Power consumption of central cities in the context of the rise of Central China

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Abstract. In March 2004, Premier Wen Jiabao of the State Council explicitly stated for the first time in the government work report to promote the rise of the central region. 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 central region is a key area to undertake China's industrial transfer. Studying the characteristics of power consumption in urban agglomerations under the background of the rise of the central region and new urbanization will be of great significance to the scientific rationality of future power demand forecasting.

1. Introduction
Cities are the center of regional economic and social development. 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].

The central region is still in the middle and late stages of industrialization, accounts for 21.4% of GDP and 18.9% of the electricity consumption of the whole society in 2018. The central region is bounded by the east and the west, and connecting the south and the north. It plays a pivotal strategic position in the regional development pattern of the country and is a breakthrough for narrowing the regional gap. In December 2016, the State Council approved the “13th Five-Year Plan” to promote the rise of the central region [4]. The central region will be built into an important advanced manufacturing center in the country, a national key urbanization key area, a national core area for modern agricultural development, a national demonstration zone for ecological civilization construction, and an important supporting area for all-round opening. Therefore, it is necessary to study the characteristics of urban power consumption in the central cities to analyze the impact of new urbanization on China's power consumption [5]. At the same time, it is of great significance for scientifically and reasonably predicting future power demand.
2. Urbanization development in the central region

The central region includes 6 provinces including Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan, as shown in Fig. 1. At present, the central region is still in the middle and late stages of industrialization. It is heavily dependent on resources, labor factors and investment. Industrial upgrading and kinetic energy conversion are more difficult [6, 7]. The urbanization rate is still low and the quality is not high. The development of agriculture and rural areas is in the critical period of cracking various problems. In 2017, the urbanization rate in the central region was 54.3 %, 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 central region](image1)

![Figure 2. Urbanization rate and electricity consumption in the central region](image2)

The impact of new urbanization on the central region is mainly reflected in the following points. First, for economic development, new urbanization will promote the quality change, efficiency change, and dynamic change of economy. 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 contributes to the development of power demand. 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. Fifth, for space coordination, according to the “National Main Functional Area Plan”, there are 6 urbanization main functional areas in the central region [8], the industrial structure of these zones will be further optimized, 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 central cities
There are 0 megacities, 2 megalopolis, 3 type-I large cities, 10 Type-II large cities, 41 medium-sized cities, 27 Type-I small cities, and 0 Type-II small cities in the central 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 central 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.

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| City type         | Quantity | Cities                         |
|-------------------|----------|-------------------------------|
| Megalopolis       | 2        | Zhengzhou, Wuhan              |
| Type-I large city | 3        | Taiyuan, Hefei, Changsha      |
| Type-II           | 10       | Datong, Wuhu, Huainan, Nanchang, Zhengzhou, Kaifeng, Luoyang, Nanyang, Zhuzhou, Hengyang |
| Medium-sized city | 41       | Yangquan, Jinzhong, Linyi, Changzhi, Handan, Ma'anshan, Huaibei, Tongling, Anqing, Fuyang, Fuzhou, Yichun, Pingdingshan, Anyang, Xinxian, Jiaozuo, Fuyang, Xuchang, Weihe, Sanmenxia, Yichang, Jingmen, Xiaogan, Jingzhou, Xiantang, Shaoyang, Yueyang, Changde, Yiyang, Zhangzhou, Suzhou, Lu’an, Jiujiang, Shangrao, Shangqiu, Xinyang, Huangshi, Shiyan, Yongzhou, Huaihua, Loudi |
| Type-I small city | 27       | Luzhou, Luliang, Yuncheng, Zhangzhou, Jincheng, Huangshan, Zhangzhou, Zhangzhou, Chizhou, Xuancheng, Yingtang, Jían, Hebi, Zhoukou, Zhumadian, Fuyang, Ezhou, Huanggang, Xianning, Suizhou, Jingdezhen, Pingxiang, Zhangjiajie, Chaohu*, Xinyu*, Enshi*, Xiangxi* |
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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 central region is obtained as shown in Table 2. From 2005 to 2017, the per capita electricity consumption of all types of cities in the central region showed an increasing trend year by year, and there is a big gap between different city types. In general, as the size of the city shrinks, the electricity consumption per capita decreases in turn. However, the per capita electricity consumption level of Type-I small cities is very high, far exceeding that of medium-sized cities and Type-II large cities, which is close to the level of Type-I large cities. This is mainly because the Type-I small cities such as Yuncheng and Jincheng belong
to the powerful heavy industry cities, thus raising the per capita electricity consumption of the Type-I small cities. In 2017, the per capita electricity consumption of all types of cities by size ranked 7383, 4732, 3116, 2788 and 4543 kWh/person respectively.

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

| City type             | 2005  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  |
|-----------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Megalopolis           | 3294  | 4720  | 5117  | 5214  | 6054  | 5970  | 6540  | 6932  | 7383  |
| Type-I large city     | 2100  | 3381  | 3376  | 3748  | 4025  | 4131  | 4235  | 4460  | 4732  |
| Type-II large city    | 1332  | 2271  | 2521  | 2622  | 2801  | 2866  | 2766  | 2898  | 3116  |
| Medium-sized city     | 1187  | 1980  | 2198  | 2300  | 2465  | 2490  | 2474  | 2596  | 2788  |
| Type-I small city     | 1790  | 3216  | 3577  | 3807  | 4037  | 4081  | 4095  | 4238  | 4543  |

**Figure 3. Trends in per capita electricity consumption of cities in the central region**

According to the growth rate of electricity consumption per capita in various types of cities, the growth rate of electricity consumption in Type-I small cities is the highest. With the expansion of the city scale, the growth rate of electricity consumption has decreased in turn. From 2005 to 2017, the growth rate of electricity consumption of various types of cities was 7.0%, 7.0%, 7.3%, 7.4% and 8.1% respectively. However, since entering the new economic normal, the growth rate of electricity consumption in megalopolises and type-I large cities has surpassed that of small-scale cities, reflecting that with the development of high-quality economy and new urbanization, the development of large-scale cities in the central region is accelerating, and the development speed of smaller-scale cities is lagging behind. The average growth rate of electricity consumption in various types of cities in 2012-2017 was 6.3%, 5.8%, 3.6%, 4.0% and 4.1% respectively.

**Figure 4. Per capita electricity consumption in all types of cities in the central region**

3.2. *Per capita living electricity consumption*

Through calculation, the per capita living electricity consumption of various types of cities in the central region is shown in Table 3. During the period of 2005-2017, the per capita living electricity consumption
of all types of cities in the central region increased year by year, among which the per capita living electricity consumption of megalopolises and type-I large cities was higher with 1225 and 1047 kWh/person respectively in 2017. The per capita living electricity consumption of Type-II large cities, medium cities, and Type-I small cities is relatively low. In 2017, it was 586, 498 and 453 kWh/person respectively. The gap is very prominent, reflecting the uneven development of various cities of the central region.

Table 3. Per capita living electricity consumption in all types of cities in the central region

| City type        | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|------------------|------|------|------|------|------|------|------|------|------|
| Megalopolis      | 440  | 703  | 765  | 828  | 916  | 1002 | 916  | 1057 | 1139 | 1225 |
| Type-I large city | 413  | 718  | 710  | 819  | 911  | 848  | 904  | 975  | 1047 |
| Type-II large city | 151  | 292  | 316  | 385  | 438  | 438  | 471  | 522  | 586  |
| Medium-sized city | 135  | 262  | 294  | 343  | 383  | 384  | 410  | 448  | 498  |
| Type-I small city | 120  | 261  | 287  | 336  | 361  | 369  | 391  | 419  | 453  |

Figure 5. Trends in per capita living electricity consumption of cities in the central region

From the growth rate of per capita living electricity consumption, the growth rate of smaller-scale cities is larger than that of larger-scale cities. The growth rate of electricity consumption of various types of cities in 2005-2017 is 9.0%, 10.2%, 13.4%, 12.4% and 12.6% respectively. Since 2012, with the continuous advancement of new urbanization and the entry of economic development into a new normal, the growth rate of energy consumption in Type-II large cities has remained the highest, but the growth rate of medium-sized cities and Type-I small cities has declined, basically the same as the growth rate of megalopolis and type-I large cities. The level of residential electricity consumption is relatively balanced.

Figure 6. Per capita living electricity consumption in all types of cities in the central region
3.3. Power consumption structure

In 2005-2017, the overall effect of power consumption structure optimization in various types of cities in the central region was obvious, as shown in Table 4. The proportion of electricity consumption in the secondary industries of all types of cities decreased by a large margin, and the electricity consumption of the tertiary industry and residents increased significantly. Among them, the tertiary industry in megalopolises and type-I large cities accounted for 24.9% and 24.6% of electricity consumption in 2017 respectively, increase by 6.9 and 8.8 percentage points from 2005.

In 2017, among the cities of the central region, the living and tertiary industries electricity consumption of megalopolises and type-I large cities accounted for 43.9% and 49.1% respectively. The proportion of Type-II large cities, medium-sized cities and Type-I small cities is relatively small with 35.3%, 32.8% and 34.2% respectively.

In 2017, among the cities of the central region, the living and tertiary industries electricity consumption of megalopolises and type-I large cities accounted for 43.9% and 49.1% respectively. The proportion of Type-II large cities, medium-sized cities and Type-I small cities is relatively small with 35.3%, 32.8% and 34.2% respectively.

Table 4. Electricity consumption structure and its changes of cities in the central region

| Industrial classification | Industrial consumption | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Range of change |
|---------------------------|------------------------|------|------|------|------|------|------|------|------|------|-----------------|
| Primary industry          | Megalopolis            | 13.4 | 13.3 | 13.4 | 13.4 | 13.4 | 13.4 | 13.4 | 13.4 | 13.4 | 0.1             |
| Secondary industry        | Megalopolis            | 75.9 | 75.9 | 75.9 | 75.9 | 75.9 | 75.9 | 75.9 | 75.9 | 75.9 | 0.1             |
| Tertiary industry         | Type-I large city      | 3.7  | 3.7  | 3.7  | 3.7  | 3.7  | 3.7  | 3.7  | 3.7  | 3.7  | 0.1             |
| Residential               | Type-I large city      | 4.7  | 4.7  | 4.7  | 4.7  | 4.7  | 4.7  | 4.7  | 4.7  | 4.7  | 0.1             |
| Primary industry          | Type-II large city     | 8.2  | 8.2  | 8.2  | 8.2  | 8.2  | 8.2  | 8.2  | 8.2  | 8.2  | 0.1             |
| Secondary industry        | Type-II large city     | 74.6 | 74.6 | 74.6 | 74.6 | 74.6 | 74.6 | 74.6 | 74.6 | 74.6 | 0.1             |
| Tertiary industry         | Medium-sized city      | 14.7 | 14.7 | 14.7 | 14.7 | 14.7 | 14.7 | 14.7 | 14.7 | 14.7 | 0.1             |
| Residential               | Medium-sized city      | 4.3  | 4.3  | 4.3  | 4.3  | 4.3  | 4.3  | 4.3  | 4.3  | 4.3  | 0.1             |
| Primary industry          | Type-I small city      | 11.2 | 11.2 | 11.2 | 11.2 | 11.2 | 11.2 | 11.2 | 11.2 | 11.2 | 0.1             |
| Secondary industry        | Type-I small city      | 73.7 | 73.7 | 73.7 | 73.7 | 73.7 | 73.7 | 73.7 | 73.7 | 73.7 | 0.1             |
| Tertiary industry         | Type-I small city      | 9.3  | 9.3  | 9.3  | 9.3  | 9.3  | 9.3  | 9.3  | 9.3  | 9.3  | 0.1             |
| Residential               | Type-I small city      | 12.2 | 12.2 | 12.2 | 12.2 | 12.2 | 12.2 | 12.2 | 12.2 | 12.2 | 0.1             |

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

4. Conclusion

This paper analyzes the power consumption of cities in the central part of China under the background of new urbanization, and counts the electricity consumption, per capita electricity consumption, per capita living electricity consumption and electricity consumption structure of 79 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 central 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 shrinks, the electricity consumption per capita decreases in turn, but the per capita electricity consumption of type-I small cities far exceeds that of medium-sized cities and type-II large cities. This is mainly because the Type-I small cities such as Yuncheng and Jincheng belong to the powerful heavy industry cities, thus raising the per capita electricity consumption of the Type-I small cities. Third, the economic structure optimization effect is obvious, and the secondary industry still dominates. The proportion of secondary industry electricity consumption in megalopolises and type-I large cities is significantly lower than that in other cities. The proportion of tertiary industry electricity consumption and residential electricity consumption is significantly higher than that of other cities, reflecting the uneven structural optimization level of cities of different sizes in the central region.

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