |
| Project sustainability | Heavy metal emissions | Acid gas emissions | 3.74%        |
| Incineration waste treatment | Dioxin emissions | Heavy metal emissions | 4.90%        |
| Environmental protection | Leachate treatment | Dioxin emissions | 6.00%        |
|                        | Fly ash processing | Leachate treatment | 1.17%        |
|                        | Slag treatment | Fly ash processing | 1.01%        |
|                        | Odor control situation | Slag treatment | 1.44%        |
|                        | Noise control situation | Odor control situation | 9.14%        |

4. Analysis of operational performance evaluation criteria

4.1. Determination of the standard value of index evaluation
The operational performance evaluation standard of urban garbage disposal PPP project is the yardstick for measuring the performance of the project. It is necessary to estimate the actual completion of the evaluation project according to the standard. When studying operational performance evaluation criteria, it is first necessary to determine the basis for the value of operational performance evaluation criteria. This paper will be based on the research project of the “Research on the Optimization and Evaluation Standards and Methods of Performance Evaluation Index System for Government Investment Capital Construction Projects”, and the value basis of the operational performance evaluation criteria for urban garbage disposal PPP projects is divided into two types: normative indicators and reference indicators.
The first is the normative indicators, which are called horizontal comparison standards. These indicators are classified into four categories according to the relevant provisions of the *Standardization Law of the People's Republic of China*, which are national standards, industry standards, local standards and corporate standards. Based on the above criteria, the standard value of performance indicators based on normative indicators, as shown in Table 3.

| Index                                      | Evaluation standard value | Standard value characteristics | Index                                      | Evaluation standard value | Standard value characteristics |
|--------------------------------------------|---------------------------|--------------------------------|--------------------------------------------|---------------------------|--------------------------------|
| Own capital in place rate                  | 100%                      | The bigger the better          | Safe operating rate                        | 100%                      | The bigger the better          |
| Annual garbage disposal rate               | 100%                      | The bigger the better          | Staff training rate                        | 100%                      | The bigger the better          |
| Treatment plant operating load rate        | 95%                       | The bigger the better          | Operational technical reliability          | 95%                       | The bigger the better          |
| Soot emissions                             | 30mg/m3                   | The smaller the better         | Dioxin emissions                           | 0.1ng TEQ/m3              | The smaller the better         |
| Acid gas emissions                         | NOx: 300 mg/m3            | The smaller the better         | Hg: 0.1 mg/m3                              |                           |                                |
|                                            | SO2: 100 mg/m3            |                                | Pd: 1.0 mg/m3                              |                           |                                |
|                                            | HCl: 60 mg/m3             |                                |                                            |                           |                                |
|                                            | CO: 100mg/m3              |                                |                                            |                           |                                |
| Odor control situation                     | 10 (dimensionless)        | The smaller the better         | Noise control situation                    | Daytime ≤65dB             | The smaller the better         |
|                                            |                           |                                |                                            | Night ≤55dB               |                                |

Secondly, the reference standard, also known as the vertical comparison standard, is leveraged. It is different from the normative indicator and usually does not need to be approved and filed by relevant government departments [3]. Such standards include benchmarking standards, planning standards, historical standards, empirical standards, etc. According to the above criteria, the evaluation criteria for performance indicators based on reference indicators are shown in Table 4.

| Index                                      | Evaluation standard value | Standard value characteristics | Index                                      | Evaluation standard value | Standard value characteristics |
|--------------------------------------------|---------------------------|--------------------------------|--------------------------------------------|---------------------------|--------------------------------|
| Economic internal rate of return           | 8%                        | The bigger the better          | Increase in employment opportunities in the project area | 0.3                       | The bigger the better          |
| Increase in average income of residents in the project area | 0.16%                    | The bigger the better          | Promote industry innovation and fair competition | 90 marks                  | The bigger the better          |
| Government satisfaction                    | 90 marks                  | The bigger the better          | Operating cost control rate                | 6%                       | The bigger the better          |
| Public satisfaction                         | 90 marks                  | The bigger the better          | Fly ash processing                         | 99.8%                    | The bigger the better          |
Slag treatment 90% The bigger the better Leachate treatment 250m3/d The bigger the better

Management technology innovation 12% The bigger the better

4.2. Calculation of index coefficients
In the specific performance evaluation, we will use the combination of actual indicators and weights to calculate the specific performance coefficient of the project. In the above two standards, the standard value is characterized by the larger the better the setting is the forward index [4], the smaller the better the reverse index, when calculating the specific index value of the forward indicator and the reverse indicator, set the lower limit of the forward indicator score to 60 points, and the lower limit of the difference value of the reverse index is set to 40 points [5].

4.2.1. Positive index coefficient formula
(1) When the actual index value ≥ standard index value, the final score of the indicator = index weight
(2) When the actual index value < standard index value, the actual index value is converted into the percentage system.
That is, the actual index (percentage system) = (actual index value × 100) ÷ standard index value
If the actual indicator (percentage system) < 60, the final score of the indicator is 0
If the actual indicator (percentage system) ≥ 60, then the final score of the indicator = actual indicator (percentage system) × index weight

4.2.2. Reverse index coefficient formula
(1) When the actual index value ≤ standard index value, the final score of the indicator = index weight
(2) When the actual index value > standard index value, the difference between the actual index value and the standard index value is converted into a percentage system.
That is, the difference value=actual index value-standard index value
Difference value (percentage system) = (variation value × 100) ÷ standard index value
If the difference value (percentage system) ≥ 40, the final score of the indicator is 0
If the difference value (percentage system) <40, the final score of the indicator = [1 - difference value ÷ standard index value] × index weight
The project performance coefficient is obtained by summing all the indicator scores.

5. Conclusion
It can be seen from the weight of operational performance evaluation indicators that ecological benefits and project sustainability are important factors in evaluating operational performance. For waste treatment projects as quasi-operating projects, economic benefits have less impact on operational performance evaluation. More emphasis should be placed on the sustainability of the project itself and its impact on the environment during the operational phase. In addition, the indicator evaluation criteria can directly assist the performance evaluation of urban waste treatment projects.

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