Strategic Environmental Assessment at Policy Level: A Case Study of Industrial Restructuring Policy in Shandong Province

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Abstract: In order to overcome the shortage of end-of-pipe waste treatment, China is attempting to realize a sustainable development path by industrial restructuring. Analysis and prediction of the strategic environmental impacts of the industrial restructuring policy of Shandong Province indicates that such restructuring has an apparent effect on reducing energy and water consumption and SO_2 emissions, but cannot have an effective impact on reducing wastewater and Chemical Oxygen Demand discharges. Industrial restructuring policy is capable of alleviating negative eco-environmental impacts caused by economic growth, but it cannot eradicate these impacts completely. These predictions suggest that other measures like developing new and alternative energy, raising utilization efficiency of energy and water resources, shifting from extensive to intensive economic growth and strengthening pollution treatment are required if Shandong Province is to realize a balanced and sustainable development for the society, economy and environment.

Key-words: Strategic environmental assessment, Industrial restructuring, Policy

1 Introduction

After rapid economic growth averaged more than 9.5% in the past two decades, the contradiction between insufficient resource supply and rapidly-increased resource demand is becoming a serious issue in China. The nation is currently in the middle of a period of intense industrialization and ensuring that this development can be sustained is a significant challenge [1]. China's rapid industrial growth is based on extremely high resource consumption and has resulted in serious environmental pollution [2,3,4]. The output of waste gas, contaminated water and solid waste per unit GDP is much higher than in developed countries [5]. China is placing more emphasis on industrial restructuring and constructing a more energy-saving and environmentally-friendly society. Whatever the approach, industrial restructuring represents an attempt at managing and anticipating change, simultaneously tackling issues of economic, social and environmental significance.

Strategic environmental assessment considers the environmental impacts of policies, plans, and programs (PPPs) and their alternatives [6]. To be effective, the strategic environmental assessment process needs to begin at strategic policy level and "trickle down" to lower tiers of PPPs-development [7]. This article uses a case study of industrial restructuring policy making in Shandong Province to illustrate strategic environmental impacts at the policy level. The application of this technique leads to some surprising conclusions as to the impacts of industrial restructuring on energy and water consumption, and also on environmental performance.

2 Industrial Restructuring Policy Analysis

Industrial structure is a key factor within human activities that influences the eco-environment system. Its combined type and intensity have distinct impacts on economic benefit, efficiency of resource utilization and eco-environment state [8]. An industrial restructuring policy is one of the significant economic policies with which governments are able to influence environmental outcomes, with the main characteristics of a huge investment budget, a high intensity of natural resources exploitation and utilization, and an ability to provide extensive impacts to different social sectors. Moreover, it may also bring remarkable impacts to the local and regional eco-environment.

In order to ameliorate the serious conflict of economic development and natural resources supply and environmental protection, Shandong Province released its detailed industrial restructuring policy as published in the "Ecological Province Construction Compendium"[9]. The industrial restructuring policy contains a package of plans & programs and impacts upon every aspect of society. However, it is very difficult to describe the environmental impacts quantitatively, especially at the stage of implementing these plans and programs. But the industrial restructuring policy sets out a final goal of an improved industrial structure. In essence, the policy demonstrates how the tertiary sector will increase in importance at the expense of both primary and secondary industries in the period to 2020. By analyzing the different impacts, mainly in energy consumption, water consumption and environmental quality, caused by the changing proportions of the three industrial sectors, we can observe the strategic environmental impacts of the industrial policy.

3 Forecast and Assessment of Strategic Environmental Impacts

Shandong Province's GDP is 1,549 billion RMB in 2004 and is projected to reach 2,100 and 4,200 billion RMB in 2010 and 2020, respectively [9]. To forecast the environmental impacts by carrying out the industrial restructuring policy in Shandong Province, two prospective scenarios are plotted.

Scenario 1: Assessment is made assuming the continuation of industrial policy and industrial structure as in 2004. The proportion of production value for primary, secondary and tertiary industry in 2004 being 11.5:56.3:32.2.

Scenario 2: Assessment is made after Shandong Province implements industrial restructuring policy, the proportion of production value for the three industries is 9.4:45.6:45 in 2010 and 7:43:50 in 2020 respectively.

The differences of energy and water consumption, environmental quality between scenario 1 and 2 are the strategic environmental impacts of the industrial restructuring policy. In order to give prominence to the impacts of the industrial policy, all predictions of scenario 1 and 2 are made dependent on a constant energy and water consumption coefficient, wastewater and waste gas treatment efficiency as the base year 2004.

3.1 Forecast and Assessment of Impacts on Energy Consumption

The total energy output and consumption were 143.94 million and 196.06 million tce (tonnes of standard coal equivalent) in 2004. Raw coal has accounted for more than 70% of the total energy consumption in the past decade. Energy consumption coefficients of the primary, secondary and tertiary industry in the base year 2004 were 51,380, 198,790 and 27,042 tce/billion RMB respectively [10]. Based on the energy consumption efficiency of the three industrial sectors, energy consumption of the two scenarios is displayed (Table 1). The total energy consumption of 2010 and 2020 is predicted as 265.72 million and 531.44 million tce in scenario 1, and it changes to 226.06 million and 430.90 million tce in scenario 2.

Table 1 show that after industrial restructuring, in 2010 and 2020, energy consumption is reduced by 39.67 million and 100.54 million tce, 14.93% and 18.92% less than the situation of non adjustment of industrial structure. Industrial restructuring has a distinct effect on reducing energy consumption.

Shandong Province's main energy sources, the remaining coal reserves represents only 2.2% of China's total coal reserve after a long period of high-intensity mining, and crude oil output can not be increased significantly in the near future. So the total energy output of Shandong Province will stay approximately at the level of 2004. But energy consumption in 2010 will still rise to 226.06 million tonnes in scenario 2, which is a 57% increase of energy output from 2004. The increased energy demand will leave Shandong Province with a serious energy crisis over the next few years. So increasing energy efficiency and new and alternative energy development is necessary and should be a key element of state policy.

3.2 Forecast and Assessment of Impacts on Water Consumption

In 2004, Shandong Province's water supply amount was 24.49 billion m^3; total water consumption was 21.49 billion m^3 [11]. Water consumption of the different industrial sectors is listed in Table 2. In terms of efficiency, the water consumption coefficients of the three industries were 90,086.04□ 3,255.19 and 1,115.72 m^3/million RMB, respectively [14]. Based on the water consumption efficiency of the three industries, the water consumption under the two scenarios can be estimated as shown in Table 2.

Table 1 Prediction of energy consumption in Shandong Province

Energy consumption (Million tce)		2004	2010	2020
Scenario 1	Primary industry	9.14	12.41	24.81
	Secondary industry	173.43	235.03	470.06
	Tertiary industry	13.49	18.28	36.57
	Total	196.06	265.72	531.44
Scenario 2	Primary industry	9.14	10.14	15.11
	Secondary industry	173.43	190.36	359.01
	Tertiary industry	13.49	25.55	56.78
	Total	196.06	226.06	430.90

Table 2 Prediction of water demand in Shandong Province

Water demand (billion m^3)		2004	2010	2020
Scenario 1	Primary industry	16.02	21.75	43.50
	Secondary industry	2.84	3.85	7.69
	Tertiary industry	0.56	0.75	1.51
	Total	19.42	26.36	52.72
Scenario 2	Primary industry	16.02	17.78	26.48
	Secondary industry	2.84	3.12	5.88
	Tertiary industry	0.56	1.05	2.34
	Total	19.42	21.96	34.73

After industrial restructuring, the total water consumption by the three industrial sectors in Shandong Province is decreased by 4.4 billion and 17.99 billion m^3 in 2010 and 2020, 16.68% and 34.12% will be saved than before (Table 2). Industrial restructuring has positive effects on reducing water consumption and relieving the tense demand-supply relationship.

Future exploitation of local surface water, ground water, rainfall harvesting, reclaimed water, sea water, and water from the Yangzi River by "South-North Water Diversion Project", suggest that the water supply for the three sectors can reach 25.2 billion and 28.9 billion m^3 in 2010 and 2020, respectively [12]. Compared with the predicted water demand of the two scenarios, it is demonstrated that water shortages will exist in each year under Scenario 1, while under Scenario 2, supply can more than satisfy demand in 2010, leaving however, a severe shortage in 2020 as Scenario 1. Although industrial restructuring is able to curtail water demand substantially, a supply shortage is becoming distinct.

It is clear at a policy level that all industries, especially agriculture and other large-scale water consumption trades in secondary industry, should increase water efficiency and utilize water resources comprehensively, in order to realize a sustainable utilization.

3.3 Forecast and Assessment of Impacts on Environmental Quality

3.3.1 Forecast and Assessment of Impacts on Atmospheric Environment

This paper focuses on the effects of SO_2 emissions from industrial restructuring, which has caused serious air pollutions in Shandong Province. In 2004, SO_2 emissions of Shandong Province were 1.821 million tonnes with 1.544 million tonnes from secondary industry [13].

SO_2 emissions are mainly released by burning coal, while the energy consumption pattern in the next decades will remain similar, using coal as the main source. Coal consumption for the primary and tertiary sectors was 1.05 and 1.367 million tce in 2004 [10]. On the assumption of a positive relationship between coal consumption and SO_2 emissions in each industry, the SO_2 emissions from primary and tertiary industry can be calculated as 120,340 and 156,660 tonnes. The emission coefficients for the three sectors were 676.71, 1,769.72 and 314.08 tonnes/billion RMB respectively. The estimated SO_2 emissions under the two scenarios are illustrated by Table 3.

It is illustrated that after industrial restructuring, SO_2 emissions in 2010 and 2020 are reduced by 343.07 thousand and 881.65 thousand tonnes, being 13.9% and 17.86% less than the business as usual scenario. Industrial restructuring has an apparent effect of reducing SO_2 emissions.

Shandong's acceptable environmental capacity of SO_2 is 1.34 million tonnes [14]. Despite the prediction of a distinct reduction in scenario 2, the SO_2 emissions in 2010 will be 2,125.07 thousand tonnes which is 1.59 times the acceptable environmental capacity. To alleviate air pollution caused by excessive emissions of SO_2, the construction of new desulphurization facilities, raising desulphurization efficiency in the electric power industry and shifting the basis of energy consumption away from coal to a more diverse base, are all necessary policies.

3.3.2 Forecast and Assessment of Impacts on Water Environment

Industrial wastewater and domestic sewage are the major sources of wastewater in Shandong Province. The total wastewater and COD discharges in 2004, broken down by industrial sectors, are listed in Table 4. The wastewater discharges per million RMB production value were 1,478.59 tonnes for secondary industry and 584.37 tonnes for tertiary industry in 2004, while the average COD discharges per million RMB production value was 400 kg for secondary industry and 185.7 kg for tertiary industry. Then, wastewater and COD discharges under the scenarios 1 and 2 can be calculated (Table 4).

Table 3 Prediction of SO_2 emissions in Shandong Province

SO_2 emissions (thousand tonnes)		2004	2010	2020
Scenario 1	Primary industry	120.34	163.43	326.85
	Secondary industry	1,544	2,092.35	4,184.68
	Tertiary industry	156.66	212.38	424.76
	Total	1,821	2,468.15	4,936.29
Scenario 2	Primary industry	120.34	133.58	198.95
	Secondary industry	1,544	1,694.68	3,196.11
	Tertiary industry	156.66	296.81	659.57
	Total	1,821	2,125.07	4,054.64

Table 4 Prediction of wastewater and COD discharges in Shandong Province

Category		Wastewater discharges (million tonnes)			COD discharges (thousand tonnes)		
		2004	2010	2020	2004	2010	2020
Scenario 1	Primary industry	-	-	-	-	-	-
	Secondary industry	1,290	1,748.14	3,496.28	349	472.94	945.89
	Tertiary industry	291.48	395.15	790.31	92.63	125.57	251.14
	Total	1,581.48	2,143.29	4,286.58	441.63	598.52	1,197.03
Scenario 2	Primary industry	-	-	-	-	-	-
	Secondary industry	1,290	1,415.90	2,670.34	349	383.06	722.44
	Tertiary industry	291.48	552.23	1,227.18	92.63	175.49	389.97
	Total	1,581.48	1,968.13	3,897.52	441.63	558.55	1,112.41

With reference to the data of Scenario 2, the wastewater and COD discharges are reduced by 389.06 million and 84.62 thousand tonnes in 2020, being 9.1% and 7.1% less than scenario 1. Compared with the reduction of energy and water consumption and SO_2 emissions, there is not a distinct change in the total wastewater and COD discharges between Scenario 1 and 2. The significant increase of wastewater and COD discharges in the tertiary sector counteracts their reduction in other industries. It is illustrated that industrial restructuring has limited effects on decreasing wastewater and COD discharges.

With the increasing proportion of tertiary industry in the overall industrial structure, much labor will transfer to this sector and settle in urban areas, inducing an enormous rise in the discharges of domestic sewage and COD. To solve the problem, it will be vital to improve the utilization efficiency of water resources, and strengthen industrial wastewater and domestic sewage treatment to reduce pollutants discharges.

4 Conclusions

Compared with the situation of non industrial restructuring, after industrial restructuring, in 2010 and 2020, energy consumption is reduced by 14.93% and 18.92%, water savings are 16.68% and 34.12% and SO_2 emissions reduce by 13.9% and 17.9%. Thus the three industrial sectors being restructured have an apparent impact on reducing energy and water consumption and SO_2 emissions. Although industrial wastewater and COD discharges can be reduced after industrial restructuring, sewage discharges from the tertiary sector are raised, leading to a minor change of 9.1% and 7.1% in the total wastewater and COD discharges in 2020. With the increased development of tertiary industry, the development of urban areas will be stimulated, resulting in a large amount of domestic sewage and COD discharges in cities. Thus, the industrial restructuring policy cannot have an effective impact on reducing wastewater and COD discharges.

The industrial restructuring policy can be judged beneficial to the environment, easing the tension between energy and water supply and demand, as well as improving atmospheric quality in Shandong Province. However, the analysis reveals that with rapid development of the economy, energy and water consumption and total discharges of pollutants are likely to increase overall. Industrial restructuring, by itself, cannot eradicate these important negative environmental impacts. Only through shifting away from a policy of extensive economic growth to a policy of intensive growth, developing new and alternative energy sources and technologies, raising energy and water efficiency, strengthening pollution treatment and cutting down contaminant emissions, allied to an industrial restructuring policy, can Shandong Province realize a balanced and sustainable development of its society, economy and environment.

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