# Scenario prediction of energy consumption and carbon emissions in Lingang New Area based on LEAP model

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**Abstract—**Based on the statistical data of Lingang New Area in 2021, the LEAP-Lingang model was constructed, and the energy consumption and carbon emissions of Lingang New Area from 2022 to 2035 were predicted and studied by setting three scenarios: benchmark, policy and low carbon. The results show that under the policy scenario, the new area can maintain low energy consumption and carbon emission development, but fails to peak carbon emissions before 2035, and can basically peak carbon emissions around 2030 under low-carbon conditions. On the basis of existing policies, the new area can further promote clean energy development, accelerate regional industry and energy efficiency upgrading, and actively promote green power and green certificate trading to accelerate the process of carbon peaking.

## 1. Introduction

With the process of reform and opening up, China's economy has developed rapidly, and with the development of the economy, the total energy consumption continues to increase, which has brought huge carbon emissions. At present, China has become the largest carbon emitter in the world, and the pressure from the international community to reduce emissions is increasing. At the same time, emission reduction is not only a requirement that China should assume as an international power, but also a requirement for its own environmental, social, economic and internal self-sustainable development transformation. How to reduce carbon emissions to achieve the goal of carbon peak and carbon neutrality has become an important topic in China's research. The establishment of Lingang New Area is a major strategic deployment for further opening up made by China to take charge of the overall situation and make scientific decisions, and is an important measure to demonstrate China's adherence to all-round openness and clear attitude and take the initiative to lead the healthy development of economic globalization in the new era. While carrying an important mission, the Lingang New Area should actively explore the path to achieve the dual carbon goal, and observe the sustainable and low-carbon development of the new area.

Based on carbon emission calculations, the LEAP model is a bottom-up comprehensive evaluation model that is flexible enough to analyze and predict an industry sector or an entire region. Through the LEAP model and the setting of benchmark scenarios and peak scenarios, Liu Fangzhou predicted the carbon emissions of a city, and found that clean energy and sustainability are the key to future development. Jeong used the long-term energy option planning system model to simulate the CO2 emissions of the consumption sector in South Korea, and analyzed and predicted it. At present, most of the research focuses on the analysis of a single technology, and lacks research on the comprehensive consideration of economic society and various technologies, so this paper takes the Lingang New Area as an example to comprehensively consider the economy, society and energy environment, and explore a low-carbon development path suitable for the Lingang New Area.

## 2. Construction and Geometrical Dimensions of Specimens

### 2.1 LEAP model

LEAP (Long-Term Energy Alternative Planning System) is a bottom-up energy consumption model based on scenario analysis. It was jointly developed by the Stockholm Environment Institute and Boston University. The LEAP model can simulate the development path of various industries in society in detail. In particular, it can reflect the implementation effects of various technologies and policies, thereby guiding policy choices. These advantages make the model widely used in energy policy development and climate change mitigation assessment. The general LEAP model consists of three core modules: the final requirements module, the transformation and allocation module, and the resource module. Since Lingang is not a country, resource modules are not considered in the model. Specifically, the main hypothetical modules include GDP, population, and industrial structure. The final demand module includes daily consumption, primary industry, secondary industry, and tertiary industry sectors. The conversion

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and distribution module includes energy transmission and distribution loss and input-output loss, and the model structure is schematically shown in the figure.

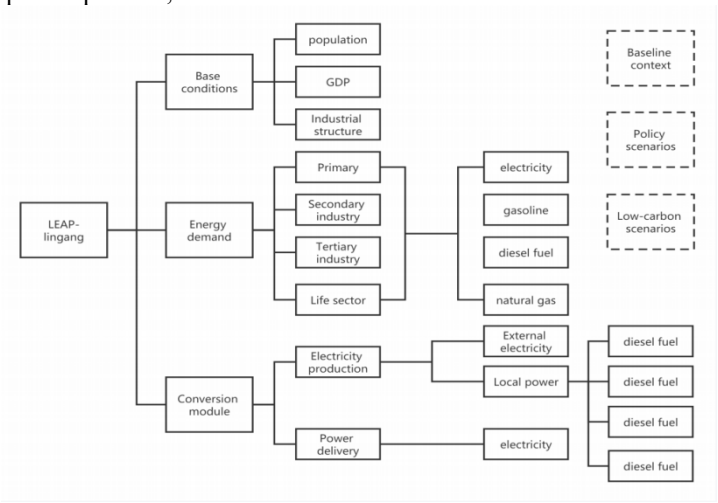



Fig.1 Schematic diagram of the structure of the LEAP-Lingang model

### 2.2 Context settings

(1) Baseline scenario:Imagine that the current economic and social development goals have been achieved without adopting carbon policies. In this context, the industrial and energy structure of the new area remains basically unchanged, the development of energy use and transportation technology is slow, and the change in living consumption level is not significant.

(2) Policy scenarios: Based on the current economic and social development goals, policies such as the "Low Carbon Development Action Plan for Lingang New Area", the "Low Carbon Development Plan for Lingang New Energy", and the "14th Five Year Plan" for the development of Lingang New Area should be referenced. Changing the production and usage ratio of clean energy to a certain extent improves the energy efficiency level of terminal devices and reduces the level of energy consumption to a certain extent.

(3) Low-carbon scenario: Under the premise of completing the current economic and social development goals, measures to deepen energy consumption and mitigate climate change will be taken from the following aspects: the level of electrification has increased significantly, and the industrial structure has been tilted to a certain extent. The scale of clean energy production has been further expanded, and the energy-saving level of terminal equipment has been further improved. At the same time, energy transmission and distribution technology has improved, and the living consumption level has been further reduced.

## 3. Test Results and Discussions

### 3.1 Analysis of energy consumption under different scenarios

(1) Total energy demand

The total energy demand includes three parts: electricity, oil and natural gas, of which the oil part mainly includes two parts of gasoline and diesel consumption, and the electricity is regional external electricity and local renewable energy generation, and all kinds of energy are calculated at discount. Picture belowshows the total energy consumption forecast results, it can be seen that due to the development of population and economy, the energy consumption of the three scenarios continues to grow, from 1.9413 million tons of standard coal in 2021 to 12.1858 million tons of standard coal in 2035 under the baseline scenario, under the policy scenario, through the adjustment of energy structure and the advancement of energy utilization technology, part of the growth of energy consumption is controlled, and it will be 7.2539 million tons of standard coal by 2035. Under the low-carbon scenario, adopt economic transformation strategies to adjust the industrial structure, while further adjusting the energy structure, using more efficient energy utilization technologies, and better controlling the growth of total energy consumption, to 5.3015 million tons of standard coal by 2035.

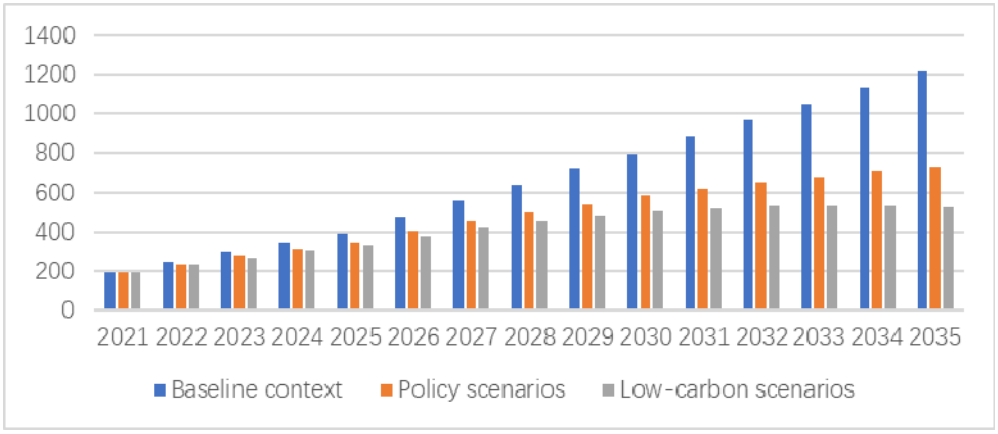
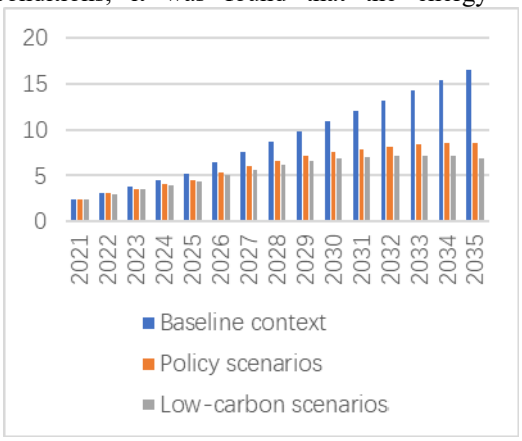


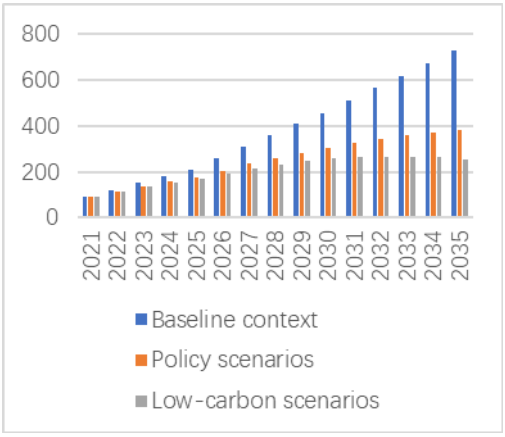

Fig.2Total energy consumption under each scenario

(2) Energy demand by sector

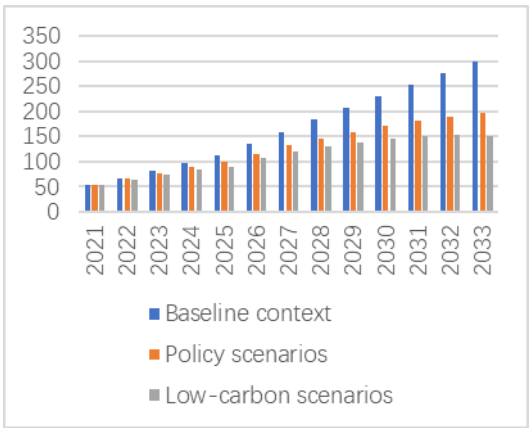
The following figure shows the energy consumption forecast results of each department in the new area. The results indicate that with the rapid growth of population and economy, energy consumption in different industries is increasing year by year. As shown in the figure, the proportion of energy consumption in the secondary industry to the total energy consumption is absolutely high, which reflects the need to reform the industrial structure, develop high value-added industries, and eliminate outdated high carbon industries. Comparing departmental energy consumption under different operating conditions, it was found that the energy consumption under policy and low-carbon operating conditions was lower than that under baseline operating conditions. The policy scenario has improved energy consumption and consumption structure, reduced energy intensity of all sectors to a certain extent, and reduced energy consumption of all sectors to a certain extent. In the low-carbon scenario, the degree of electrification is higher than other scenarios, the energy structure is further optimized, and the energy intensity of each department is lower, thus significantly reducing energy consumption.



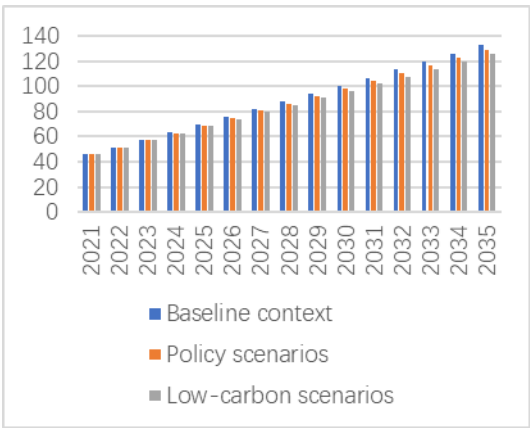

(a) Primary




(b) Secondary industry




(c) Tertiary industry




(d) Life sector

Fig.2Forecast results of energy consumption by sector

### 3.2 Analysis of carbon emissions under different scenarios

The total carbon emissions are composed of four parts: diesel, gasoline, natural gas and electricity, of which diesel, gasoline and natural gas are the carbon emissions generated by their respective corresponding energy consumption, because non-fossil energy power generation consumption does not produce carbon emissions, so "electricity" is only the indirect carbon emissions generated by fossil energy generation consumption in external power transfer, and the method of converting power emission factors is used to calculate.

(1) Total carbon emissions

The carbon emission forecast results are shown in the figure, and the carbon emissions under the baseline scenario continue to rise from 2.9411 million tons in 2021 to 17.9438 million tons in 2035, a cumulative increase of 15.0027 million tons. Under the policy scenario, carbon emissions will continue to rise from 2,941,100 tons in 2021 to 9,728,300 tons in 2035. Compared with the baseline scenario, it has dropped by 8,215,500 tons, and although it has not peaked in 2030, the total carbon emissions have been well controlled, and the growth of carbon emissions has been declining year by year. In this scenario, the new precinct is in a state of relative economic, social and environmental harmony. Under the low-carbon scenario, carbon emissions will increase from 2,941,100 tonnes in 2021 to 6,381,200 tonnes in 2030, and then decline year by year to 5,552,800 tonnes in 2035. Total carbon emissions have been further controlled.

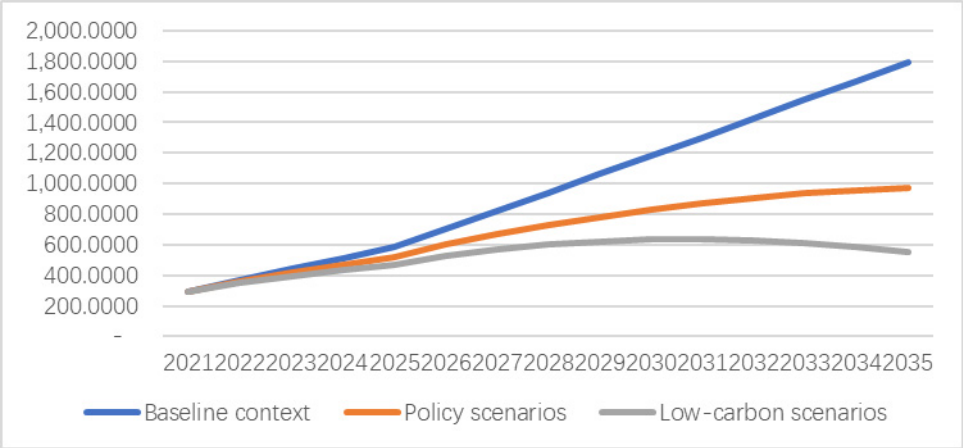
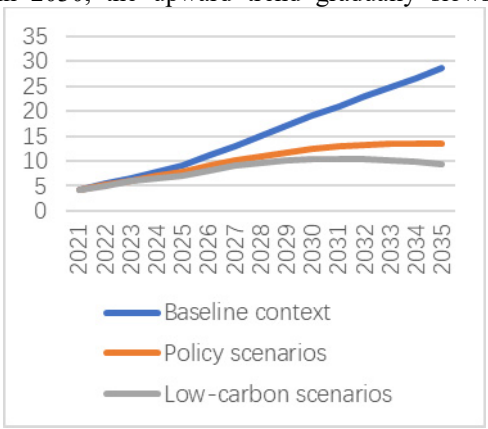


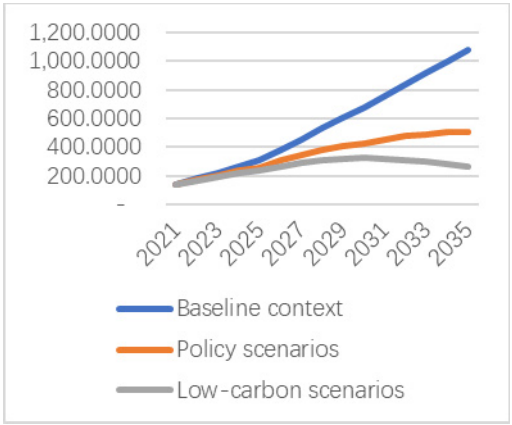

Fig.3Total carbon emissions under each scenario

(2) Carbon emissions of each sector

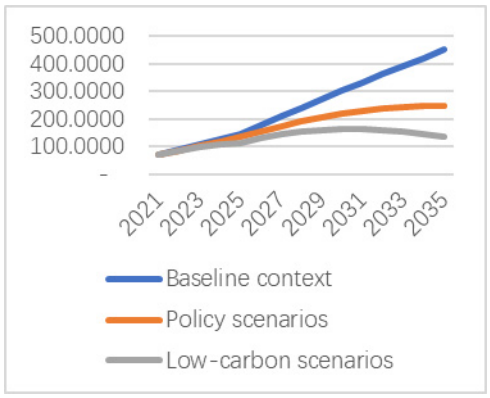
Among the three working conditions, the carbon emissions of the second industry sector are significantly higher than those of other sectors, and carbon emissions continue to increase under baseline and policy conditions. However, in 2030, the upward trend gradually slows down under policy conditions and decreases under low-carbon conditions. In these three scenarios, the trends in the primary and tertiary sectors, as well as the emissions from the secondary and domestic consumption, are increasing year by year.



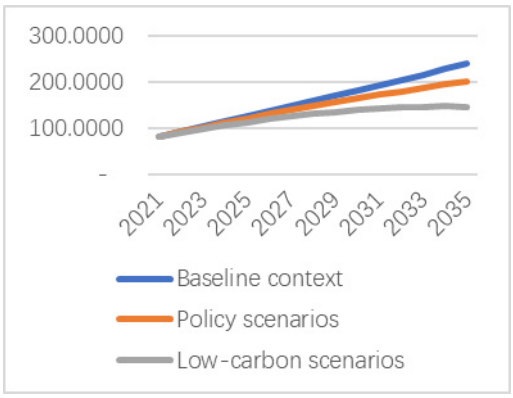

(a) Primary




(b) Secondary industry




(c) Tertiary industry




(d) Life sector

Fig.4Carbon emission projections by sector

## 4. Conclusion

Based on the analysis and simulation results of the LEAP model, the Lingang New Area can maintain low emission development under the policy scenario, but it will not peak before 2035. In the low-carbon scenario, it can peak in 2030. Considering the rapid economic and population development of the new area, the government may consider appropriately accelerating the peaking process on the basis of existing policies and seeking a balance between economic and social development and carbon emissions. Based on this, this paper puts forward the following relevant policy recommendations.

(1) Promote the development of clean energy. From the analysis of the LEAP model, it can be seen that the increase in the proportion of clean energy can effectively curb the growth of carbon emissions. In the future, the proportion of local non-fossil energy power generation and external clean electricity can be gradually increased, the construction of the power grid structure can be further strengthened, the proportion of new energy connected to the grid can be increased, the development of distributed energy trading can be encouraged, and more clean energy can be absorbed. Support the development of clean energy on a large scale and diversification of use, so as to increase the proportion of clean energy in the region, thereby reducing carbon emissions.

(2) Accelerate regional industrial upgrading. In terms of investment promotion, we will further introduce enterprises with low carbon emission intensity, appropriately reduce the proportion of secondary production, and gradually promote the transformation of regional industries to green and low-carbon.

(3) Energy efficiency improvement. From the previous analysis, it can be seen that by promoting the improvement of energy efficiency in the end sector, the energy demand and carbon emissions of the Lingang New Area can be effectively reduced. Formulate scientific and effective energy-saving measures to strengthen energy conservation and emission reduction, and promote energy efficiency improvement in the end-consuming sector. Publicize low-carbon, energy-saving and environmental protection work, and use cluster modeling and other technical controls to ensure the efficient use of resources.

(4) Actively promote the trading of green electricity and green certificates. In the future, the electricity demand of the new area will further increase, and it will be difficult for local green power to meet the regional green power demand, while external green power will also face a shortage. Actively promoting participation in green power trading can effectively obtain green electricity and promote the low-carbon development of the new area.

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