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Study on Construction and Application of Circular Economy Evaluation Index System in Petrochemical Industry

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Petrochemical industry is the focus of circular economy construction, circular economy evaluation index system is an important task.This article briefly introduced the circular economy and circular economy evaluation system, clarified the construction of chemical enterprises circular economy evaluation system principles.Using analytic hierarchy process, given the weight of the index system.The article selects 24 quantitative indicators from the aspects of resource utilization, resource recycling and waste disposal and disposal, and objectively, accurately and effectively determines the weight of indicators,and evaluate and analyze the development of circular economy in petrochemical industry from 2014 to 2017 in our country.

1. Introduction

Petroleum is an important strategic material and energy resource, and also an important chemical raw material. It is called "industrial blood" and "black gold", playing an important role in today's economy and society. The circular economy of petroleum industry is a development mode based on the continuous circular utilization of petroleum resources and their living resources and environments with the features of the low consumption and high utilization of natural resources and the low emission of wastes. The outstanding problem of sustainable development in today's society is the contradiction between "development" and "resource environment". The development of circular economy is an important measure of China to implement the scientific concept of development and construct environment-friendly and resource-saving enterprises, and it is an objective need to guarantee the sustainable development of petrochemical enterprises. Under the environment of increasing shortage of resources and energy, vigorously adjusting industrial structure and promoting transformation and upgrading, it's an arduous task of chemical groups to further develop circular economy.

At present, the research of circular economy evaluation index system in petrochemical industry is mainly in qualitative analysis, which cannot reflect the development level of circular economy in chemical industry. Therefore, in order to promote the development of circular economy in chemical industry, a more targeted and quantifiable index system should be adopted (Zhang, 2018). Thus, this study sets up a quantifiable circular economy evaluation index system in petrochemical industry, in order to carry out a quantitative evaluation of the development level of the circular economy in petrochemical industry.

1.1 Brief introduction of circular economy and its evaluation index system

Circular economy is the abbreviation of closing materials cycle economy, that is to say, in the large system of human, natural resources and science and technology, the materials and energy are used with a step-by-step and closing circulation manner in the whole process of resource input, enterprise production, product consumption and abandonment, so as to continuously improve the utilization efficiency of resources, and transform the traditional development relying on the linear increase of net consumption of resources into an economic operation mode relying on ecological resource circulation, as shown in Figure 1 (Yang et al., 2012). Circular economy is divided into three levels: inter-enterprise circulation; regional circulation, which mainly refers to the industrial park circulation; and social circulation, which mainly refers to the circulation between

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enterprises and society (Thomas et al., 2018). The generally considered evaluation methods for judging circulation at each level is shown in Table 1:

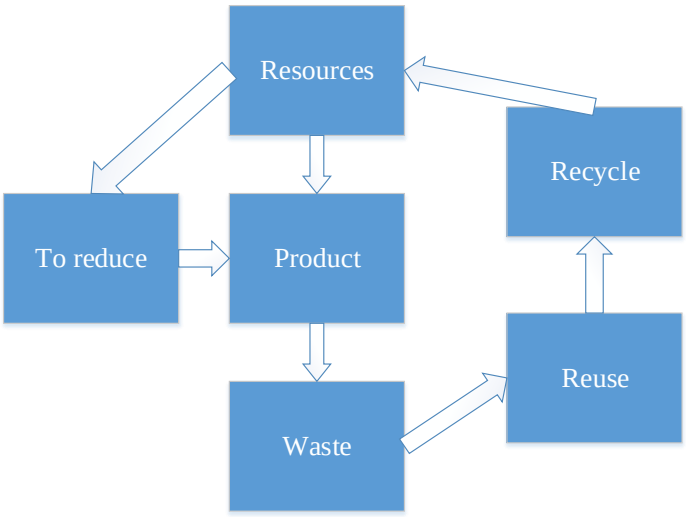

Figure 1: The basic mode of circular economy

Table 1: The evaluation methods of circular economy cycle

Evaluation method	Concept
Life cycle method	Evaluate the environmental impact of each phase of the product life cycle
Cleaner Production Audit method	In accordance with certain procedures and standards, to investigate and diagnose the service and production process, find out the reasons of high pollution, high consumption and low efficiency, put forward plans to reduce consumption and efficiency, and then choose a set of improved production technology to promote corporate clean production
Material flow analysis method	Quantitatively estimate material flows in society

The index system of circular economy is the theoretical basis for formulating the development goal and plan of circular economy, and it is also a quantitative evaluation tool for assessing the effect of circular economy. The development goal of circular economy is to achieve the balance between environmental protection and economic development on the basis of making full use of resources and energy and reducing pollution emission to the maximum extent (Xiao, 2013; Guneet et al., 2017).

1.2 Principle of circular economy evaluation index system in petrochemical industry

According to the theories and objectives of circular economy development, the following principles should be followed in establishing circular economic evaluation index system of petroleum industry: systematicness, scientificalness, operability and cohesion (Wang et al., 2017, Ju Ran., 2016).

2. Construction of Recycling Economy Index System in Petrochemical Industry

2.1 Selection and construction of evaluation index

According to the target size, this study divides the circular economic evaluation index system into target level, criterion level and index level. The actual value, the reference value or the set reference value of the index, and the determined weight need to be taken into account during the evaluation (Yin et al., 2016). The corresponding index system is detailed in Figure 2. In the index system, 24 quantitative indexes, such as total energy consumption, crude oil processing amount, coal consumption, resource consumption for industrial output value of ten thousand yuan in petrochemical industry, standard rate of discharge of waste and rate of change in final disposal of industrial wastes, are selected from three aspects of resource utilization, resource recycling reuse and waste discharge and disposal, serving quantitative evaluation indexes of recycling economy in petrochemical industry. The evaluation index system is divided into positive indexes and reverse

indexes. Among them, the energy consumption index and pollutant index are reverse indexes, and the smaller the value is, the better it is to meet the requirement of circular economy. The others are positive indexes, and the larger the value is, the more it conforms to the requirements of circular economy.

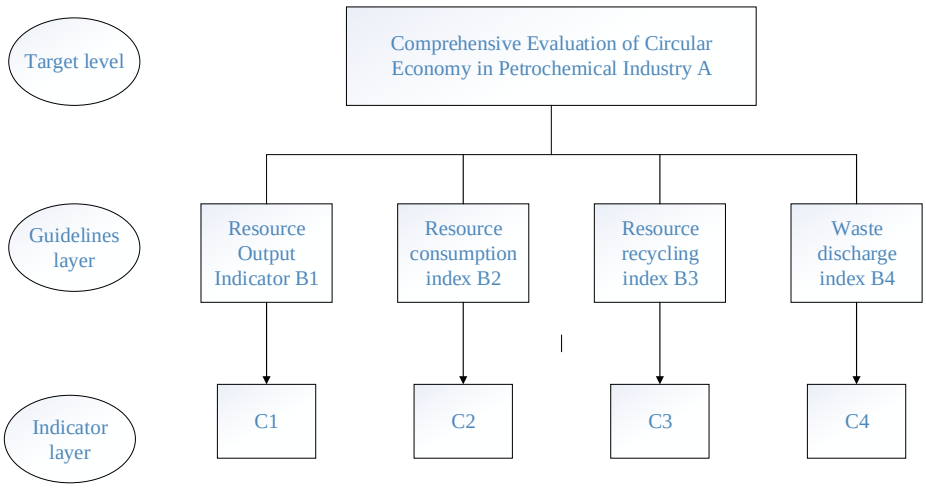

Figure 2: The framework of Circular economy index system in etrochemical industry

2.2 Determination of weight of evaluation index

In the large system of evaluation index, the subsystem or element of each level has different importance to the whole system, so when describing the change characteristics of the composite system of evaluation index system, it is necessary to determine the importance degree of different indexes relative to the evaluation index system, that's, to determine the weight of the evaluation index system. Among the many methods, this paper adopts the analytic hierarchy process (AHP) (Andrea, 2017), which is widely used at present. See Figure 3 for the solution process of AHP.

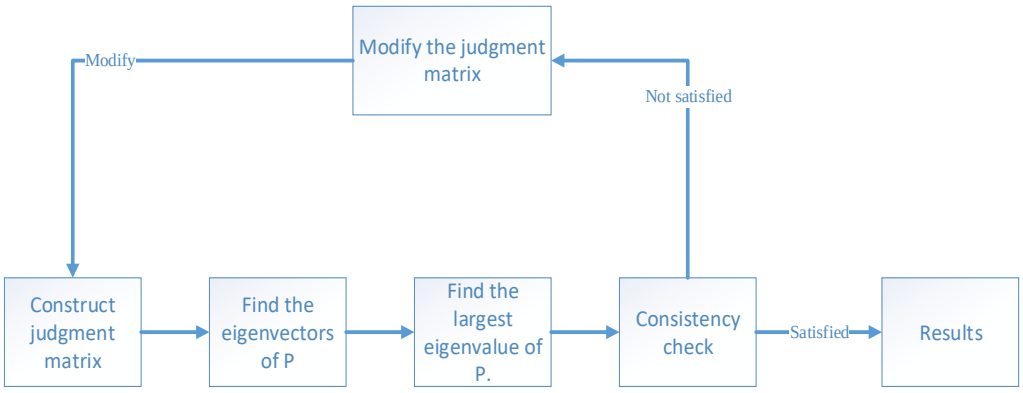

Figure 3: The Process of Analytic Hierarchy

2.3 Comprehensive evaluation index

The general evaluation model of multi-index comprehensive evaluation method is the index scoring method based on weighted average. This method combines the single index evaluation value (dimensionless result) of multiple indexes into one (or several) comprehensive evaluation value by means of weighted average. It has the advantages of conciseness, intuition, clear conclusion and strong maneuverability. The calculation formula is:

$$P = \sum_{i=1}^{n} W_i P_i \tag{1}$$

Where, P is comprehensive evaluation value for the evaluated object and ranges from 0 to 1; P_i is the evaluation score of the ith index of the evaluated object; W_i is the weighted value of the ith index of the evaluated object; n is the number of indexes of the evaluated object (Yao et al., 2010. Wang et al., 2013). Therefore, by referring to domestic and international data and grade division of clean production evaluation system for high energy consumption industries, the five-level circular economy standard is designed, as shown in Table 2.

Table 2: Comprehensive evaluation index of circular economy development enterprises

Circular economy development level	Circular Economy Development Index	Comment
The first level	P >0.9	Circular economy has a high level of development
second level	0.8 <P≤0.9	Circular economy has a less high level of development
The third level	0.7 <P≤0.8	Circular economy development is in general
The fourth level	0.6 <P≤0.7	Circular economy development level is low
Fifth level	P≤0.6	Circular economy development level is very low

3. Applied Research on Recycling Economy Index System in Petrochemical Industry

The circular economy evaluation index system of petrochemical industry established in the above is used to evaluate the development of the circular economy in China's petrochemical industry from 2014 to 2017.

3.1 Data source processing

Due to the lack of data on the consumption of water resources in the petrochemical industry, the consumption of water resources and the repetition rate of industrial water in the petrochemical industry are eliminated in the evaluation process, and gasoline, diesel, ethylene, benzene and plastic resins are selected as key products.
The energy consumption data and "three wastes" emission data of petrochemical industry all come from China Statistical Yearbook. The industrial output value, industrial added value and key product output of petrochemical industry come from China Economic Yearbook and China Chemical Industry Yearbook. The ratio index is calculated according to the calculation method of AHP. See Table 3 for data processing results.

3.2 Data analysis

According to the quantitative indexes of resource utilization and "three wastes" emission, from 2014 to 2017, the solid waste emission has been controlled, but the resource consumption and waste water and waste gas emission of the petrochemical industry have increased year by year, which poses a great threat to resources, as well as causes serious pollution to the atmosphere and water resources. It’s necessary to vigorously develop circular economy. This proves that the contradiction between environmental pollution and resource constraint determines the urgency of developing circular economy in petrochemical industry and demonstrates the rationality of the index system. In terms of resource utilization, although the total energy consumption, crude oil, coal, natural gas and electric power are all increasing, the industrial output value per unit energy source is also increased and the resource utilization efficiency is enhanced. The energy consumption per ten thousand yuan of output value in the petrochemical industry is reduced and the energy consumed for per ten thousand yuan of industrial output value is also reduced. Generally speaking, since 2014, the energy consumption of the petrochemical industry has been increased, but the energy use efficiency has also been improved. In the aspect of resource recovery and reuse, both the level of waste recovery and the level of resource recycle have been improved. The recovery rate of sulfur dioxide is increasing, which indicates that the pollution control level of sulfur dioxide in petrochemical industry is improving. The recovery rate of smoke and dust doesn’t change obviously, and the pollution control has not been improved. The wastewater discharge compliance rate and the recovery rate of solid wastes have been improved. The comprehensive utilization, the comprehensive utilization rate, and the resource utilization rate of solid wastes, the output value of comprehensive utilization products of "three wastes" and the recycling utilization rate of resources have all been improved year by year. In the aspect of waste discharge and disposal, the discharge amount of solid wastes and solid waste with the industrial added value of ten thousand yuan decreases year by year, the discharge amount of waste gas and waste water and the discharge amount of waste gas and waste water with the industrial added value of ten thousand yuan increases year by year. Pollution of the atmosphere and water

resources should not be ignored. The rate of change in the final disposal of industrial waste is very unstable. In 2014 and 2016, the rate of change in the final disposal of industrial wastes was negative, the final discharge amount of wastes is reduced, and the degree of environmental pollution is reduced; the rate of change in the final disposal of industrial wastes in 2015 was significantly higher than that in other four years, with significant increases in waste emissions and pollution level.

Table 3: Evaluation of circular economy in petrochemical industry

Target level	Guidelines layer	Indicator layer	Specific indicators	2014	2015	2016	2017
Data processing results of Evaluation Index System of Circular Economy in Petrochemical Industry	Resource utilization	Resources Consumption	Total energy consumption (10,000 tons of standard coal)	7898.3	8784.3	9112.4	12229.3
			Crude oil processing capacity (10,000 tons)	20093	21930	22587	26983
			Coal consumption (10,000 tons)	8533.1	9890.2	16382.1	17839.4
			Natural gas consumption (100 million cubic meters)	15.39	15.49	19.37	20.47
			Electricity consumption (100 million kilowatt hours)	267.38	332.93	427.2	438.9
		Resource utilization efficiency	Resource productivity (RMB / tonne crude oil)	2192.3	2912.4	3011.7	3290.6
		Resource consumption intensity	Petrochemical industry yuan industrial output value of resource consumption (Tons of crude oil / million)	4.98	4.98	4.11	4.97
			Unit petrol production crude oil consumption	5.98	5.37	5.33	5.19
			Unit Diesel Production Crude Oil Consumption	2.69	2.62	2.89	2.94
			Unit Ethylene production Crude oil consumption	45.33	43.65	47.23	40.16
			Unit benzene production Crude oil consumption	121.45	127.43	131.48	130.57
			Unit plastic resin production Crude oil consumption	17.48	18.31	18.99	19.32
	Recycling of resources and discharge	Waste recycling	Sulfur dioxide recovery (%)	51.44	59.38	58.29	61.02
			Soot recovery rate (%)	89.03	91.38	89.03	99.47
			Dust recovery rate (%)	61.22	62.99	69.03	68.29
			Wastewater discharge compliance rate (%)	99.19	101.28	95.48	96.72
			Solid waste recovery rate (%)	67.34	67.39	69.11	71.35
		Esource recycling	Comprehensive utilization of solid waste (10,000 tons)	98.32	99.19	102.22	101.49
			Solid waste comprehensive utilization rate (%)	76.32	87.98	76.39	72.38
			Solid waste recycling rate (%)	67.44	77.92	87.23	76.61
		Waste discharge	Exhaust emissions (100 million standard cubic meters)	5.41	5.92	6.11	6.97
			Sulfur dioxide emissions (10,000 tons)	55.98	58.98	59.48	61.86
			Industrial dust emissions (10,000 tons)	0.283	0.078	0.029	0.097
	Waste disposal	Waste disposal	Industrial waste final disposal change rate (%)	-12.66	32.89	-1.39	19.37

4. Conclusion

The petrochemical industry is an intensive industry with energy, water resources and resource consumption. It is also the most promising, most qualified and most urgent industry that needs to develop a recycling economy.This article is in accordance with the requirements of circular economy development, using circular economy development principles and theories as a guide, and according to the current situation of circular economy in our country, constructed a circular economy evaluation index system for the petrochemical industry. The article selects 24 quantitative indicators from the aspects of resource utilization, resource recycling and waste disposal and disposal, and objectively, accurately and effectively determines the weight of

indicators,and evaluate and analyze the development of circular economy in petrochemical industry from 2014 to 2017 in our country.

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