ICAEE2011

Predicating Energy Demand and Carbon Emissions of the Yellow River Delta High-efficiency Eco-economic Zone

Wenjun Wang\textsuperscript{a}, Lijun Ren\textsuperscript{*}, Qianwen Guo\textsuperscript{a}, Tong Chen\textsuperscript{a}

\textsuperscript{a}School of Environmental Science and Engineering, Shandong University, Ji’nan 250100, China

Abstract

The regional condition and natural resources of the Yellow River Delta are superior, but the issues and constrains there are also quite pronounced. So the development of high-efficiency ecological economy is confronted with serious challenges. Take the Yellow River Delta High-efficiency Eco-economic Zone as the evaluation object and at the basis of the analyses of the development situation in the area, the energy consumption and carbon emissions were forecasted and estimated in the paper. The results indicate that the total energy use in 2015 and 2020 would be 1.62 and 2.22 times higher than that in 2009, respectively. The average annual growth rate of carbon emissions is 8.40% from 2009 to 2015 and that would be 6.50% from 2015 to 2020. The amount of carbon emissions of the area in 2015 and 2020 will take up 13.35% and 16.16% of Shandong Province, respectively. Finally, some suggestions were proposed to guarantee the sustainable energy use and the realization of carbon emission reduction.

© 2011 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of the organizing committee of 2nd International Conference on Advances in Energy Engineering (ICAEE). Open access under CC BY-NC-ND license.

Keywords: The Yellow River Delta High-efficiency Eco-economic Zone, Energy consumption, Carbon emissions

1. Introduction

Low-carbon economy is a new economic development model, which is based on low energy consumption, low pollution and low emissions. The key factors of this new model are changing the developing direction of economy, reducing the dependence of fossil fuels, such as coal, oil and nature gas, and encouraging the development of economic to get rid of carbon, including the carbon dependence during the industrialization and urbanization \cite{1-4}.
The impact of urbanization and industrialization on energy use, carbon emissions, populations and environment has been extensively studied. Domestic and international experience show that regional rapid economic development is often at the expense of high consumption of energy resources and environmental degradation. However, in recent years, many scholars believe that due to the difference in economic industry structures, energy consumption composition and regional development levels, the energy use, carbon dioxide emissions and other pressures on social environment are not the same in different regions. For some areas, rapid urbanization and industrialization will not only have no pressure on the society and environment, but to promote energy conservation and reduction of carbon emissions. The reason is that if the economy and society have developed to a certain stage, the benefits of technological innovation and the use of clean alternative energy are much more than the social and environmental pressures. Therefore, the only way to determine the relationship between economic development and different environmental stress factors is to have a reasonable comprehensive analysis of a certain region.

The State Council officially endorsed the “The Development Planning of the Yellow River Delta High-efficiency Eco-economic Zone” on November 23, 2009. The development of the Yellow River Delta is a national strategy and an important part of the regional coordinative development strategy now. The construction of the Yellow River Delta High-efficiency Eco-economic Zone will surely bring rapid economic development, but it will also face a high demand for energy resources. This paper studies the current energy use of the Yellow River Delta High-efficiency Eco-economic Zone. Then the energy demand and carbon emissions are predicted and analyzed in 2015 and 2020 according to the planning objectives of the Yellow River Delta, which can not only help the government to make scientific and rational decisions, but also lay a theoretical foundation for the region to achieve the goal of low-carbon energy use and sustainable development.

2. The general situation and planning analysis of the Yellow River Delta High-efficiency Eco-economic Zone

2.1. The general situation of the Yellow River Delta High-efficiency Eco-economic Zone

The Yellow River Delta High-efficiency Eco-economic Zone is based on the historical Yellow River plain and coastal areas of northern Shandong province and formed by the extended surrounding. It includes 19 counties (cities and districts) in six municipalities. It involves all the cities of Dongying and Binzhou, and Hanting, Shouguang, Changyi, Leling, Qingyun, Gaoqing and Laizhou which has similar nature environment with Dongying and Binzhou. The region has a total area of $2.65 \times 10^4 \text{km}^2$, which is 1/6 of Shandong. After years of construction, the area has a rapid economic development and special industries begin to take shape. The energy use and economic situation can be seen in Fig.1 and Fig.2.

Fig. 1 Energy use and GDP of the Economic Zone

Fig. 2. GDP trend of the Economic Zone from 1990-2009
Based on the statistical data from the regional bureaus, Fig.1 notes that the total energy use and energy use per unit of GDP in 2009 were 41.8369 million tce and 0.89 tce/10^4 Yuan, respectively. From 1990 to 2009 (Fig.2), GDP of the area was increasingly in small scales, which accounted for 12.20%~14.87% in the GDP of Shandong province and 0.98%~1.48% in the nation, respectively. The GDP of the Economic Zone reached 479.476 billion in 2009, which was 25.99 times than that in 1990. Meanwhile, it took up 14.15% in Shandong and 1.41% in the country.

2.2. The planning analysis of the Yellow River Delta High-efficiency Eco-economic Zone

In the new historical conditions, in order to promote the economic development of the Yellow River Delta High-efficiency Eco-economic Zone and improve the layout of the nation’s coastal economy, the plan says that by 2015: The Economic Zone will form a new ecological economic development model of which economic and social development is compatible with the resources and environment carrying capacity and strive to double the per capita GDP; The ecological environment will be improved and energy saving achieve remarkable results; The industrial structure will be further optimized and a basic system of circular economy will be formed; Infrastructure, water security and efficiency will be significantly improved; Public service capacity will be strengthened and the quality of life will be dramatically increased. The plan also says that by 2020: People and nature will get well along with each other and the ecological environment and economic development will be highly integrated; The capacity for sustainable development will be significantly increased and the ecological civilization construction will achieve remarkable results; A more competitive modern eco-industrial system will be formatted, the level of an open economy will be substantial increased and social enterprise would flourish; The Economic Zone intend to be constructed to be the first national high-efficiency economic zone which has prosperous economic, beautiful environment and rich life [8] (Table 1).

Table 1. Planning objectives of the Yellow River Delta High-efficiency Eco-economic Zone

<table>
<thead>
<tr>
<th>Indicators</th>
<th>2008</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP (10^8 Yuan)</td>
<td>4756</td>
<td>9300</td>
<td>15000</td>
</tr>
<tr>
<td>GDP per capita (Yuan)</td>
<td>48336</td>
<td>90000</td>
<td>140000</td>
</tr>
<tr>
<td>Core area (10^4 mu)</td>
<td>400</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>Decrease ratio of energy use per unite of GDP (%)</td>
<td>/</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>Reduce ratio of the main pollutants (%)</td>
<td>/</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Forest coverage (%)</td>
<td>18.7</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>Urbanization rate (%)</td>
<td>42.5</td>
<td>54</td>
<td>60</td>
</tr>
</tbody>
</table>

3. Energy forecast of the Yellow River Delta High-efficiency Eco-economic Zone

In light of “The Development Planning of the Yellow River Delta High-efficiency Eco-economic Zone”, the energy use per unit of GDP will decrease by 22% in 2015 compared to 2008, and that will drop by 15% in 2020 compared to 2015. Consequently, the energy use per unit of GDP will decrease to 0.73 tce/10^4 Yuan and 0.62 tce/10^4 Yuan in 2015 and 2020, respectively. Meanwhile, reference to the planning, the GDP will stand at 930 billion Yuan and 1.5 trillion Yuan in 2015 and 2020, separately. Table 2 details that the total energy use in 2015 and 2020 would be 1.62 and 2.22 times higher than that in 2009, respectively. The gap between the energy consumption and GDP is enlarging gradually, that
is, the amount of energy use is cut down via improving the energy efficiency or introducing clean and renewable energy in the period of the high-speed economic development in the area.

Table 2. The results of the energy consumption in the Yellow River Delta High-efficiency Eco-economic Zone.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>2008</th>
<th>2009</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP (10^8 Yuan)</td>
<td>4600.20</td>
<td>4694.76</td>
<td>9300.00</td>
<td>15000.00</td>
</tr>
<tr>
<td>Energy consumption per GDP (tce/100million)</td>
<td>0.94</td>
<td>0.89</td>
<td>0.73</td>
<td>0.62</td>
</tr>
<tr>
<td>Energy consumption (10^4 tce)</td>
<td>4331.02</td>
<td>4183.69</td>
<td>6789.00</td>
<td>9300.00</td>
</tr>
</tbody>
</table>

4. Carbon emissions forecast

Carbon emissions can be divided into natural and artificial discharge. Artificial emission is due to human activities, mainly including fossil fuels, biomass combustion and so on. Particularly, the emission of CO₂ from fossil fuels accounts for more than 95% [9-11]. Therefore, fossil fuels were selected as the major carbon source to calculate the carbon emissions in Shandon Province. Due to China has not direct carbon emissions test data, the majority of studies are based on estimates of the energy consumption. Based on the assumption that there exists positive correlation between energy consumption and carbon emissions and take the energy structure into account, the carbon emissions in the area were calculated by means of a converted formula [9]. The equation can be described as,

\[
\overline{F} = \frac{E_1F_1 + E_2F_2 + \ldots + E_iF_i}{E_j} \quad (1)
\]

Where, \( \overline{F} \) is the coefficient of average carbon emissions; the subscript \( i \) denotes the different types of energy; \( E_i \) is the energy consumption of \( i \); \( F_i \) is the carbon emission coefficient of \( i \); \( E_j \) is the total energy consumption.

According to the comprehensive report “China’s Sustainable Development of Energy and Carbon Emissions under Different Development Scenarios” from Energy Research Institute National Development and Reform Commission and other relevant empirical data [12-14], the coefficients of carbon emissions from different energy are shown on Table 3.

Table 3. Coefficient of carbon emissions of different energy

<table>
<thead>
<tr>
<th>Energy</th>
<th>Coal</th>
<th>Oil</th>
<th>Natural gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficients</td>
<td>0.7476</td>
<td>0.5825</td>
<td>0.4435</td>
</tr>
</tbody>
</table>

The coefficient of average carbon emissions reflects the comprehensive effect of the carbon emissions per unit energy consumption from different energy structures in different regions. Regarding the formula above, the results imply that the coefficients were fluctuating in a small scale (0.69~0.71 ton carbon/tce) from 1985 to 2009.

The carbon emission coefficients were 0.709 ton carbon/tce and 0.707 ton carbon/tce in 2008 and 2009 in Shandong, and the amount of carbon emissions will stand at 361.1933 million ton and 408.5712 million ton in 2015 and 2020, respectively. From the perspective of the data availability, the carbon emissions from 2008-2020 in the Yellow River Delta Economic Zone were computed referencing to the average carbon emission coefficients of Shandong. In the paper, 0.71 ton carbon/tce was employed as the average carbon emission intensity. The results can be seen in Table 4.

Carbon emissions reflect the level of a region's overall carbon discharges. The results show that carbon emissions of the area are growing on the whole during 2008-2020, although it was slightly lower in 2009. The amount of Carbon emissions in 2008 was 30.7502 million tons, which was higher by 1.046
million tons than that of in 2009. Projections show that carbon emissions will reach 48.2019 and 66.03 million tons in 2015 and 2020, and these are 1.62 and 2.22 times of the carbon emissions in 2009 respectively. In terms of the average annual growth rate, the ratio of carbon emissions is 8.40% during 2009-2015, and it will be 6.50% during 2015-2020.

Table 4. The results of the carbon emissions

<table>
<thead>
<tr>
<th>Year</th>
<th>Carbon emissions in Shandong (million tons)</th>
<th>Carbon emissions of the Yellow River Delta Economic Zone (million tons)</th>
<th>The proportion of the Zone’s carbon emissions in Shandong. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>228.5598</td>
<td>30.7502</td>
<td>13.45</td>
</tr>
<tr>
<td>2009</td>
<td>244.2545</td>
<td>29.7042</td>
<td>12.16</td>
</tr>
<tr>
<td>2015</td>
<td>361.1933</td>
<td>48.2019</td>
<td>13.35</td>
</tr>
<tr>
<td>2020</td>
<td>408.5712</td>
<td>66.0300</td>
<td>16.16</td>
</tr>
</tbody>
</table>

5. Forecasting results and evaluation

In light of the security level of Shandong province to the Yellow River Delta High-efficiency Eco-economic Zone, with the acceleration of urbanization in Shandong province, the total energy consumption is increasing rapidly. Shandong became a net energy import province firstly in 2004, and the energy import volume in 2009 reached at 167.364 million tce. According to the "Long-term Energy Development Plan in Shandong Province" [15] and combined with the existing condition of energy reserves and production, we can draw the conclusion that the energy volume in Shandong province can not meet the need of long-term sustainable economic development. The energy gap is increasing, the supply situation is more and more serious and the dependence on foreign energy is growing. Consequently, the energy of Shandong province is far from meeting the need of sustained, rapid, coordinated and healthy development, and also not able to ensure the sustainable supply of the Economic Zone. Therefore, the rapid development of the place faces enormous energy pressure.

The carbon emissions of the place will account for 13.35% and 16.16% of Shandong province in 2015 and 2020, respectively. The increasing carbon emissions are not only impede the healthy development of the economy, but also lead to further deterioration of the environment. Coal-based energy system in Shandong province has been formed, and will not change in a long time, this means that the energy system of the Yellow River Delta High-Efficiency Eco-economic Zone will be also coal-based and not change in a long run.

At present, the influence of the carbon dioxide released by burning coal on global climate has become a political and national image issue [16]. In 2009 the slogan "Low-carbon Economy" was proposed, therefore how to reduce carbon dioxide emissions turn out to be a big problem for the Economic Zone. Carbon capture, storage and use will be a new technology that needs to be developed and improved. Reducing carbon emissions by optimizing the energy structure and strengthening the development and utilization of renewable energy also play a very significant role. Many foreign scholars used different methods to analyze the reasons of the decline in carbon emissions, noting that the decline in energy intensity is the main reason [17].

6. Conclusion

Speed up the economic development of the Yellow River Delta High-efficiency Eco-economic Zone is not only related to the overall strength promotion and regional development of the Bohai Sea region, but also connect with the ecological environment protection of the Bohai Sea and the lower Yellow River. Hence, the concept of sustainable development should be reflected in the development of the Yellow
River Delta. And it is imperative to promote ecological industrial structure and high-class economic structure; improve efficient functioning and highly open of economic systems with the goal to achieve the organic unity of the social development, environmental protection, economic growth.

Acknowledgements

This work is supported by “The Study on the Early Warning Model of the Resources and Environmental Security in the Yellow River Delta High-efficiency Eco-economic Zone” sponsored by the Department of Science & Technology of Shandong province (Project number: BS2010HZ011).

References


