Investigation on Ecological Compensation during the Development of Oil and Gas Resources

---Illustrated by the example of Shengli Oil Field

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Abstract: With the development and utilization of oil and gas resources, the surrounding environment suffers from more and more bad influence. There are many theories of ecology and environment protection home and abroad, among which, the ecological compensation is a hot topic. Taking Shengli Oil Field as an example, this thesis analyzes the oil and gas resources development's impact on our ecology and environment. It points out that although the ecological compensation expresses our willing to protect the environment, its implementation efforts are not enough. In the final part of this paper, it gives some suggestions that we should build up an effective ecological compensation mechanism during the development of oil and gas resources development.

Key Words: oil and gas resources development, ecological compensation mechanism, environmental protection, the standard of ecological compensation

1. Overview of ecological compensation

Now the definition of ecological compensation has many different versions due to the different research angles of varied subjects. And the scholars around the world yet haven't reached an agreement. But all these include the following aspects: in connection with actual problems; in accordance to the relevant disciplinary theory, not colliding with current definition and policies; easy to understand and compare among different definitions.

Dictionary of Environmental Science [1] defines nature ecological compensation as "The expressive moderation for the interference, when the living creatures, stocks and community feel disturbed. They adjust their status to maintain the ability of ecology or it can be seen as a reversion capablility or a compensation and moderation function of ecological environment disruption caused by the economic activities."

Mao Xianqiang[2] analyzed the cost and benefit of the main active body from the exterior theory. And he holds the opinion that ecological compensation is a way to charge (or compensate) of the activity of scathing (or protecting) environment and resources, increase the cost (or benefit) of that activity to encourage (or protect) the behavior to reduce (or increase) the exterior non-economical (or exterior economical) activity so as to achieve the goal of protecting environment.

2. Analysis of the effect on ecological environment of oil and gas development

2.1 Effect on the atmospheric environment

In the process of exploiting oil and gas resources, there are many pollutant sources of the atmosphere, such as the drilling well field, exterior oil extraction, Union stations, water stations, processing stations, separation stations, oil and gas development aid projects and oil and gas storage containers and transport vehicles.

2.2 Effect on water resource

The main pollutants brought by oil and gas development are oily waste water, drilling mud and crude oil on the ground whose pollutants are: COD, oil, heavy metals(like Cr、Hg、Pb、Zn、As) , Sulfide, phenol, salt (especially chloride), alkali and so on.

2.3 Effect on the land resource

The heaviest pollutants of soil are ground crude oil, oily waster water, solid matter, drilling mud and so on. The leaking crude oil covers the earth surface. Retention and adsorption can make most of the oil remain on the soil surface which may change the soil's

physical and chemical property, decrease the ability of soil's water permeability, air permeability and decrease pervious capability. It also influences growth of microbe and plants. This breakage may recover in many years. With the extended development time of oil field, the exploited crude oil contains more and more water, the main effects of which are the rising of the shallow ground water in some areas, soil salinization, and the loss of land use value.

3. Ecological compensation standard calculation of oil and gas resources development by Shengli Oil Field

Ecological compensation is the one for ecology environment disruption. It is a compensation for the resources developer and compensation beneficiary. Thus the main basis lies in the damage extent.

Compensation fee may charge differently according to different mineral resources. And the main imposition methods are the total investment, product sales, product yield, comprehensive imposition, disruption area compensation deposit system, the amount of used resources and so on. [3] According to the products sales, the following shows a ratio of compensation cost against product sales This compensation is collected on the basis of the developing and manufacturing companies' sales amount.

This method can avoid the change of market price. Although it may be effected by the periodicity of oil and gas resources development, the collection method is quite simple while the execution cost is low.

Compensation calculation:

$$EC = EC_1 + EC_2 \quad (3\text{-}1)$$

(EC-ecology loss EC_1—direct ecology loss EC_2—indirect loss of environment pollution)

During the oil and gas resources development, the loss of environment is relatively complicated. We adopt the calculation method of opportunity cost and market value to evaluate the loss. And divide the loss into direct ecology disruption and indirect environment pollution loss. Finally combine them with sales amount to get the compensation charge standard

Calculation of direct ecology loss(EC_1)

Direct ecology loss contains the disruption of earth, water resource, vegetation during the development of oil plus the cost to recover them. The calculating index includes: earth resource, water resource and vegetation resource. It is formulated by: （i=1，2，3 separately represent the earth resource, water resource and vegetation resource）

$$EC_1 = \sum_{i=1}^{n} E_s L_i + \sum_{i=1}^{n} E_f L_i \quad (3\text{-}2)$$

$E_s L_i$ -is the direct disruption loss of Resource i. and $E_f L_i$ is its recovery expenses. The loss of earth resource is the land use loss, therefore we may need to calculate the land area of oil field. The loss of water resource is disruption loss. And the vegetation loss can be seen as its value decreasing. The total land area of Shengli Oil Field is 9255 Mu. And the temporary land area occupied 38.7% of the total illustrated by Table 3-1.

Table 3-1 oil field land area (Unit: Mu)

Land occupation type	occupied area
Arable land	5664
Woodland	148
Lawn	3184
Wetlands	259

Source: Environmental protection Bureau of Dongying City, 2009

According to the 2009 national statistics data [4], the whole nation, 31 provinces (regions, cities)'s total

grain yield is 530,820,000 tons. Our total planting area is 108,970,000 hectares, i.e. around 324.8kg per Mu. The output value of 1 Mu land is 600.9 Yuan based on the grain price 1.85 Yuan/kg in 2009.The national fifth investigation on the timber resource shows that our forestry land area is around 0.267 billion Ha.. Refer to the calculation of forestry land value in Beijing [5]. The total value of forestry land is 3400.5 billion Yuan. That is to say its annual output value per Mu. is 849 Yuan. Value of lawn is 200 Yuan/Mu. The research date of UNEP indicates: Wetland ecological system values 14,000 USD/Hectare annually which means one Mu. Wetland can create a value (economical and ecological value) around 7467 Yuan every year. Thus the loss of land resource is:

E_3L_1=5664x600.9+148x849+3148x200+259x7467 =6,093,000 Yuan

The exploitation of petroleum not only destroys the ground water resource but also influences its purity. Experts and typical data estimate that a representative oil field may damage around 10 tons ground water when exploiting 1 ton petroleum. That is to say every year there are 222,400,000 tons water disrupted by Shengli Oil Field who in 2009, put out 27,800,000 tons crude oil, 0.7 billion cubic meters natural gas. And the average price of national industrial use water is 2.35 Yuan/cubic meter. Thus the loss of water resource is:

$E_5L_2=2.224x10^8$ X2.35=522,640,000 Yuan

To calculate the loss of vegetation, we should consider the value of it. The value of vegetation includes the present value and the potential value. The ecological benefit given by the vegetation lies in six aspects [6]: Soil and water conservation, regulating climate and weather, pollution control, prevention of biological hazards, biodiversity and renewable energy use. The benefit of soil and water conservation may contain: water resource protection (prevent drying), avoid floods, soil erosion, maintain soil fertility (nitrogen fixation), prevent sedimentation, desertification and stabilize coast. The value of regulating climate and weather is: micro climate and local climate (adjustment) prevent fire and storm, store carbon and carbon sequestration. Biodiversity return us the direct use of biodiversity and tourism value of nature as we can see from the following table whose data is from the biodiversity team of Council for International Cooperation on Environment and Development in China

Table 3-2 Ecological benefit of vegetation (Unit: billion Yuan)

Ecosystem benefit	Present value	Lowest potential value
soil and water conservation		
water protection	200	1079
floods prevention	2980	2980
soil erosion prevention	320	320
keep soil fertility	67	144
prevention of sedimentation	151	151
avoidance of desertification	54	280
stabilization of coast	2	2
regulating climate and weather		
micro and local climate	impossible to assess	impossible to assess
fire prevention	4.3	4.3
storm prevention	3	3
storing of carbon	474	474

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carbon sequestration	20	20
pollution control	20	99
prevention of biological hazards	80	160
biodiversity		
direct use value	336	618
nature tourism	12	12
renewable energy	43	236
lowest value	4746.3	6582.3

Source origin: China biodiversity team of Council for International Cooperation on Environment and Development in 2010

From the above table, the lowest ecological value of vegetation is

I = 4746.3 billion + 65823 billion

= 11328.6 billion

China's total land area of 960 million hectares, equivalent to:

S = 960 × 15 = 144,000,000 Mu

Thus, the direct loss of vegetation:

E_5L_3 = 7.87 × 9255 = 728,369,000 Yuan

Total direct loss:

$\sum_{i=1}^{n} E_5 Li$ = 609.3 + 52264 + 72836.9

= 1.257（billion）

The recovery cost of ecosystem is different due to diverse resources. As for earth resource, long-time occupied soil can not be recovered. It only works to the temporary land or resource land which can not produce oil or gas any more.

Generally, the oil-gas field will become rugged and dilapidated. Therefore we need to cut slope, lower elevation and level it down. Measures like transformation of forest, backfilling of grassland or cultivated land, trenching, building drainage, road construction and large investment.

According to the estimation of Huzhou and Shaoxing, renovation of mines costs 30,000-35,000 Yuan per Mu. [7] Combined the local circumstances of Dongying City, the land remediation cost per mu is about 32,000 or so. The most influenced vegetation in Dongying City is cultivated land, grassland and forest. And their cost of recovery and newly reclaiming is almost the same. So the expenses of cultivated land, grassland and woodland can be calculated equally.

Once the water is polluted, it must get water from a far away place. According to the research on the Dongying Oil Field's influence on domestic water use, it takes 4600 Yuan to restore the running water pipe. And we can calculate the underwater recovery cost according to the population effected. Take Dongying Yidong Oil Field (a medium size oilfield) as an example, the influenced residents is around 65 families. There are 42 oil fields in Dongying City. Domestic water use problem cause by oil exploitation influence 65 families. And in 2009, the total is 2370 families. The term of oil field development is 20 years. Thus the cost for recover water resource is 628,000 Yuan.

As for vegetation resource, once it is destroyed, it is hard to recover in a short period. So the vegetation recovery expenses depend on the time factor. The time element is too hard to calculate. However, the land where the vegetation used to grow can be transformed to woodland or grassland. This transformation may be seen as a way to recover the vegetation. We can consider the vegetation recovery cost into the restoration of land resource

Total recovery cost:

$\sum_{i=1}^{n} E_j L_1 = 3.2 \times 9255 \times 0.387 + 62.8 = 0.115$ (billion Yuan)

Then with formula (4-2) we can get the direct ecology loss:EC = 1.257 + 0.115 = 1.372

(2)Indirect environmental pollution loss (EC_2) calculation

Indirect pollutions include the loss of soil pollution, air pollution, water pollution and noise pollution. And the calculation index should contain these four aspects. Formula as follows:

$$EC_2 = EL_s + EL_A + EL_w + EL_N$$

EL_5 represents soil pollution loss; EL_A for air pollution loss, EL_W for water pollution loss and EL_N for noise pollution loss.

Soil pollution mainly refers to the solid waste pollution. In the exploitation, the solid waste contains sediment and drilling mud etc. The current equipment can work for 10 years. From the data given by Dongying Environmental Protection Bureau, Shengli Oil Field spends 1,810,000 Yuan in controlling the solid waste. The annual ground crude oil made by Shengli is 211,200 tons, waste mud 257,800 tons and oil sludge around 141,200 tons. The State Council's "Sewage Collection and Management Regulations" (State Council Decree No. 369) stipulates that oil sludge is hazardous solid waste and 1,000 Yuan per ton should be collected for the sewage treatment. Then three of the pollution costs should be charged 610.2 million Yuan. Therefore, the annual cost for treating solid waste is: EL_5=181/10+61020=612.281(million)

And it is the same calculation method for air pollution loss, water pollution loss and noise pollution loss. The pollution treatment equipment also serves for 10 years. From the official data, in 2009, the cost of controlling air pollution is around 28.98 million Yuan, 379.03 million Yuan of water pollution treatment, and 1.72 million for managing noise pollution.

$$EL_A = 2898/10 = 289.8$$
$$EL_w = 37903/10 = 3790.3$$
$$EL_N = 172/10 = 17.2$$

(i.e. 2.898 million Yuan,37.903 million Yuan and 172,000 Yuan respectively)

Then the total indirect pollution loss is

$$EC_2 = 61228.1 + 289.8 + 3790.3 + 17.2 = 6.53$$

(i.e. 653 million Yuan)

(3)Compensation standard calculation Formula:

$$\alpha = EC / TS$$

α -compensation standard; EC -total ecology loss; TS -total output value

As for the environmental compensation of oil and gas resource development, we get the ecology loss according to formula 3-1:

$$EC = 13.72 + 6.53 = 20.25$$

(i.e. 2.025 billion Yuan)

Data obtained from financial futures shows in 2009, the ex-factory price of crude oil is about 3900 Yuan per ton. National Development and Reform Commission statistics show that the year 2009, ex-factory price of natural gas is at 0.69 Yuan per cubic meter. In 2009, the total output of Shengli Oil Field was 27.8 million tons and natural gas production was 700 million cubic meters. So in 2009 the output value is:

$$TS = 2780 \times 3900 + 70000 \times 0.69 = 1089.03$$

(i.e. 108.903 billion Yuan)

(4) The theoretical value of compensation comparison of the actual value

Through looking up some relevant resources, we get the 2009 ecological compensation cost [8] as follows:

(a) Young crop compensation fee: 899 million Yuan

(b)City water treatment and protection charges: 100 million Yuan

(c)City river maintenance fee: 39.96 million Yuan

(d)City water resource fee 28.75 million Yuan. It is used to support the water resource facilities construction.

(e) Rural road overrun compensation: 12.50 Yuan

(f) Nature reservation management fee and fire prevention fee: 8 million Yuan.

4. Conclusion

Adopting the mechanism of ecological compensation is a good way to improve companies' consciousness of active environment protection which make the ecology and economy both grow. The theory of compensation mechanism is more matured in China. And quite a few rules and regulation come out. But in the practical execution, there are still many problems and this mechanism is now mainly applied in the fields of mines and water resource protection. It seldom appears in the oil and gas resource development. Therefore, we should work harder on the research work of this aspect.

Through the investigation during writing this thesis, we calculate the compensation cost of Shengli Oil Field to its surrounding environment theoretically.And the compensation standard is 1.86%. Compared with the actual compensation cost in 2009,we can see that our current compensation is not enough.

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