Analysis of current situation of power consumption in eastern cities under the background of new urbanization

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Abstract. Urbanization is the only way to modernize, and it is also a strong support for rural revitalization and regional coordinated development. In March 2014, the State Council issued the “National New Urbanization Plan (2014-2020)”, which is a macroscopic, strategic and basic plan to guide the healthy development of new urbanization in the future. The new urbanization will affect China's economic development model and social progress level, thus affecting the total amount, structure and layout of power demand. The eastern region is the most economically developed region in China's four major regions. Studying its characteristics of urban power consumption under the background of new urbanization will be of great significance to the forecast of power demand in China's future urban agglomerations.

1. Introduction
Since the 14th National Congress of the Communist Party of China has clarified the general goal of establishing a socialist market economic system, the city has been the center of regional economic and social development, and its status and role have received unprecedented attention. In November 2002, the 16th National Congress of the Communist Party of China clearly stated that "it is necessary to gradually improve the level of urbanization, adhere to the coordinated development of large, medium and small cities and small towns, and take the road of urbanization with Chinese characteristics” [1]. Since then, the new development of urban construction in China has been unveiled, and urbanization and urban development were unprecedentedly active. In March 2014, the State Council issued the "National New Urbanization Plan (2014-2020)", proposing ecological civilization, urban and rural planning, spatial coordination and other development models [2]. By the end of 2018, the national urbanization rate has increased to 59.6%. In 2019, the Development and Reform Commission issued a notice on the publication of the "Key Tasks for New Urbanization Construction in 2019" [3].

As the most developed region in China, the eastern region accounts for 53.4% of GDP and 47.9% of the electricity consumption of the whole society in 2018. Therefore, it is necessary to study the characteristics of urban power consumption in the eastern cities to analyze the impact of new urbanization on China's power consumption [4]. At the same time, it is of great significance for scientifically and reasonably predicting future power demand.

2. Urbanization development in the eastern region
The eastern region includes 10 provinces and municipalities including Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan, as shown in Fig. 1. As the most developed
region in the four major regions, the urbanization rate in the eastern region is significantly higher than the national urbanization rate. In 2017, the urbanization rate in the eastern region was 67.0%, while the national urbanization rate was only 58.5%. There is a positive correlation between electricity consumption and urbanization rate growth.

Figure 1. Provinces and municipalities in the eastern region.

Figure 2. Urbanization rate and electricity consumption in the eastern region.

The impacts of new urbanization on the eastern region are as follows. First, for economic development, new urbanization will promote the quality change, efficiency change, and dynamic change of economy [5, 6]. Second, for social progress, the improvement of people's living standards, the enhancement of environmental awareness, and the improvement of medical and health insurance levels contribute to the development of power demand [7, 8]. Third, for ecological civilization, under the constraints of environmental protection, the energy supply structure has been continuously optimized rapidly, and the level of electrification has been continuously improved. Fourth, for urban and rural integration, the integration of urban and rural infrastructure, the integration of urban and rural industries, and the integration of urban and rural public services will promote the development of rural electricity demand and further narrow the gap between urban and rural power demand [9]. Fifth, for space coordination, according to the “National Main Functional Area Plan”, there are 8 urbanization main functional areas in the eastern region, the industrial structure of these zones will be further optimized [10], and the population agglomeration effect will be more obvious, and the power consumption structure and total volume will change.

3. Status of electricity consumption in eastern cities
There are 4 megacities, 4 megalopolis, 4 type-I large cities, 32 Type-II large cities, 32 medium-sized cities, 11 Type-I small cities, and 0 Type-II small cities in the eastern region, as shown in Table 1. This
section analyzes the per capita electricity consumption, per capita living electricity consumption and electricity consumption structure in the eastern region. Since electricity consumption or demographic data are not available in some cities (with the suffix "*"), this paper only measures cities with data sources and the latest data is 2017.

### Table 1. Cities of all types in the eastern region and cities used in this study.

| City type          | Quantity | Cities                                      |
|--------------------|----------|---------------------------------------------|
| Megacity           | 4        | Beijing, Shanghai, Guangzhou*, Shenzhen*    |
| Megalopolis        | 4        | Tianjin, Nanjing, Hangzhou, Dongguan*       |
| Type-I large city  | 4        | Suzhou, Xiamen, Jinan, Qingdao              |
| Type-II large city | 32       | Shijiazhuang, Handan, Baoding, Tangshan, Qinhuangdao, Zhangjiakou, Xuzhou, Changzhou, Wuxi, Nantong, Lianyungang, Huai’an, Yanhecheng, Yangzhou, Ningbo, Wenzhou, Shaoxing, Taizhou, Fuzhou, Quanzhou, Zibo, Yantai, Weifang, Jining, Tai’an, Linyi, Zhuhai*, Shantou*, Foshan*, Jiangmen*, Huizhou*, Haikou* |
| Medium-sized city  | 32       | Xingtai, Hengshui, Zhangzhou, Chengde, Langfang, Zhenjiang, Taizhou, Suqian, Jiaxing, Huzhou, Jinhua, Zoushan, Putian, Zhangzhou, Zaozhuang, Binzhou, Dezhou, Liaoqiao, Heze, Dongying, Weihai, Rizhao, Laiwu, Shuanguan*, Zhanjiang*, Maoming*, Zhaoqing*, Qingyuan*, Zhongshan*, Chaohou*, Jieyang*, Sanya* |
| Type-I small city  | 11       | Quzhou, Lishui, Sanming, Nanping, Longyan, Ningde, Meizhou*, Shanwei*, Heyuan*, Yangjiang*, Yunfu* |

The cities with a permanent population of 500,000 or less are small cities, of which less than 200,000 to 500,000 are small cities of type I (Type-I small city), and those with less than 200,000 are small cities of type II (Type-II small city); cities with permanent population of less than 500,000 and less than 1 million are Medium-sized cities; cities with a permanent population of 1 million to 5 million in urban areas are large cities, of which 3 million to 5 million are cities of type I (type-I large city), and cities with more than 1 million and 3 million are type II large cities (type-II large city); Cities with a capacity of more than 5 million and less than 10 million are megalopolis; cities with a permanent population of over 10 million in urban areas are megacities.

#### 3.1. Per capita electricity consumption

Through calculation, the per capita electricity consumption of various types of cities in the eastern region is obtained as shown in Table 2. From 2005 to 2017, the per capita electricity consumption of all types of cities in the eastern region showed an increasing trend year by year. Among them, the per capita electricity consumption of the megacities cities was the lowest, followed by the Megalopolis. The per capita electricity consumption of type-I large city, type-II large city, medium-sized city and type-I small city increased by a large margin. The value of per capita electricity consumption in each type of city in 2017 was 5271, 6127, 5394, 5296, 4191, 4158 kWh/person. Except for type-I small cities, they are all higher than the national average of 4516 kWh/person.

### Table 2. Electricity consumption per capita in all types of cities in the eastern region.

| City type          | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|--------------------|------|------|------|------|------|------|------|------|------|
| Megacity           | 4509 | 4944 | 4956 | 5011 | 5133 | 5040 | 5143 | 5239 | 5271 |
| Megalopolis        | 3951 | 5462 | 5852 | 5904 | 6167 | 6075 | 5929 | 6024 | 6127 |
| Type-I large city  | 2904 | 4404 | 4698 | 4736 | 4931 | 4998 | 5016 | 5247 | 5394 |
| Type-II large city | 2370 | 3904 | 4297 | 4450 | 4800 | 4878 | 4828 | 5122 | 5296 |
| Medium-sized city  | 1842 | 3297 | 3682 | 3878 | 4162 | 4316 | 4320 | 4697 | 4911 |
| Type-I small city  | 1687 | 2639 | 3194 | 3257 | 3494 | 3656 | 3650 | 3976 | 4158 |
According to the growth rate of electricity consumption per capita in various types of cities, the growth rate of electricity consumption in megacities is the lowest among all types of cities, followed by megalopolises. The growth rate of electricity consumption in type-I large cities, type-II large cities, medium-sized cities, and type-I small cities is basically a trend of increasing by type of cities, and type-I small cities have the largest fluctuations in electricity consumption. The average growth rate of electricity consumption in various types of cities in 2005-2017 was 1.9%, 4.3%, 5.9%, 7.6%, 9.1%, and 8.2%, respectively.

3.2. Per capita household electricity consumption

Through calculation, the per capita living electricity consumption of various types of cities in the eastern region is shown in Table 3. During the period of 2005-2017, the per capita household electricity consumption of all types of cities in the eastern region increased year by year, among which the growth rate of megacities was the lowest, followed by megalopolis. The per capita household electricity consumption of type-I large cities, type-II large cities, medium-sized cities, and type-I small cities has increased by a large margin. The value of per capita household electricity consumption in all types of cities in 2017 was 805, 834, 889, 675, 596, 620 kWh/person. The per capita household electricity consumption can reflect the living standards of residents very well. It can be seen that the living
standards of megacities, megalopolis, type-I large cities are higher than those of other cities. The per capita household electricity consumption of medium-sized cities is lower than that of type-I small cities, to a certain extent, it reflects that the type-I small cities have achieved faster development under the promotion of urban-rural integration policies.

### Table 3. Per capita household electricity consumption in all types of cities in the eastern region.

| City type        | 2005  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Megacity         | 598   | 724   | 734   | 786   | 800   | 750   | 786   | 798   | 805   |
| Megalopolis      | 432   | 658   | 665   | 740   | 789   | 743   | 798   | 824   | 834   |
| Type-I large city| 439   | 656   | 658   | 689   | 754   | 772   | 828   | 872   | 889   |
| Type-II large city| 260  | 458   | 493   | 538   | 594   | 587   | 609   | 656   | 675   |
| Medium-sized city| 212   | 389   | 424   | 455   | 499   | 497   | 526   | 574   | 596   |
| Type-I small city| 197   | 364   | 427   | 465   | 507   | 547   | 559   | 612   | 620   |

**Figure 5.** Trends in per capita household electricity consumption of cities in the eastern region.

From the growth rate of per capita household electricity consumption, megacities have the lowest, followed by megalopolis. The growth rate of type-I large cities, type-II large cities, medium-sized cities, and type-I small cities has basically increased by type. The average growth rate of per capita household electricity consumption of various types of cities in 2005-2017 was 3.3%, 6.2%, 7.8%, 8.9%, 9.5%, and 10.4%, respectively. Since entering the new economic normal, the growth rate has slowed down. For Various types of cities, the growth rate in 2012-2017 is respectively 1.6%, 3.8%, 5.1%, 5.4%, 5.8%, 6.4%.

**Figure 6.** Per capita household electricity consumption in all types of cities in the eastern region.

It can be seen that, similar to the per capita electricity consumption level, among the various types of cities in the eastern region, the growth rate of megacities and megalopolis is relatively slow due to their matured development. For type-I large cities, type-II large cities, medium-sized cities, and type-I small cities, the growth rate is faster because of rapid economic development. The gap in electricity consumption per capita between cities of various types has shrunk year by year.
3.3. Power consumption structure
In 2005-2017, the overall effect of power consumption structure optimization in various types of cities in the eastern region was obvious, as shown in Table 4. Except for medium-sized cities, the proportion of secondary industries in megacities, megalopolises, type-I large cities, type-II large cities, medium-sized cities, and type-I small cities has declined, among which megacities and megalopolises have the largest declines, reduced by 17.4 and 13.7 percentage points respectively. The proportion of electricity consumption in the tertiary industry has increased, with the largest increase being the megacities and megalopolises, up by 12.9 and 9.3 percentage points respectively.

| Type of city | Industrial classification | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | Range of change |
|--------------|---------------------------|------|------|------|------|------|------|------|----------------|
| Megacity     | Primary industry          | 1.2  | 1.1  | 1.1  | 1.1  | 1.1  | 1.1  | 1.1  | -0.1           |
|              | Secondary industry        | 60.0 | 53.  | 52.  | 50.  | 49.  | 49.  | 47.  | -17.4          |
|              | Tertiary Industry         | 24.  | 30.  | 31.  | 33.  | 33.  | 34.  | 36.  | 12.9           |
|              | Residential               | 8    | 8    | 9    | 0    | 8    | 0    | 7    | 4.5            |
| Megalopolises| Primary industry          | 1.6  | 1.2  | 1.2  | 1.2  | 1.2  | 1.2  | 1.2  | -0.4           |
|              | Secondary industry        | 73.  | 70.  | 70.  | 68.  | 68.  | 67.  | 65.  | -13.7          |
| Type-I large city| Tertiary Industry     | 14.  | 16.  | 16.  | 17.  | 18.  | 19.  | 20.  | 9.3            |
|              | Residential               | 1    | 0    | 6    | 6    | 2    | 1    | 2    | 4              |
| Type-II large city| Primary industry    | 1.0  | 0.8  | 0.7  | 0.6  | 0.6  | 0.7  | 0.8  | 0.8            |
|              | Secondary industry        | 77.  | 76.  | 76.  | 74.  | 73.  | 74.  | 72.  | 6.9            |
| Medium-sized city| Tertiary Industry   | 7.6  | 8.3  | 8.8  | 9.5  | 10.  | 10.  | 11.  | 5.0            |
|              | Residential               | 1.1  | 11.  | 11.  | 12.  | 12.  | 12.  | 12.  | 3.6            |
| Type-I small city| Primary industry     | 5.0  | 3.9  | 2.9  | 2.3  | 2.3  | 2.3  | 2.4  | -3.0           |
|              | Secondary industry        | 76.  | 76.  | 77.  | 77.  | 76.  | 77.  | 75.  | -7.7           |
|              | Tertiary Industry         | 7.1  | 7.5  | 8.0  | 8.7  | 9.0  | 9.2  | 10.  | 1.8            |
|              | Residential               | 11.  | 11.  | 11.  | 12.  | 12.  | 12.  | 12.  | -0.5           |
|              | Primary industry          | 0.8  | 0.7  | 0.8  | 0.8  | 0.8  | 0.9  | 1.1  | 0.4            |
|              | Secondary industry        | 79.  | 76.  | 77.  | 75.  | 75.  | 74.  | 73.  | -9.8           |
|              | Tertiary Industry         | 8.0  | 9.0  | 8.8  | 9.0  | 9.1  | 9.4  | 10.  | 3.6            |
|              | Residential               | 11.  | 13.  | 13.  | 14.  | 14.  | 15.  | 15.  | -5.8           |

Table 4. Electricity consumption structure and its changes of cities in the eastern region.
In 2017, among the various types of cities in the eastern region, the proportion of the tertiary industry in the megacities was the highest with 37.7%, and the proportion of the secondary industry was the lowest with 43.4%, which was far from the other types of cities. Followed by Megalopolises and type-I large cities, the proportion of the tertiary industry was 23.4% and 16.0% respectively. In the type-I small city, the tertiary industry accounts for a higher proportion than the medium-sized cities because it contains some tourist cities.

**Figure 7.** Electricity consumption structure of cities in the eastern region in 2017.

4. Conclusion
This paper analyzes the power consumption of cities in the eastern part of China under the background of new urbanization, and counts the electricity consumption, per capita electricity consumption, per capita household electricity consumption and electricity consumption structure of 64 cities of different scales. The findings are as follows. First, with the continuous improvement of the urbanization rate, the electricity consumption of the whole society in the eastern region continues to increase, and the growth rate has slowed down since entering the new normal of the economy. Second, as the size of the city increases, the growth rate of per capita electricity consumption and per capita household electricity consumption declines in turn, indicating that large cities have developed more mature, electricity consumption has reached saturation earlier, and small-scale cities have room for future development. The gap among all types of cities will continue to shrink. Third, the electricity consumption structure of megacities is close to the level of developed countries, and the effect of structural adjustment is remarkable. The proportion of tertiary industry in other types of cities is still low, and the secondary industry occupies a dominant position. Fourth, as a whole, as the city scales up, its electricity consumption shows a strong regularity, but compared with other cities in the eastern region, the type-I small cities have higher levels of per capita household electricity consumption and more optimized power consumption structure. This aspect shows that the urban-rural integration has achieved relatively obvious results, and on the other hand, it is also due to the relatively high proportion of industries in the medium-sized cities.

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References
[1] Chen Mingxing, Sui Yuwen, Guo Shasha, The new trend of China's new urbanization after the "Nineteenth National Congress", Geographical Research, 2019, 01, pp. 108-111.
[2] Information on http://www.gov.cn/gongbao/content/2014/content_2644805.htm
[3] http://www.gov.cn/xinwen/2019-04/08/content_5380457.htm
[4] Xiao Xin, Zhou Yuhui, Zhang Ning, Research on the Relationship between Urbanization Process and Power Demand Growth, Electric Power, 2015, 02, pp. 73-77.

[5] Yuan Dan, Ou Xiangjun, Tang Zhaoqi, The spatial characteristics and influencing factors of the coordinated development of urbanization and public services in the eastern coastal population, Economic Geography, 2017, 03, pp. 55-59.

[6] Wang Fayuan, Zheng Jun, Pei Xiao, Spatial Dynamic Analysis of Urbanization Development in the Yangtze River Economic Belt, Regional Economic Review, 2019, 02, pp. 81-84.

[7] Ren Zhengwei; Mi Hong, The Driving Effects of the Multi-dimensional Characteristics of Regional Population Urbanization on Residents' Electricity Consumption, Population Research, 2016, 04, pp. 78-91.

[8] Yang Zhen, Lei Jun, Temporal and Spatial Patterns and Influencing Factors of Urbanization Development in China's Prefecture Level and Above, Journal of University of Chinese Academy of Sciences. 2019, 01, pp. 15-17.

[9] Chen Lisha, On the Role of New Urbanization Strategy in Realizing the Strategy of Rural Revitalization, Social Sciences in Yunnan, 2018, 06, 97-102.

[10] Liu Zhihua, Li Tiezheng, Xiao Ruiqing, Empirical Analysis on the Coordination Degree of Urbanization Development in Beijing-Tianjin-Hebei Region, Statistics & Decision, 2019, 07, pp. 53-57.