

Carbon Peaking and Neutrality Pathways for Beijing's Power Sector

Jiaxuan Xie^{1, #}, Wei Li^{2, #}, Le Huang^{3, *, #}

¹ North China Electric Power University, Beijing, China

² Jiangxi University of Science and Technology, Ganzhou, China

³ Shanghai University of Electric Power, Shanghai, China

* Corresponding Author Email: 894104249@qq.com

#These authors contributed equally.

Abstract. The power sector is an important area for achieving the 'double carbon' target. To achieve the "double carbon target" in Beijing as early as possible, this thesis is based on the LEAP model, which is a bottom-up study of the carbon peaking and carbon neutral pathways in the power sector from the perspective of the whole chain of source, grid, load and storage. It also combines scenario analysis, taking into account emission reduction targets, electricity demand and resource deployment, to design four comparison scenarios. These are the basic scenario, the energy efficiency improvement scenario, the transport electrification scenario and the renewable energy development scenario. The study focuses on the potential for emission reduction and feasible paths for the energy transition in Beijing's power sector. Finally, policy recommendations are made to promote the energy transition in Beijing.

Keywords: *carbon Peaking, carbon neutrality, LEAP model, power sector.*

1. Introduction

To address the global climate change caused by the greenhouse effect, since September 2020, General Secretary Xi Jinping has repeatedly proposed that China will strive to achieve peak carbon by 2030 and carbon neutrality by 2060 (the "double carbon" goal). As a key area in China's blue-sky defense and an early demonstration area of energy policy, needs to vigorously promote carbon emission reduction, clarify the goal of carbon neutrality, and make positive contributions to China's early achievement of the "double carbon" goal. Therefore, it is of great theoretical and practical significance to study how to promote the transformation of the electric power industry and promote carbon emission reduction in Beijing.

Many scholars have researched and analyzed issues related to carbon emission reduction. For example, Wu et al. [1] analyzed the peak carbon emission states of each Chinese province using the Tapio decoupling model to classify the peak provinces scientifically. Xiao et al. [2] investigated the impact of CCUS and renewable energy penetration under peak carbon based on the SD-CGE model to reveal the industrial and macro shadows of CCUS application policies. Xie et al. [3] used an improved PDA model to decompose the carbon emission changes in China's thermal power industry accordingly, and proposed policy suggestions for provinces with similar characteristics through cluster analysis. Cui et al. [4] investigated the driving forces of carbon emission changes in Beijing using the log-mean-division (LMDI) method, and concluded that importing green energy is one of the most important means to reduce carbon emissions in Beijing based on two scenario analyses. Zhang et al. [5] analyzed the relationship between power generation consumption and carbon emissions in Beijing based on the IPCC sectoral accounting rules and combined the Kaya constant and LMDI methods for a reasonable decomposition of carbon emission changes in power generation. Yang et al. [6] studied the renewable energy-led power system and the carbon peak realization path using the DRCVaR model. Jiang et al. [7] established a prediction model to analyze the structural emission reduction of China's power and heating industries under the "double carbon" target through the input-output perspective. Zhang et al. [8] The SBM-Undesirable model and the spatial Durbin model are used to analyze the

energy efficiency and its influencing factors under the carbon peak and carbon neutrality in China. Su et al. [9] studied the time to peak carbon emissions in China based on the scenario analysis of the optimal control and STIRPAT models. Khanna et al. [10] used a bottom-up national end-use model to simulate the impact of maximum renewable energy and accelerated electrification in 2050 to study the energy and CO₂ impacts of decarbonization strategies in China.

While bottom-up models are often used in energy system planning and carbon reduction simulations, LEAP's scenario analysis capabilities and modeling flexibility are superior to other energy models. The LEAP model is a long-term modeling tool that primarily uses a scenario analysis framework to analyze pathways for energy substitution implications. For example, Cai et al. [11] explored the pathways to peak carbon emissions and carbon neutrality of a typical Chinese state-owned power producer under five scenarios from 2020-2060 based on the LEAP model and incorporating technology learning curves for power generation technologies, carbon capture rates, and environmental costs of fossil fuel generators in the modeling process. Emodi et al. [12] explored the future energy demand, supply, and associated GHG emissions in Nigeria using the LEAP model with a scenario-based analysis approach. Shahid et al. [13] used the LEAP system to simulate Pakistan's power system from 2016 to 2040, and made projections of provincial electricity demand, simulating five scenarios on the supply side. Chen et al. [14] quantified the various environmental impacts of decarbonization policies in Jinan based on a city-level LEAP model and combined with a life-cycle assessment (LCA). A LEAP model was developed in Yang et al. [15] to analyze the key transition pathways and socio-environmental benefits of energy substitution by forecasting energy consumption and related GHG emissions in Zhangjiakou city by sector.

However, most of the existing literature lacks consideration of realistic policy scenarios and does not provide a detailed analysis of the reduction pathways to achieve carbon neutrality in Beijing. Based on the LEAP model, we explore the pathways to peak carbon emissions and achieve carbon neutrality from Beijing's power sector under four scenarios from 2020 to 2060. The main contributions are: 1) the emission reduction potential, feasible pathways, and future policies for the energy transition of Beijing's power sector are comprehensively analyzed; 2) the simulation method of Beijing's carbon peaking pathways is proposed based on the LEAP model, taking into account the emission reduction targets, power demand, and resource deployment; 3) four comparison scenarios are designed and validated.

2. Research Methodology and Model Description

2.1. LEAP model

The LEAP model, Long-range Energy Alternatives Planning (LEAP), is an econometric, energy and environmental scenario analysis model developed by the Stockholm Environment Institute, which is a typical bottom-up end-use energy consumption model based on scenario analysis, covering energy consumption activities in the energy conversion and energy end-use sectors.

2.2. Grey Forecasting

We introduce the principle of $GM(1,1)$. We refer to the equation $x^{(0)}(k) + az^{(1)}(k) = b$ as the basic form of $GM(1,1)$, ($k = 2, 3, \dots, n$), where, b denotes the amount of grey action, and $-a$ denotes the development factor.

Here we introduce the matrix form:

$$u = (a, b)^T, Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix}, B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{bmatrix} \quad (1)$$

Thus, the GM (1,1) model $x^{(0)}(k)+az^{(1)}(k)=b$ can be expressed as

$$Y = Bu \tag{2}$$

We can use the least squares method to obtain an estimate of the parameters a , and b , which is

$$\hat{u} = \begin{pmatrix} \hat{a} \\ \hat{b} \end{pmatrix} = (B^T B)^{-1} B^T Y \tag{3}$$

The nature of GM (1,1) model is a conditional exponential fit:

$$f(x) = C_1 e^{C_2(x-1)} \tag{4}$$

The model is used in this paper to forecast data such as the number of cars to assist in the determination of future scenarios.

2.3. Framework for simulating carbon peaking in Beijing

We develop a LEAP model for Beijing from the perspective of the power industry from the perspective of source, grid, demand, and storage. The model parameters are used to set up different scenarios, predict the carbon emission trends and optimization paths by substituting the parameters, and propose the transformation direction and low-carbon development technology paths for the power industry to achieve the national carbon peaking. The general framework is shown in Fig. 1.

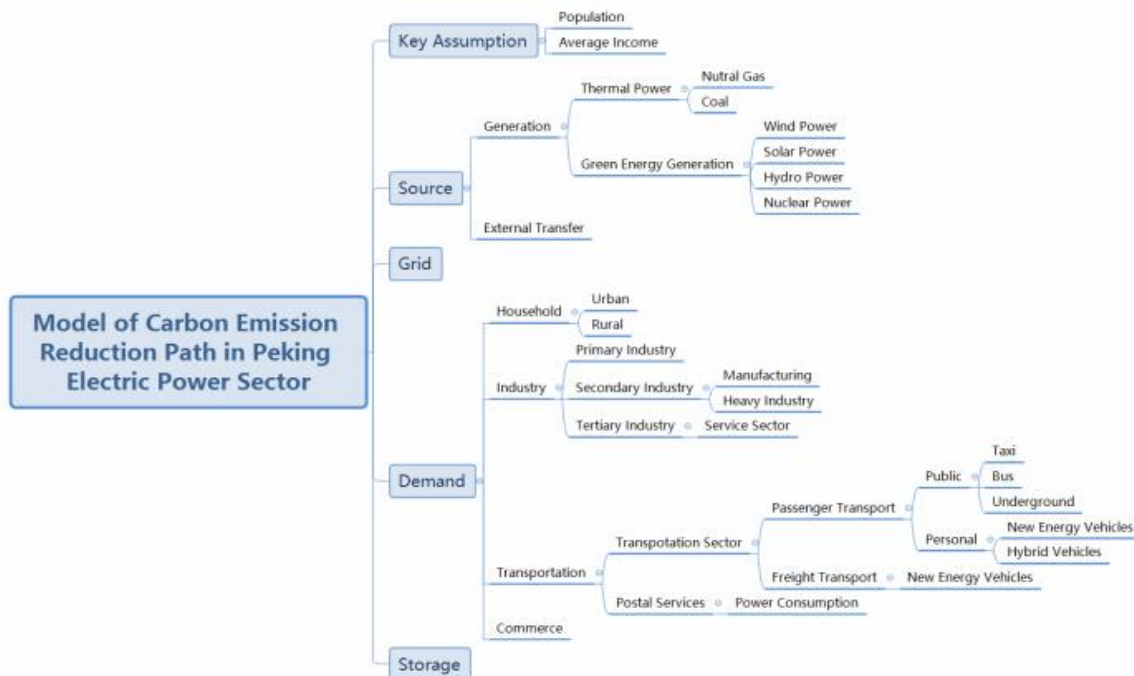


Figure 1. Framework of the Beijing carbon peaking pathway model

Current studies show that the future energy transition policy in Beijing will focus on renewable energy development, transport electrification and energy efficiency improvement.

2.3.1. Electrification of transportation scenario

The transport sector is closely linked to greenhouse gas emissions, accounting for 28% of Beijing's carbon dioxide emissions from fuel consumption, making it a significant obstacle to achieving the country's dual carbon targets. One way to reduce carbon emissions in the transport sector is to replace

traditional fuels with energy alternatives, such as natural gas, bioenergy, electricity, and hydrogen. Secondly, to strengthen the construction of rail transport. Beijing's rail transport is mostly electrically driven, which is cleaner compared to the large proportion of rail transport driven by traditional internal combustion engines.

2.3.2. Renewable energy development scenario

The power sector is the largest source of production-based carbon emissions in Beijing. Beijing's power sector accounted for 32.6% of the city's total carbon emissions. The decarbonization of the electricity structure is inevitable for energy restructuring. Beijing is rich in solar energy, with an annual radiation output of about 5.61×10^6 kJ/m², annual sunshine hours of 2,761 hours, and a total annual average radiation of 1,460 kW/m², which is suitable for the development and utilization of solar energy.

2.3.3. Energy efficiency improvement scenario

To achieve China's goal of achieving peak carbon and carbon neutrality, energy efficiency improvement is bound to be a major trend in future development. Research results show that in the short term, the emission reduction effect of renewable energy policies is better than energy efficiency policies, and in the long term, the overall benefit of energy efficiency improvement is better than renewable energy policies.

As a typical mega-city, Beijing's high population density and active socio-economic activities have a greater realistic disturbance and potential pressure on carbon emission reduction. Compared with other regions, there is more room for the development of clean energy such as nuclear energy, hydro energy and offshore wind energy in the southeastern coastal region, and the northwestern region has the advantage of natural resources for the development of wind energy and photovoltaic energy and the anthropological geography of a vast area, Beijing is more restricted in the development of clean energy on the carbon neutral path. Beijing also plays a leading and demonstration role as the capital. This paper selects Beijing as the study area, integrates population, policy, socio-economic, natural resources and other factors to construct a model, and objectively analyses its carbon reduction potential based on the simulation results, which provides a certain reference role for the study of carbon reduction paths in other regions.

3. Data & Scenario Design

In the current Beijing policy context, it is assumed that Beijing will not strengthen the intensity of energy policy implementation after the base year, the existing energy policy intensity and the intensity of electricity consumption in each sector remain stable. The trend projections for its sectoral parameter variables are referenced to the average growth rate of increment from 2016-2020. 2020 is taken as the base year, 2021 is the first year of the simulation, and 2060 is the final year of the simulation.

3.1. Basic scenario

A baseline scenario was constructed to represent the current status and current trends of end-use energy consumption in Beijing.

3.1.1. Data analysis

Data analysis and forecasting of Beijing's GDP and population concerning Beijing Statistical Yearbook 2016-2020. For the analysis of the GDP growth rate, the historical data of Beijing's average GDP from 2015-2019 were combined to establish a grey prediction model, and the values of GDP for the next four decades were predicted. For the population growth rate, according to the Beijing Urban Master Plan (2016-2025), it is stated that the future population of Beijing will be controlled at 23 million and will be stable at this level in the long term. And urbanization is then an average conversion of the rural to the urban population of 30,000 per year.

3.1.2. Parametric design

a) Household

Based on the division into urban and rural areas, the specific parameters of the household sector are divided into per capita living area, per capita electricity consumption for lighting and per capita electricity consumption for electrical appliances, and per capita consumption of coal and natural gas. The parameters of the household sector are shown in Table 1.

Table 1. Parameters for the household sector under the baseline scenario

Category		2020	Annual average growth rate
Urban	Living space per capita	32.5 m ²	0%
	Average electricity consumption per person for lighting	285kW	1.4%
	Average coal consumption per person	6kg	-36%
	Average gas consumption per person	0.76m ³	-0.31%
Rural	Living space per capita	47.2 m ²	0%
	Average electricity consumption per person for lighting	413kW	1.4%
	Average coal consumption per person	69.35kg	-34%
	Average gas consumption per person	0.11m ³	7.36%

b) Industry sector

According to the actual situation of the industry in Beijing, the main industries in Beijing are divided into manufacturing, electricity, gas and water supply, mining, and other industries. The total output value and the average annual growth rates are shown in Table 2.

Table 2. Parameters for the industry sector in the baseline scenario

Category	2020	Annual average growth rate
Manufacturing	36953 billion Yuan	4.77%
Electricity, gas and water supply industry	11338 billion Yuan	6.90%
Mining and others	298.1 billion Yuan	-28%

c) Commercial, Construction & Others

According to the research results of commercial, construction, and other sectors of building area and electricity consumption concerning [16], the total area of public buildings in Beijing is 40 billion m² with an average annual growth rate of 0.15 billion m². [1] Concerning the Beijing Statistical Yearbook, the settings are shown in Table 3.

Table 3. Parameters for the commercial sector under the baseline scenario

Category	Data	Annual average growth rate	
Communal floor space	400 billion m ²	0.15 billion m ²	
Commercial electricity consumption	102.18kw/m ²	-0.26%	
Commercial, Construction & Others	Natural gas	386 million m ³	2.8%
	Liquefied Petroleum Gas	8 million m ³	-28%
	Coal	1.89 million tonnes	-31%
	Diesel	73 million tonnes	2.29%

d) Agriculture sector

In 2020, the gross domestic product of agriculture, forestry and fishery in Beijing will be 10.8 billion yuan, with an average annual growth rate of -5%; the consumption of raw coal will be 1.11 million tonnes of standard coal, with an average annual growth rate of -44.9%; the consumption of electricity will be 214,700 tons of standard coal, with an average annual growth rate of -1.2%; the consumption of diesel will be 1.81 million tonnes of standard coal, with an average annual growth

rate of -14%; and the consumption of gasoline will be 3.14 million tonnes, with an average annual growth rate of -7.6%. The results are shown in Table 4.

Table 4. Parameters for the agricultural sector in the baseline scenario

Category	Data	Annual average growth rate
Raw Coal	1.11 million tonnes of standard coal	-44.9%
Electricity	21.47 million tonnes of standard coal	-1.2%
Diesel	1.81 million tonnes of standard coal	-14%
Gasoline	3.14 million tonnes	-7.6%
Agriculture, forestry and fisheries GDP	108 billion	-5%

e) Transport and postal sector

The transport sector is divided into passenger transport and freight transport. Passenger transport is divided into a bus, metro, taxi, and private car. The Gompertz model is used to take advantage of its economic characteristics of starting to grow rapidly and then slowing down. Based on the historical data and fitted forecasts, results were shown in Table 5.

Table 5. Parameters for the transport sector in the baseline scenario

Category	2020	Annual average growth rate
Public Electric Vehicles	28,271 Vehicle	-0.2%
Electric taxis	3998 Vehicle	0.029%
Electric mini car	289248 Vehicle	0.02%
Electric vans	177500 Vehicle	-0.04%
Total post and telecommunications services	2760 billion	4.38%

f) Power sector

Beijing has a large proportion of purchased electricity, which is as high as 70.5 billion kWh in 2019. According to the Beijing Statistical Yearbook, using MATLAB for grey forecasting, the installed capacity of various types of energy in Beijing in 2060 in the baseline scenario is introduced as shown in Table 6.

Table 6. Parameters for the power sector in the baseline scenario

Power supply installation types	2020	2060
Thermal power	1136 million kW	1953kw
Hydroelectricity	99 million kW	117 million kW
Wind Energy	19 million kW	327 million kW
Photovoltaic	62 million kW	500 million kW

Its maximum utilization rates for thermal, hydro, wind and PV are 50.62%, 11.89%, 16.34% and 10.54% respectively. Transmission line losses were 4.32%.

3.2. Energy efficiency improvement scenario

3.2.1. Data acquisition

In the household sector, regarding Beijing's 14th Five-Year Plan to address climate change and energy conservation, the cumulative scale of promotion of ultra-low energy buildings will reach more than 5 million square meters by 2025, and it is predicted that more than 100 million square meters of ultra-low energy buildings will be built in Beijing by 2060. The General Office of the State Council issued the "New Energy Vehicle Industry Development Plan (2021-2035)". By 2025, the average electricity consumption of new electric passenger cars will be reduced to 12.0kWh/100km. 2025, the *Made in China 2025* has clarified that the energy consumption standard for passenger cars in China will be 4L per 100km in 2025 and 2.5L per 100km in 2060. 13.5% in 2020.

3.2.2. Parameter design

Breakthroughs in energy efficiency technologies are continuing, with the average electricity consumption intensity in the domestic sector expected to fall by 30% and the average electricity consumption intensity in the commercial sector by 25% by 2060. A 20% reduction in domestic fuel consumption intensity and a 30% reduction in the commercial fuel consumption intensity index. New energy vehicles with a consumption of 5kWh per 100km are expected to be available around 2040 and high-performance new energy vehicles will be largely common in Beijing around 2060. This will result in a 66.7% reduction in Beijing's transportation electricity consumption intensity index. In recent years, China's industrial energy efficiency has continued to improve, with energy consumption per unit of added value in industries above the scale falling by 5.6% in 2021 based on a 16% drop during the 13th Five-Year Plan, and the output value of the energy-saving and environmental protection industry exceeding yuan 8 trillion. At the same time, by 2025, the proportion of new energy-efficient motors will reach over 70%, and the proportion of electrical energy in the industrial sector will reach 30% of final energy consumption. It can be deduced that the industrial fuel consumption intensity index falls by 37% and the industrial electricity consumption intensity index falls by 24% in 2060.

The agricultural sector will also follow in the footsteps of carbon-peaking efforts, bringing a 38.3% reduction in the agricultural electricity consumption intensity index and a 22.17% reduction in the agricultural fuel consumption intensity index by 2060. The results are shown in Table 7.

Table 7. Parameters in energy efficiency improvement scenario

Sector	Category	2020	2060
Living sector	Electricity Consumption Intensity Index	1	0.7
	Fuel consumption intensity index	1	0.8
Commercial sector	Electricity Consumption Intensity Index	1	0.75
	Fuel consumption intensity index	1	0.7
Transport sector	Electricity consumption intensity index	1	0.333
	Fuel consumption intensity index	1	0.4873
Industry sector	Electricity consumption intensity index	1	0.76
	Fuel consumption intensity index	1	0.63
Agriculture sector	Electricity consumption intensity index	1	0.617
	Fuel consumption intensity index	1	0.7783

3.3. Electrification of transportation scenario

3.3.1. Data analysis and parameter design

In terms of private transport, the National Information Centre predicts that the average car ownership per 1,000 people in China will be about 450 units in the future, and according to Beijing's "water for people" plan, the size of In 2020, there will be around 5.24 million private cars in Beijing, growing at 0.92% per annum, with the growth of electric cars increasing from 1.3% to 4.7% per annum under the transport electrification scenario, and the average annual mileage decreasing at a rate of -1.2% per annum. In terms of public transport, based on historical data, rail distance is showing continuous growth, with a total rail distance of 656.8 million km in 2019 in Beijing, accounting for 47.2% of total passenger traffic. Based on the above scenario assumptions for carbon emission reduction in the transport sector and the ideal share of 100% of rail passenger traffic, it is reasonable to assume that the annual rail distance cap is 1,392.43 million km. In the meantime, the number of buses and taxis, as public transports, are subject to policy, and it is expected that taxis will be fully electrified by 2056. The saturation of taxis is taken to be 86,100, growing at a rate of 0.36% per year, while buses are expected to reach a saturation value of 26,700 units in 2048.

3.4. Renewable energy development scenario

3.4.1. Data analysis

In terms of private transport, the National Information Centre predicts that the average car ownership per 1,000 people in China will be about 450 units in the future, and according to Beijing's "water for people" plan, the size of Beijing's population will be controlled at about 23 million, which means that the future car ownership in Beijing will be about 10.35 million units. In 2020, there will be around 5.24 million private cars in Beijing. The data are from Beijing's 14th Five-Year Plan for the Development of New and Renewable Energy" and Du et al. [17].

3.4.2. Parametric design

The main power sources in Beijing are coal, natural gas, photovoltaic, wind power, and biomass power. In terms of installed coal power generation, all coal-fired power plants in Beijing have been closed in 2017, and the installed coal power capacity is 770MW. In terms of installed gas-fired power generation, this paper assumes that the growth rate of installed gas-fired power generation in Beijing will remain stable at 3% until 2030 and that the amount of installed gas-fired power generation will remain unchanged from 2030 to 2060.

Regarding the planning and the characteristics of Beijing's rooftop resources, in 2025, the city's entire region will have 1.2 million kilowatts of new PV power generation installations on rooftop distributed PV pilots, and 110,000 kilowatts of new wind power installations, reaching a cumulative total of 300,000 kilowatts. An additional 160,000 kilowatts of biomass energy will be installed, reaching a cumulative total of 550,000 kilowatts. Assuming that in 2060 all buildings in Beijing are installed rooftop photovoltaic, Beijing's roof area of about 200 million m², calculated 2060 Beijing distributed PV installed for 0.24 billion kW, while according to the policy requirements of the original gas all instead of PV units, and finally the total capacity of PV in 2060 for 0.41 billion kW.

In terms of the line loss rate, Beijing's line loss rate should be 4.32% in 2020, a decrease of 0.16% compared to 2015. Using grey forecasts, the line loss rate in 2060 is approximately 0.06%. The design of the renewable scenario is shown in Table 8:

Table 8. Design of parameters for the power sector in Beijing under the renewable energy development scenario

Category	Types of Energy	2020	2060
Renewable Energy	Wind Energy	19 million kW	440 million kW
	Photovoltaic	62 million kW	4110 million kW
	Biomass	35 million kW	200 million kW
Fossil Energy	Thermal Power	1136 million kW	0
Electricity transmission	Line Loss Ratio	4.32%	0.06%

4. Simulation results and discussion

4.1. Baseline scenario

By substituting the parameters in the baseline scenario into the LEAP model, the final energy consumption in Beijing in 2060 is 109.3 MtCO₂e in the industrial sector, 24.4 MtCO₂e in the commercial sector, 8.2 MtCO₂e in the transportation sector, 3.6 MtCO₂e in the domestic sector and 0.1 MtCO₂e in the agricultural sector, in descending order. The LEAP model was used to predict the final energy demand and carbon emissions of Beijing under different scenarios. From Fig. 2 and Fig. 3, it can be seen that in terms of final energy demand, the best energy savings are achieved under the energy efficiency improvement scenario; and in terms of carbon emissions, there is a reduction in carbon emissions under the renewable energy development scenario.

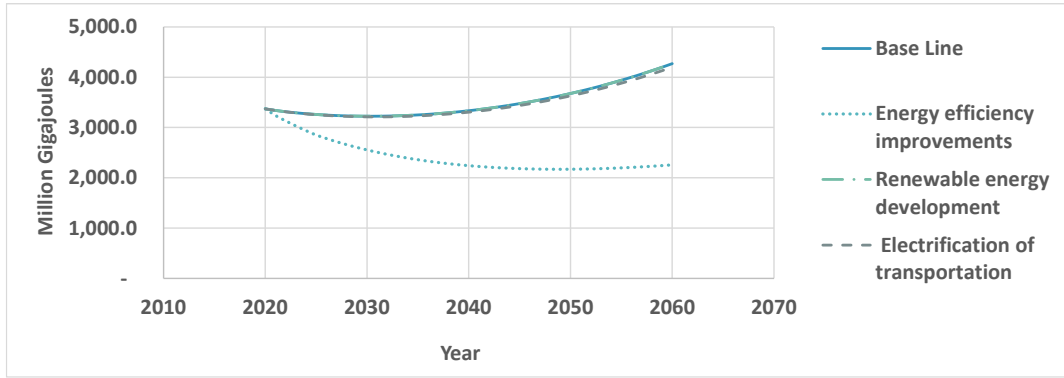


Figure 2. Final energy demand in Beijing under different scenarios

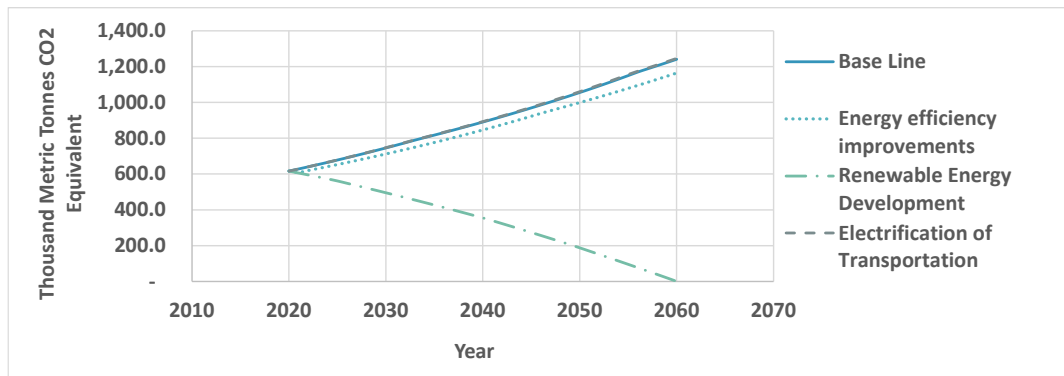


Figure 3. Carbon emissions in Beijing under different scenarios

4.2. Renewable energy development scenario

In the baseline scenario, Beijing's power generation mix is dominated by thermal power, and the amount of thermal power generated each year is increasing. Compared to the baseline scenario, the proportion of renewable energy generation in the renewable energy development scenario gradually increases, especially PV and biomass, with PV generation accounting for approximately 60% and biomass generation for approximately 27.8% by 2060, and thermal power gradually withdrawing from the generation market. The results of the prediction analysis are shown in Fig. 4 and Fig. 5.

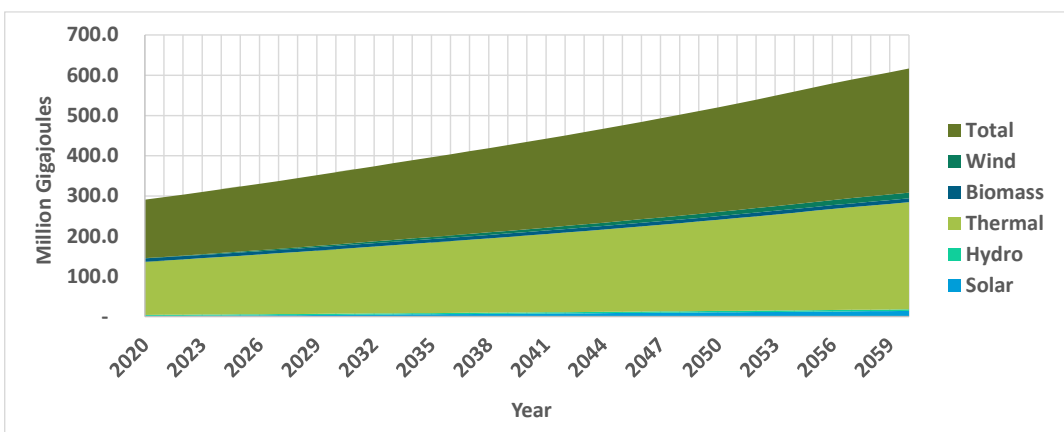


Figure 4. Different energy requirements in Beijing under the baseline scenario

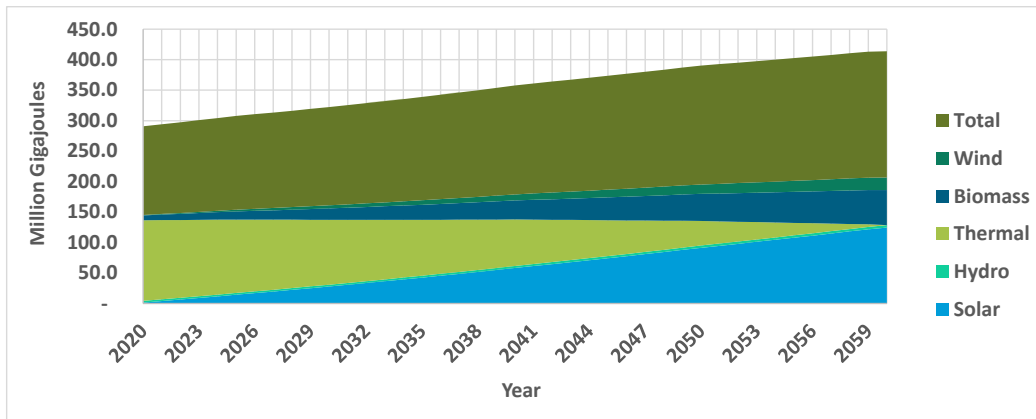


Figure 5. Different energy needs in Beijing under renewable energy development scenario

4.3. Electrification of transportation scenario

As can be seen in Fig 6 and 7, compared to the baseline scenario, the energy consumption of petrol small cars in the transport electrification scenario decreases significantly, by 61.7% in 2060 compared to 2020, and the share of electric small cars also maintains a steady upward trend. For taxis, the share of petrol taxis in the baseline scenario gradually increases. However, in the transport electrification scenario, the number of petrol taxis continues to decline and is gradually replaced by electric taxis. For the postal sector, the growth in electrical energy consumption is at the same rate in the baseline scenario and the transport electrification scenario.

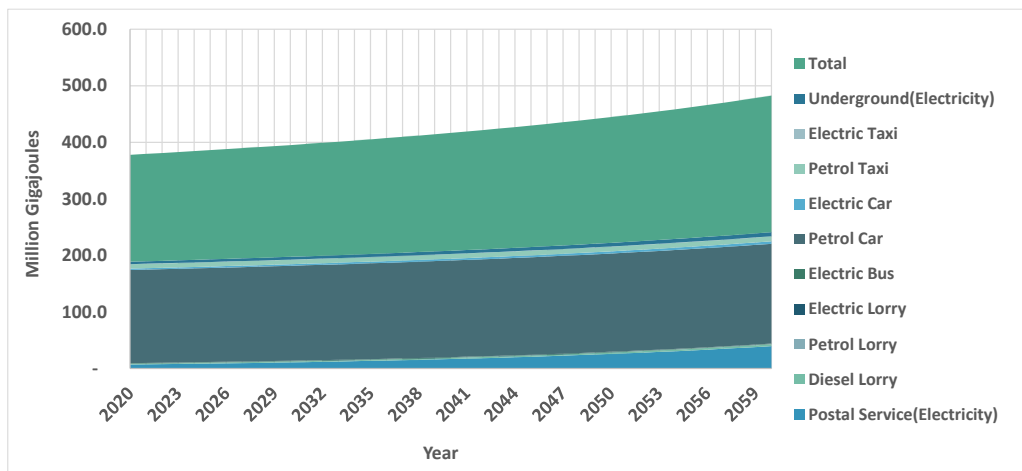


Figure 6. Energy demand in Beijing's transport sector in the baseline scenario

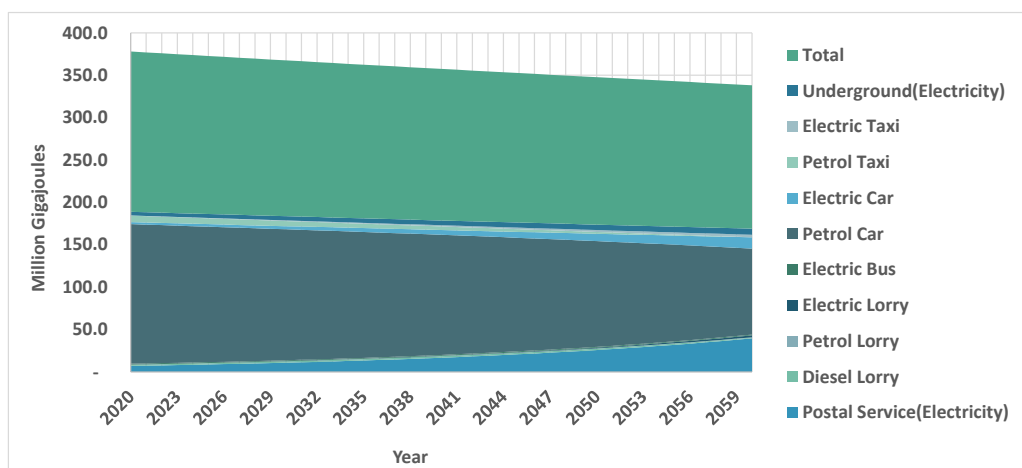


Figure 7. Energy demand in Beijing's transport sector in the electrification of transportation scenarios

4.4. Energy efficiency improvement scenario

Compared to the baseline scenario, energy consumption in the manufacturing sector decreases more rapidly under the energy efficiency improvement scenario, by around 90% from 2020 to 2060; energy consumption in the electricity, gas, and water supply sector also gradually exceeds that of the manufacturing sector. Results show that electricity consumption accounts for the vast majority and is gradually increasing, with a slower growth rate than the baseline scenario in the energy efficiency improvement scenario, where electricity consumption accounts for over 90% by 2060 with energy sources becoming progressively cleaner.

For the agricultural sector, electricity consumption dominates and decreases year by year under the energy efficiency improvement scenario. The largest share of energy consumption in the transport sector is in public transport. In the baseline scenario, public transport fuel energy consumption continues to rise, while in the energy efficiency improvement scenario, public transport energy consumption decreases. The predicted results are shown in Fig. 8 and Fig. 9.

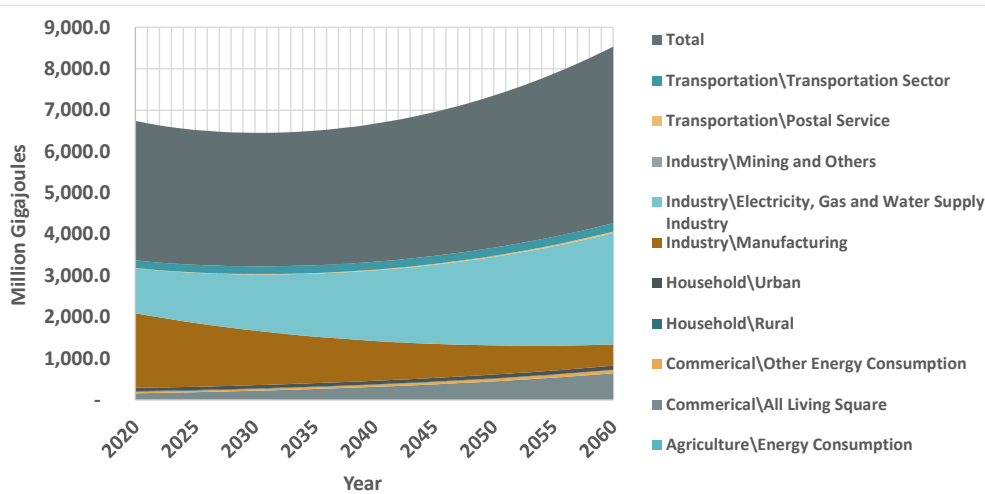


Figure 8. Energy demand by sector in Beijing in the baseline scenario

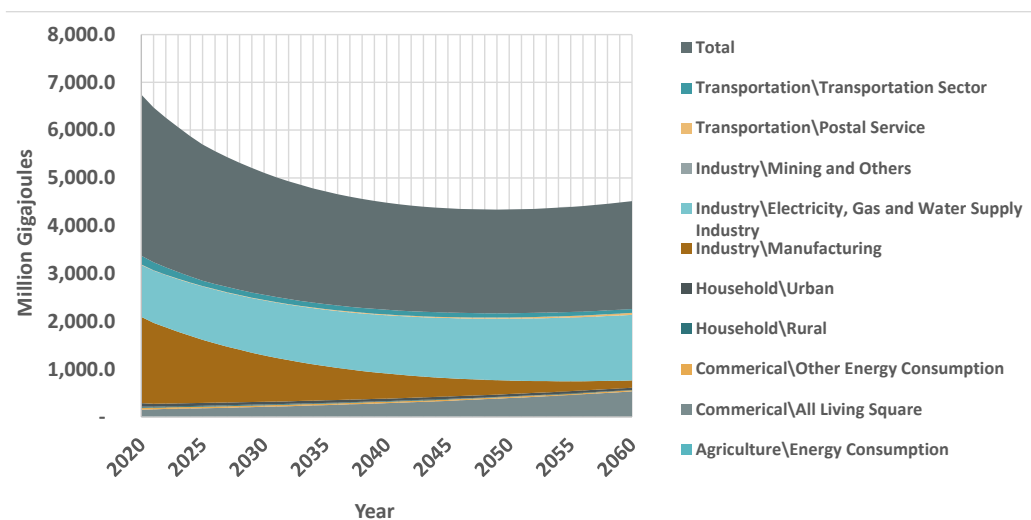


Figure 9. Energy demand by sector in Beijing in energy efficiency improvement scenario

5. Conclusions and suggestions

In this paper, we propose a LEAP model based on a bottom-up study of the power industry’s carbon pathway from the perspective of the whole chain of generation, grid, load, and storage. Four scenarios are designed taking into account Beijing’s emission reduction targets, electricity demand, and resource deployment. Simulation results show that Beijing should improve the electrification of transport and

renewable energy, promote the electrification of residential and commercial activities, and increase the scale of installed renewable energy generation on the supply side. The city should promote the electrification of the transportation sector and reduce the intensity of private car travel, and expand the areas of energy efficiency, promote the improvement of energy efficiency throughout society

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