Chinese City Carbon Peak Index

IPE 公众环境研究中心 Institute of Public & Environmental Affairs

China City Greenhouse Gas Working Group

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Institute of Public and Environmental Affairs (IPE)

The Institute of Public & Environmental Affairs (IPE) is a non-profit environmental research organization registered and based in Beijing, China. Since its establishment in June 2006, IPE has collected government and corporate environmental information into a comprehensive database. IPE's two platforms – the Blue Map website and the Blue Map app – provide environmental data to serve green procurement, green finance and environmental policymaking, using cooperation between companies, government, NGOs, research organizations and other stakeholders to promote environmental information disclosure and improve environmental governance mechanisms.

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Acknowledgements

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Summary

In September 2020, Chinese President Xi Jinping announced at the General Debate of the 75th Session of The United Nations General Assembly, "China will scale up its Intended Nationally Determined Contributions by adopting more vigorous policies and measures. We aim to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060." Compared with China's previous pledge proposed at the Paris Climate Change Conference, peaking CO_2 emissions around 2030, this statement changes only one word, which means efforts to tackle climate change will be greatly strengthened.

Peaking carbon emissions has become a significant environmental goal for China in the next ten years. It is also a key step to achieve carbon neutrality in 2060. To achieve the overall peak carbon emission requires the joint efforts of each region. The newly released 14th Five-Year Plan and the Long-Range Objectives Through the Year 2035 clearly stated that "supporting areas with favorable conditions to be the first to reach carbon emissions peak". The Central Economic Work Conference further specified this as one of the key tasks in 2021: "We must promptly formulate an action plan for peaking carbon emissions by 2030, and support areas with favorable conditions to reach the peak first."

To this end, the Ministry of Ecology and Environment, the responsible agency for tackling climate change, recently stated that during the 14th Five-Year Plan and 15th Five-Year Plan period, China would carry out actions to achieve peak carbon emissions, by clarifying peaking targets and action plans of localities and industries, and encouraging relevant departments to formulate targeted action plans on peaking carbon emissions.

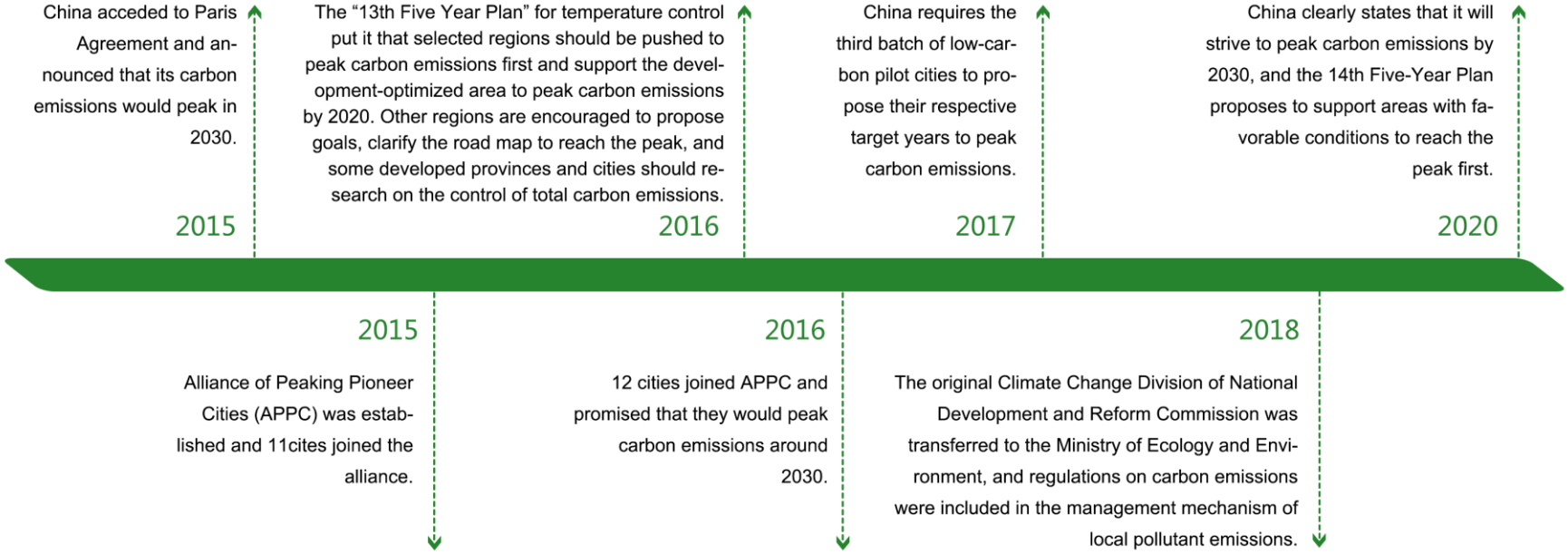
The Ministry of Ecology and Environment stated that relevant work will be taken as part of the central inspection on ecological and environmental protection, and the progress in implementing peaking action plans on the local level will be evaluated. This shows the Chinese government's resolution to promote the work on resolving climate change with the adoption of most effective policy tools.

Cities consume 67% to 76% of national energy and generate 71% to 76% energy-related CO_2 emissions. Cities being the core of controlling carbon emissions in China, their peaking of carbon emissions will have an important impact on achieving the national emission peak target by 2030.

In order to make all public sectors get aware of and cooperate with the action on peaking carbon emissions, on the basis of the collaboration with China City Greenhouse Gas Working Group, IPE developed the "City Carbon Peak Map" and the "Carbon Peak Index" of cities in China. The Carbon Peak Map displays that 80 provinces and cities have set the goal of reaching the peak. The peak index involves six levels: vanguard, leading, flat, sluggish, pressing and lagging, and evaluates from three dimensions: peak trend judgment, target year setting, and carbon intensity of cities.

CO_2 emissions of the 58 cities covered by the first evaluation accounted for 44% of the national volume. These cities contribute to 47% of the national GDP and house 32% of the total population. The evaluation results reveal that Shenzhen, Kunming, and Wuhan are rated as vanguard cities, and Beijing, Shanghai, Guangzhou, Xiamen, Nanjing, Qingdao, Changsha, Handan, and Zibo are regarded as leading cities. Some cities face challenges to peak emissions and the work on energy saving and carbon reduction needs to be strengthened urgently.

Based on this report, it is recommended that cities nationwide shall set and announce carbon peak targets as soon as possible, carry out peaking action, evaluate and release the progress annually. Leading cities should set and publish emission reduction pathways after peaking, establish mandatory and voluntary combined corporate carbon emission disclosure system. Also, leading cities shall encourage companies to make targets for emission reduction, carbon peak and carbon neutrality.


China acceded to Paris Agreement and announced that its carbon emissions would peak in 2030.
2015
The “13th Five Year Plan” for temperature control put it that selected regions should be pushed to peak carbon emissions first and support the development-optimized area to peak carbon emissions by 2020. Other regions are encouraged to propose goals, clarify the road map to reach the peak, and some developed provinces and cities should research on the control of total carbon emissions.
2016
China requires the third batch of low-carbon pilot cities to propose their respective target years to peak carbon emissions.
2017
China clearly states that it will strive to peak carbon emissions by 2030, and the 14th Five-Year Plan proposes to support areas with favorable conditions to reach the peak first.
2020
2015
Alliance of Peaking Pioneer Cities (APPC) was established and 11cites joined the alliance.
2016
12 cities joined APPC and promised that they would peak carbon emissions around 2030.
2018
The original Climate Change Division of National Development and Reform Commission was transferred to the Ministry of Ecology and Environment, and regulations on carbon emissions were included in the management mechanism of local pollutant emissions.

City Carbon Emissions Peak

City Carbon Emissions Peak refers to the status that the carbon dioxide emissions (in years) of a city reaches the peak in a period of time, then it comes the plateau period, and the emissions may fluctuate within a certain range. Next, it enters into a steady decline phase (see Figure 2). Due to economic factors, extreme weather and natural factors, etc., the city shall have a rise in carbon emissions at the plateau stage, depending on the situation, but the carbon emissions peak cannot be exceeded.

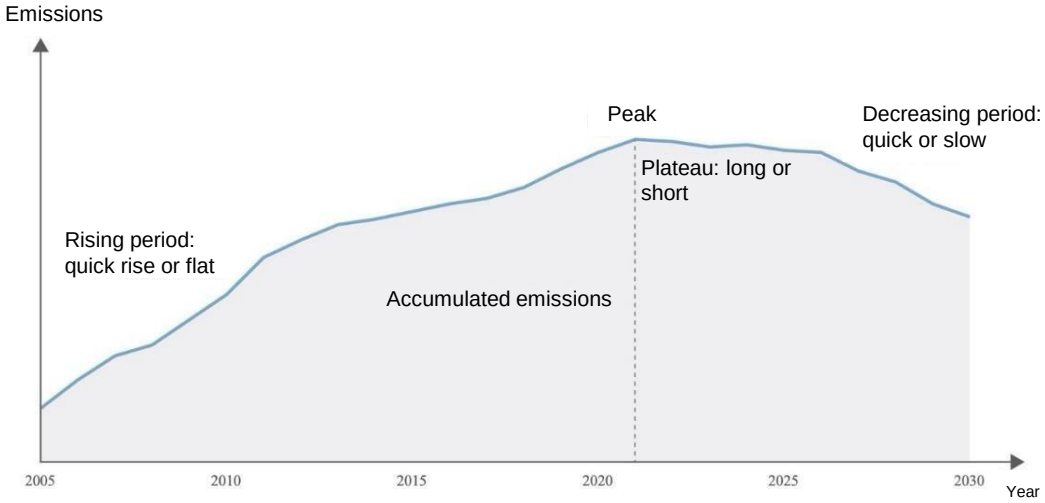


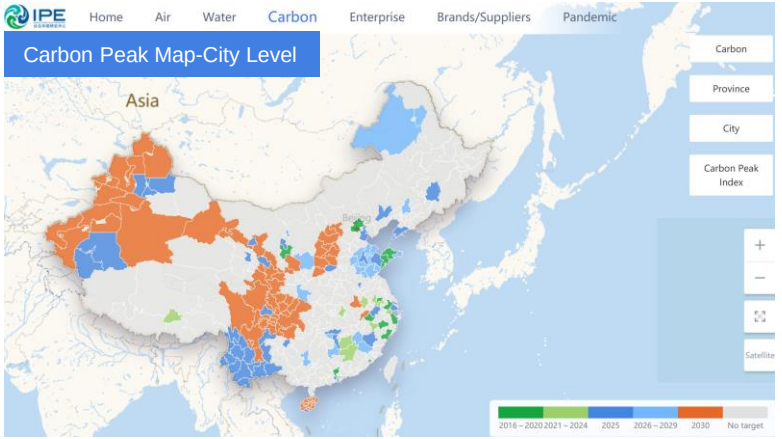
Figure 2 - Illustration of city carbon emissions peak

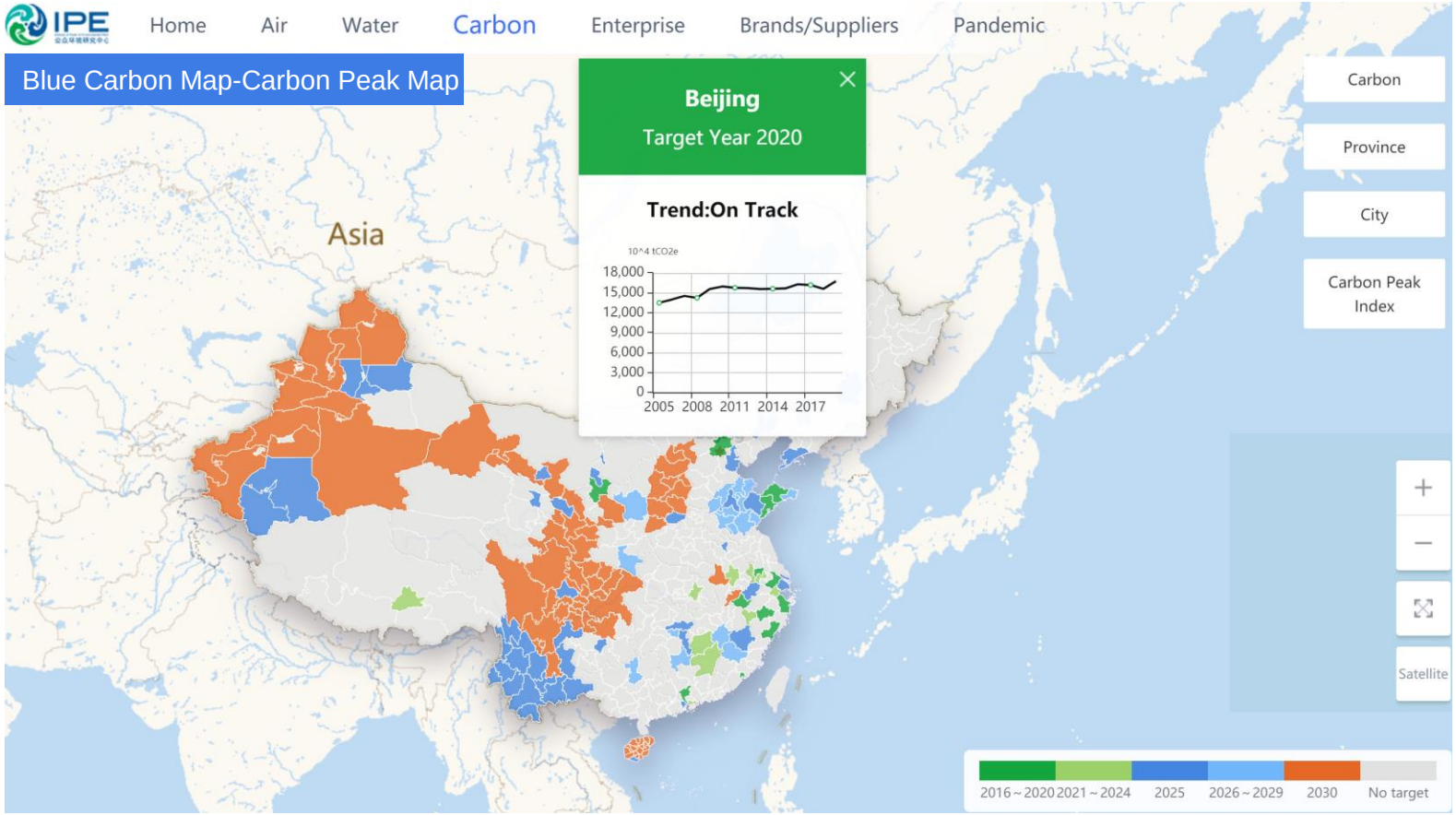
Target Year of Carbon Emissions Peak

At the first China-US Climate Smart/Low Carbon Cities Summit in 2015, the Alliance of Peaking Pioneer Cities (APPC) was established, and 11 provinces and cities including Beijing, Shenzhen, and Guangzhou proposed their respective target years to peak carbon emissions. Later, 12 more provinces and cities have joined, all of which are low-carbon pilot ones except Sichuan. In 2017, the third batch of 45 national low-carbon pilot projects announced by the National Development and Reform Commission also proposed corresponding target year.

75 of the 87 low-carbon pilot provinces and cities have proposed a target year to peak carbon emissions. In addition, Sichuan, Gansu, Shandong, Shanxi, Xinjiang and other provinces have proposed the target year in the "13th Five-Year Plan“ for controlling GHG emissions, so that a total of 80 provinces and cities have set their target year.

13 of them set the target during the "13th Five-Year Plan" period, while 43 of them set the target during the "14th Five-Year Plan" period, and 24 of them during the "15th Five-Year Plan" period.

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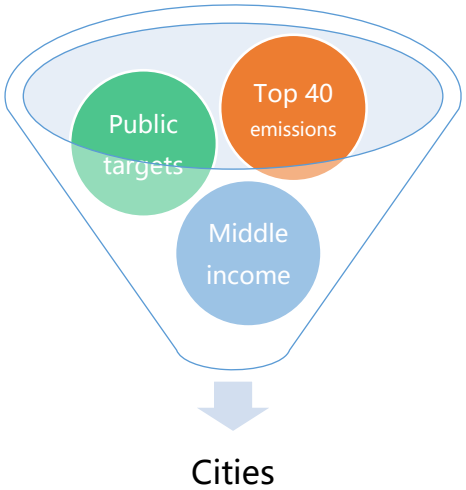
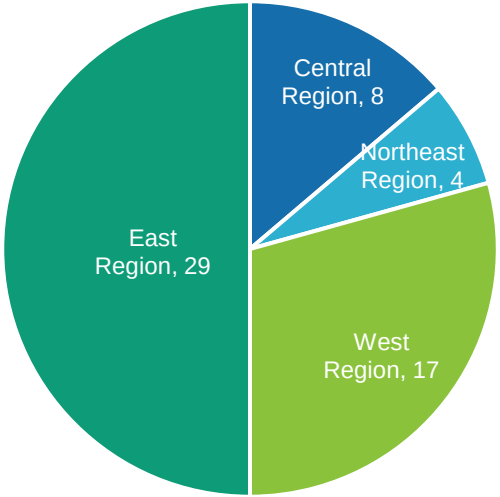
Pandemic
Blue Carbon Map-Carbon Peak Map
Beijing
Target Year 2020
Trend:On Track
10^4 tCO2e
18,000
15,000
12,000
9,000
6,000
3,000
0
2005 2008 2011 2014 2017
Asia
Carbon
Province
City
Carbon Peak Index
Satellite
2016 ~ 2020
2021 ~ 2024
2025
2026 ~ 2029
2030
No target

Cities selected for Carbon Peak Index



Distribution of Cities



In addition, 21 of the 58 cities are municipalities, capitals of provinces or autonomous regions.

The importance of City Carbon Peak Index

Enable all sectors of the society to understand and support peaking action

The basis and prerequisite of reaching national carbon emission peak before 2030 is that some developed/high carbon emissions regions first peak emissions. The cities covered by the City Carbon Peak Index account for 44% of China's total carbon dioxide emissions, 47% of GDP, and 32% of total population (see Figure 3). The evaluation of carbon peak index, shall help the government, enterprises and the society to recognize the progress and challenges of climate action in various regions, promote the peaking action of covered cities, ensure that China will reach the peak before 2030, and create favorable conditions for the ultimate goal of carbon neutrality.

The setting of peaking goals will accelerate cities' low-carbon development in the long term

The regional work plan for controlling GHG emissions is basically based on the five-year carbon intensity reduction target set by the national Five-Year Plan. The setting of the long-term peaking target is forward-looking with regard to the low-carbon development of cities in the long run.

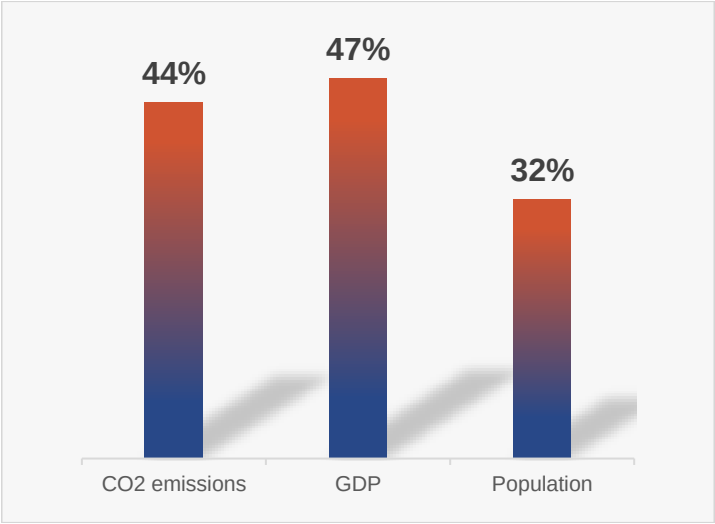


Figure 3 - The proportion of CO_2 emissions, GDP and population of carbon peak index cities in the country (2019)

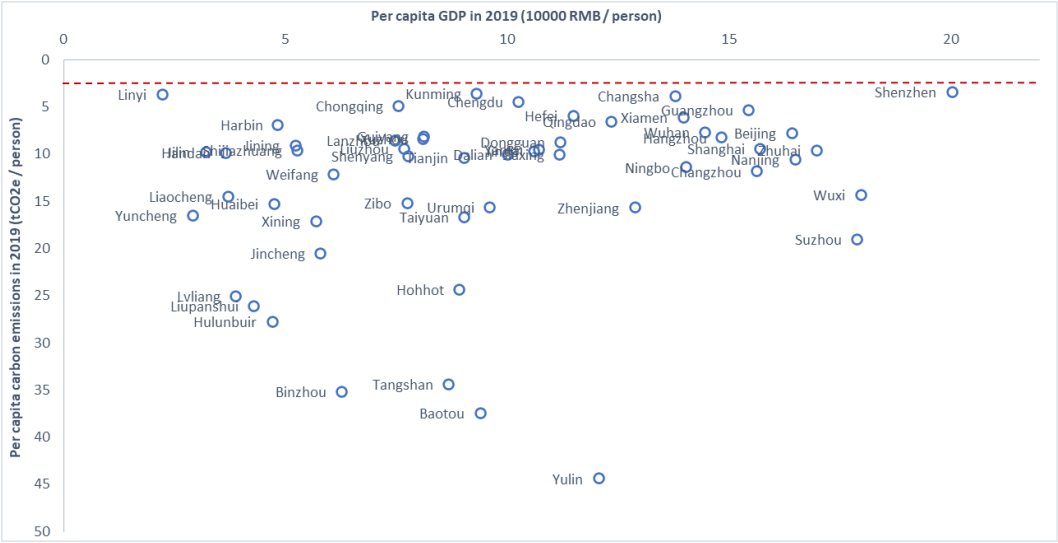
Fair low-carbon life

The per capita carbon emissions in Shenzhen is the the lowest among carbon peak index cities, which is 3.4 tons of carbon dioxide equivalent per person. This does not reach the target of 2.5 tons of per capita carbon emissions.

“

To achieve the goal of limiting the global warming below 1.5℃ in the Paris Agreement, it is necessary to reduce per capita consumption carbon footprints allocated to daily life, to approximately 2-2.5 tons of carbon dioxide equivalent by 2030.

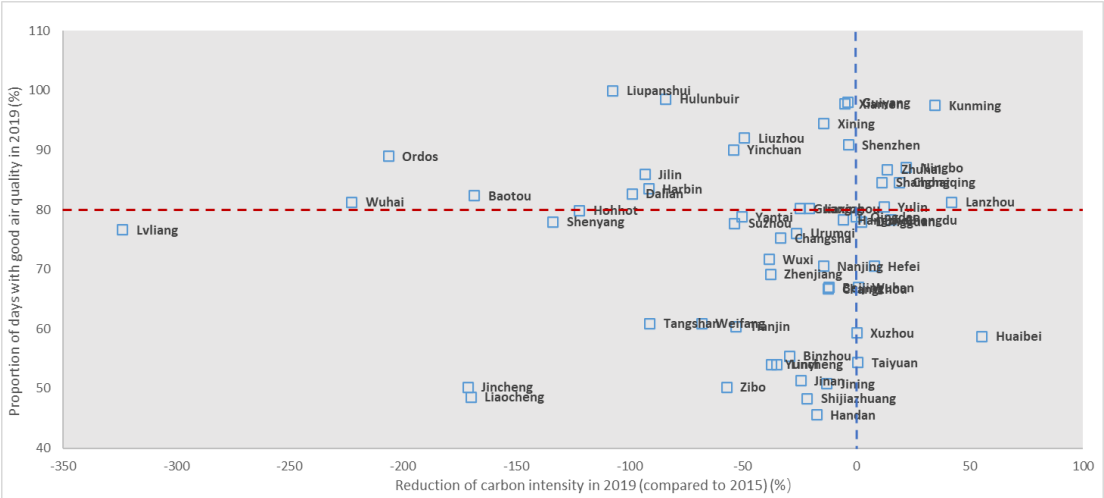
—— *《2020 Emissions Gap Report》*



Synergy of carbon emission reduction and pollution control

40% of cities with the carbon peak index have reached air quality standards in 2019, and 26% have reduced their carbon intensity in 2019 compared with 2015.

Located in the second quadrant, only 7 cities meet air quality standards with reduced carbon intensity—**Kunming, Shanghai, Chongqing, Ningbo, Lanzhou, Zhuhai, and Yulin**.

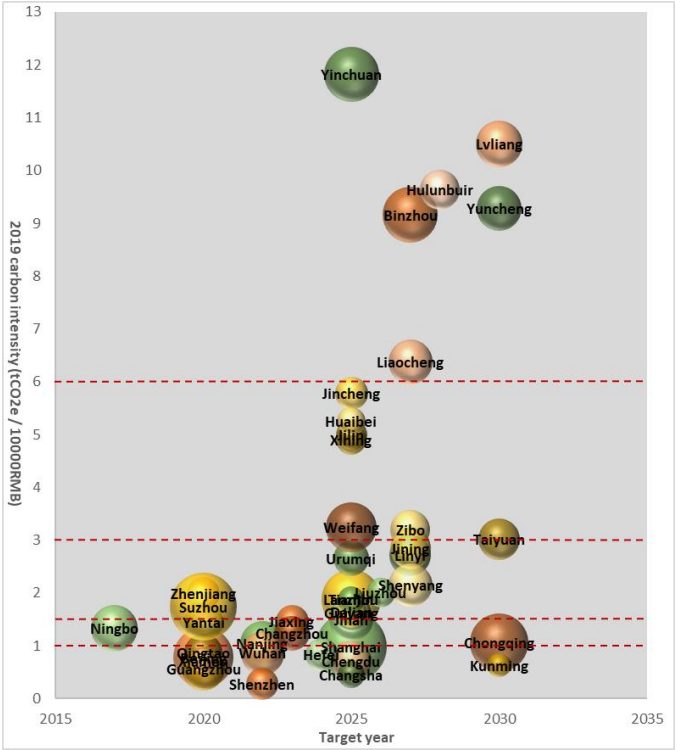


Double control of carbon intensity and emissions cap

Based on the comparison of the carbon intensity and the target year of the cities, cities with low carbon intensity and high total emissions (large bubbles) are more likely to reach the peak before 2025 (inclusive). However, from the perspective of carbon neutrality, cities with large emissions must set a path to reduce emissions after peaking.

The carbon intensity of 58 cities is divided into 5 levels:

Level	City
5	**Wuhai、Changji、Yinchuan、Lvliang、Liupanshui、Ordos、Hulunbuir、Yuncheng、Binzhou、Baotou、Tangshan、Liaocheng**
4	**Yulin、Jincheng、Huaibei、Jilin、Xining、Hohhot、Handan、Weifang、Zibo、Taiyuan**
3	**Shijiazhuang、Jining、Linyi、Urumqi、Harbin、Shenyang、Liuzhou、Zhenjiang、Tianjin、Lanzhou、Suzhou、Xuzhou、Dalian、Guiyang**
2	**Jinan、Jiaxing、Yantai、Ningbo、Wuxi、Dongguan、Changzhou、Chongqing、Nanjing**
1	**Shanghai、Zhuhai、Hangzhou、Qingdao、Wuhan、Hefei、Beijing、Xiamen、Chengdu、Kunming、Guangzhou、Changsha、Shenzhen**

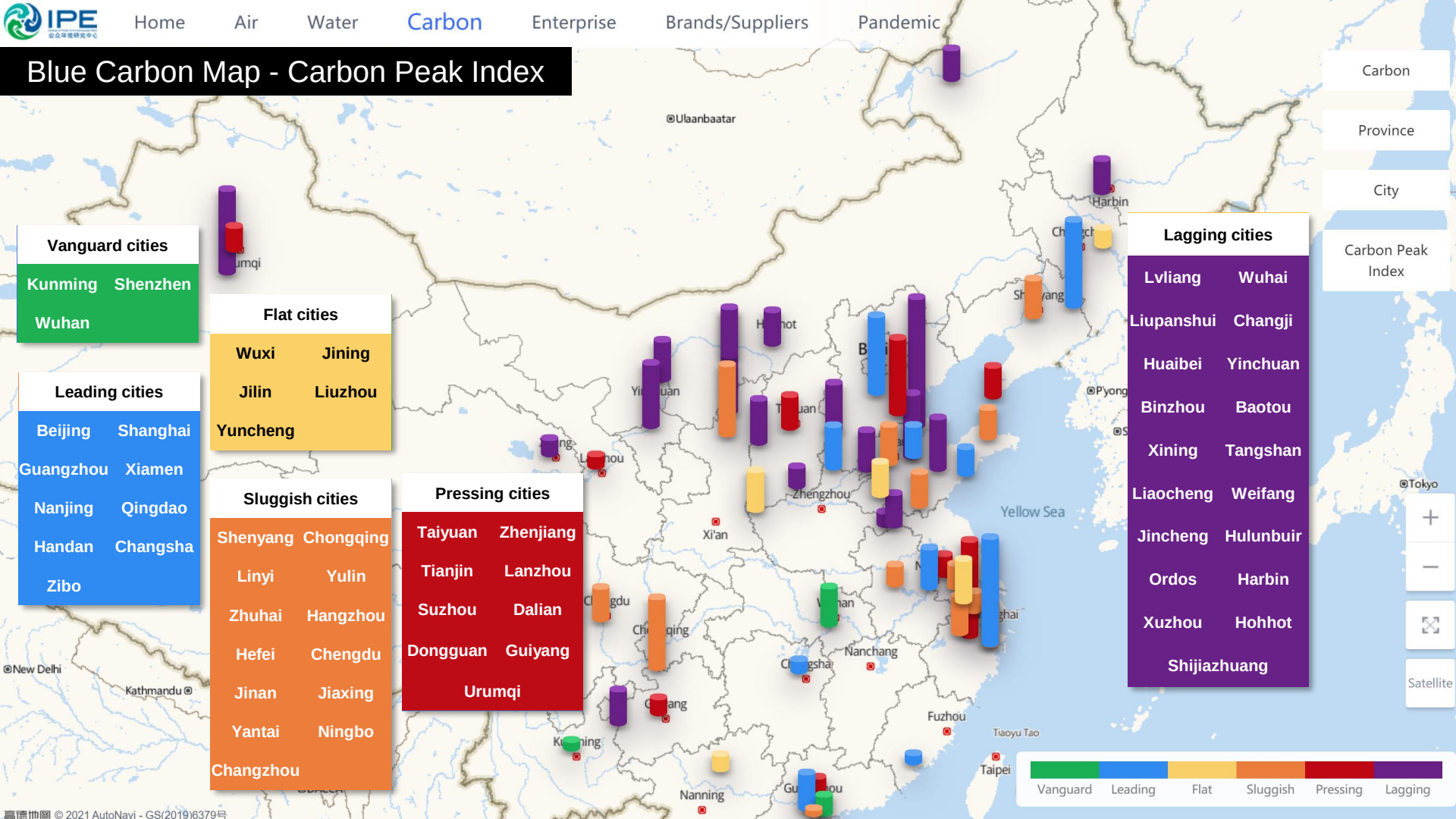


City Carbon Peak Index

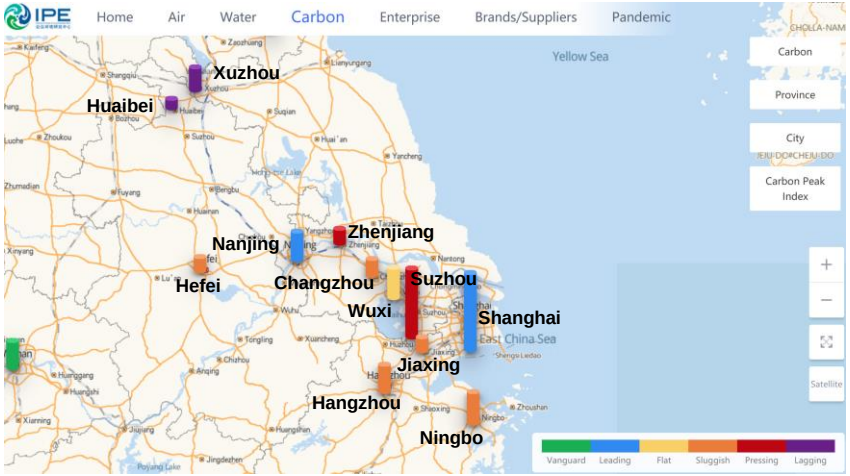
Led by many different types of pioneer cities, more cities will find suitable paths to peak.

Index		Indicator		
		Peaking trend	**Target year / Emission reduction path**	**Carbon intensity**
	Vanguard	Have reached the peak	Have published target year, or have set the emission reduction path after reaching the peak	Adjust the index based on the levels of city carbon intensity above: • The vanguard and leading cities with carbon intensity of level 5 and 4, comes down 2 and 1 level, not lower than “flat” level; • The lagging and pressing cities with carbon intensity of level 1 and 2, goes up 2 and 1 level, not higher than “sluggish” level.
	Leading	Plateau period - expected to reach the peak by 2025	Target year is before 2025 (inclusive), or have set the emission reduction path after the peak	
	Flat	Plateau period - expected to reach the peak by 2025	Target year is after 2025	
	Flat	Plateau period - expected to reach the peak by 2025	Have not yet published target year	
	Sluggish	Have not reached the peak - expected to reach the peak after 2025	Target year is after 2025	
	Pressing	Have not reached the peak - expected to reach the peak after 2025	Target year is before 2025 (inclusive)	
	Lagging	Have not reached the peak - expected to reach the peak after 2025	Have not yet published target year	

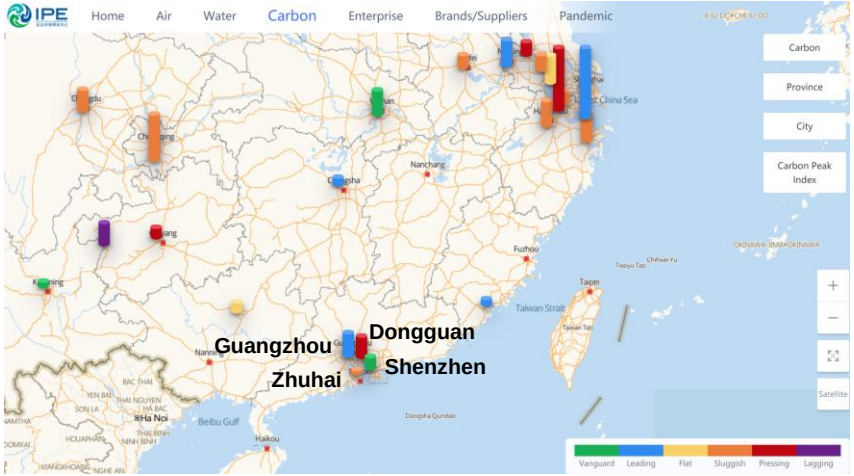
Blue Carbon Map - Carbon Peak Index



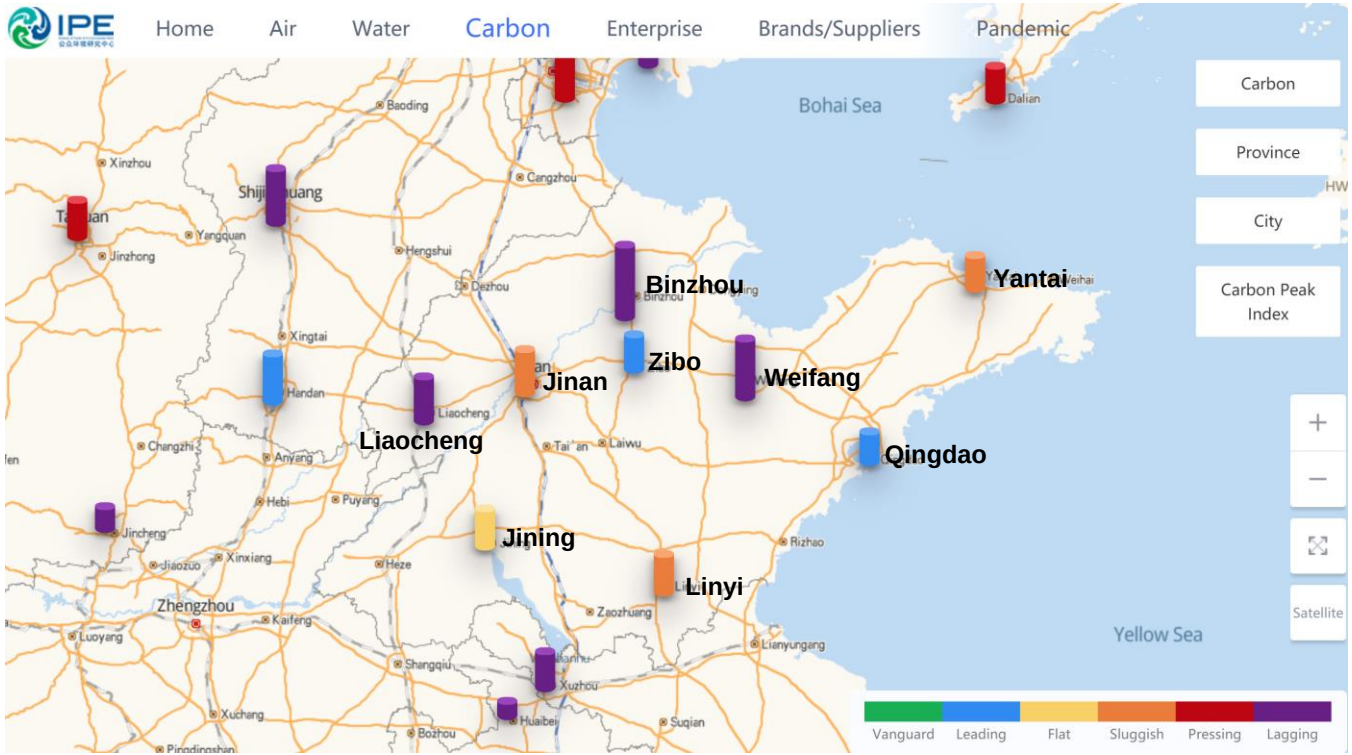
Yangtze River Delta



Pearl River Delta



Shandong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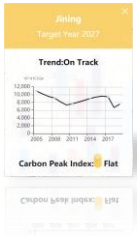
Bohai Sea
Yellow Sea
Dalian
Yantai
Binzhou
Zibo
Weifang
Jinan
Liaocheng
Qingdao
Jining
Linyi
Zhengzhou
Carbon
Province
City
Carbon Peak Index
Satellite
Vanguard
Leading
Flat
Sluggish
Pressing
Lagging

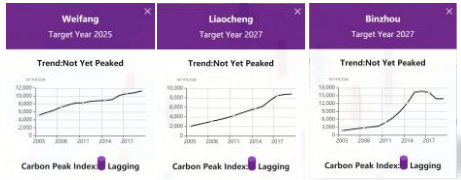
Shandong 2007

Qingdao is expected to reach its peak by 2025, and Zibo has reached the peak, taking the lead in Shandong province.

Linyi, Jinan, and Yantai have challenges to reach their peaks before 2025, and their target year is set before 2025 (inclusive), and the progress in peaking action is sluggish.



Jining is expected to reach its peak emission before 2025, and the target year is set at 2027. The progress of peak mission is relatively flat.



Weifang, Liaocheng, and Binzhou have challenges to reach their peaks before 2025. They have not set the target year for peaking, and the province's target year is set at 2027. The peaking action is lagging behind.

“Double Achieved” City

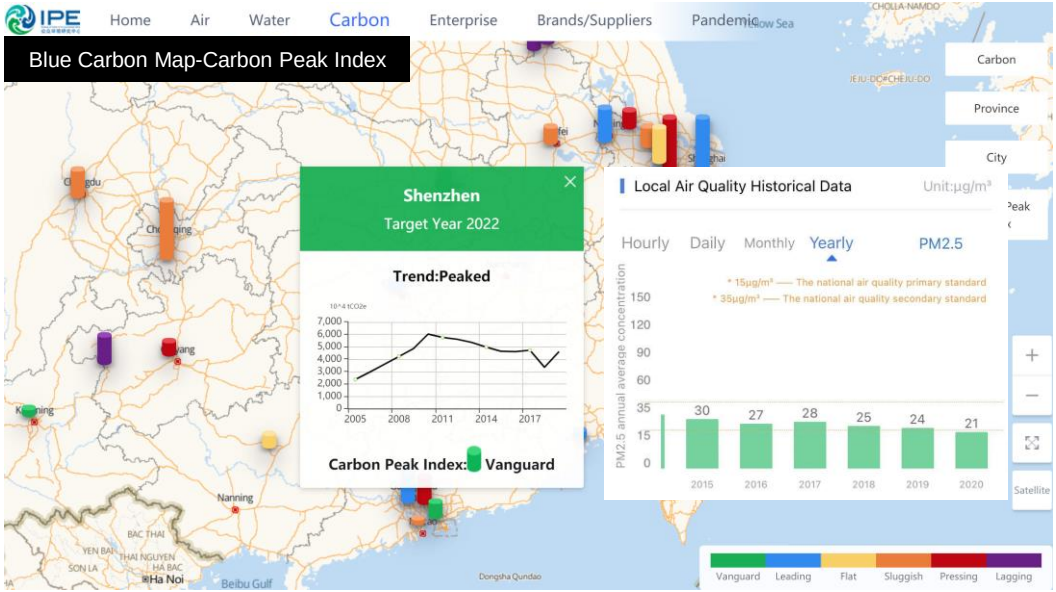
Shenzhen

In 2015, Shenzhen took the lead in proposing the goal of achieving carbon peak by 2022, and it also proposed to achieve the second phase of the World Health Organization’s air quality standard (25 micrograms/m3) by 2020, which is higher than the current national air quality standard.

Shenzhen ranked first in per capita GDP in 2019, with the lowest per capita carbon emissions, and met air quality standards. The annual average amount of PM2.5 reached its target of 25 micrograms.

Based on the long-term carbon dioxide emission sequence of Shenzhen from 2005 to 2019, the emission peak trend shows that Shenzhen has reached the peak.

It is believed that Shenzhen, a “vanguard” city, can drive more large cities to carry out coordinated governance of pollution and carbon reduction.



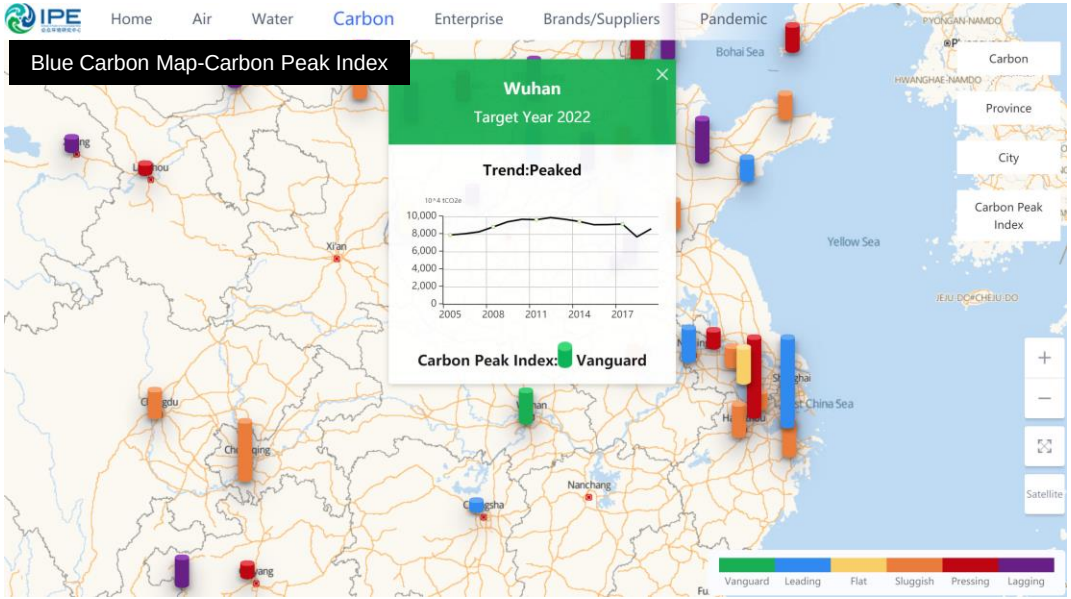
“Vanguard” City

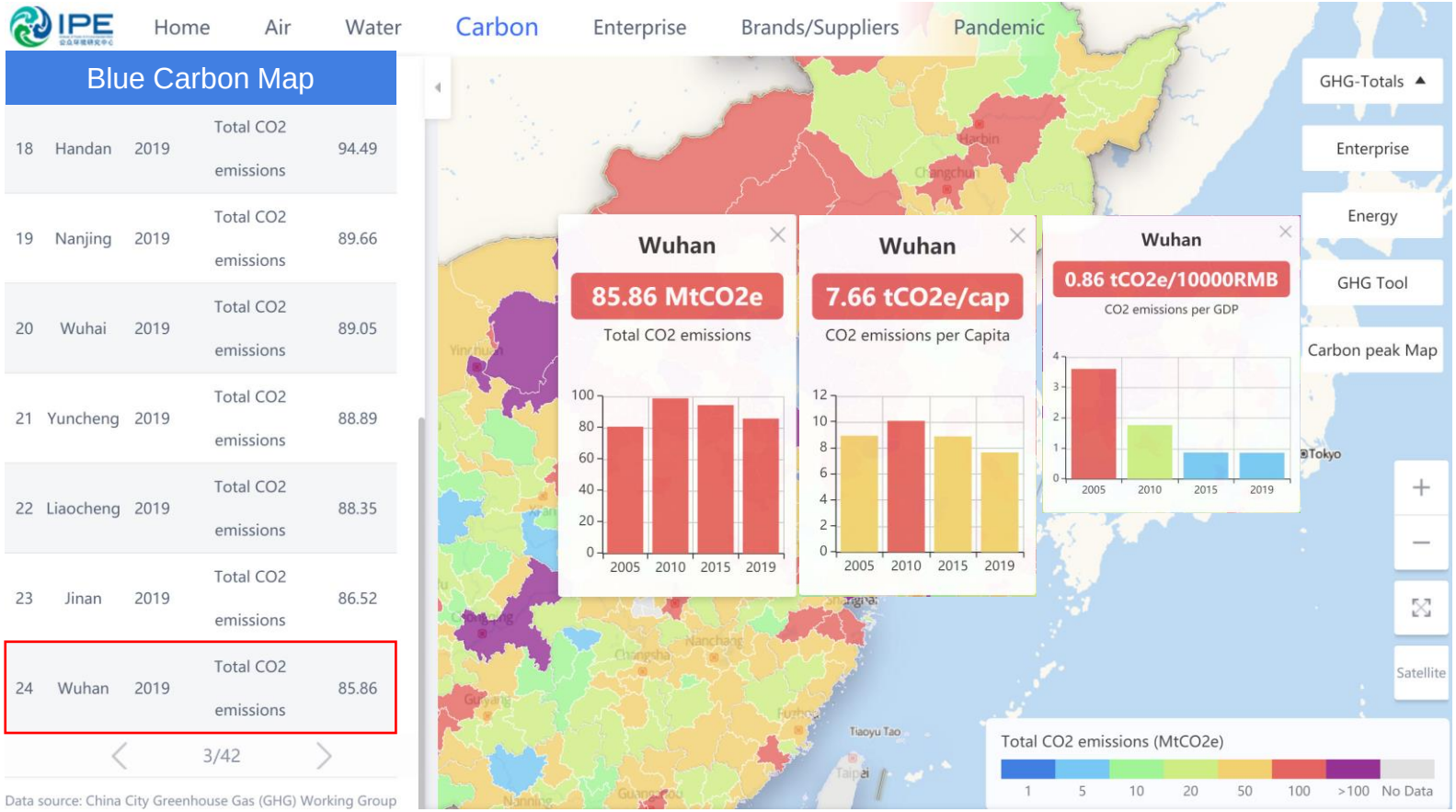
Wuhan

At the 2015 China-US Climate Smart/Low Carbon Cities Summit, Wuhan put forward the goal of reaching its peak by 2022.

Based on the long-term carbon dioxide emission sequence of Wuhan from 2005 to 2019, the emission peak trend shows that Wuhan has reached the peak.

Over the past three years, since the "Wuhan City Carbon Emission Peak Action Plan (2017-2022)" was released, as a ”vanguard" city, Wuhan would contribute to peaking carbon emissions of the country before 2030.




IPE
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Blue Carbon Map
18 Handan 2019 Total CO2 emissions 94.49
19 Nanjing 2019 Total CO2 emissions 89.66
20 Wuhai 2019 Total CO2 emissions 89.05
21 Yuncheng 2019 Total CO2 emissions 88.89
22 Liaocheng 2019 Total CO2 emissions 88.35
23 Jinan 2019 Total CO2 emissions 86.52
24 Wuhan 2019 Total CO2 emissions 85.86
3/42
Data source: China City Greenhouse Gas (GHG) Working Group
GHG-Totals
Enterprise
Energy
GHG Tool
Carbon peak Map
Satellite
Wuhan
85.86 MtCO2e
Total CO2 emissions
Wuhan
7.66 tCO2e/cap
CO2 emissions per Capita
Wuhan
0.86 tCO2e/10000RMB
CO2 emissions per GDP
Total CO2 emissions (MtCO2e)
1 5 10 20 50 100 >100 No Data

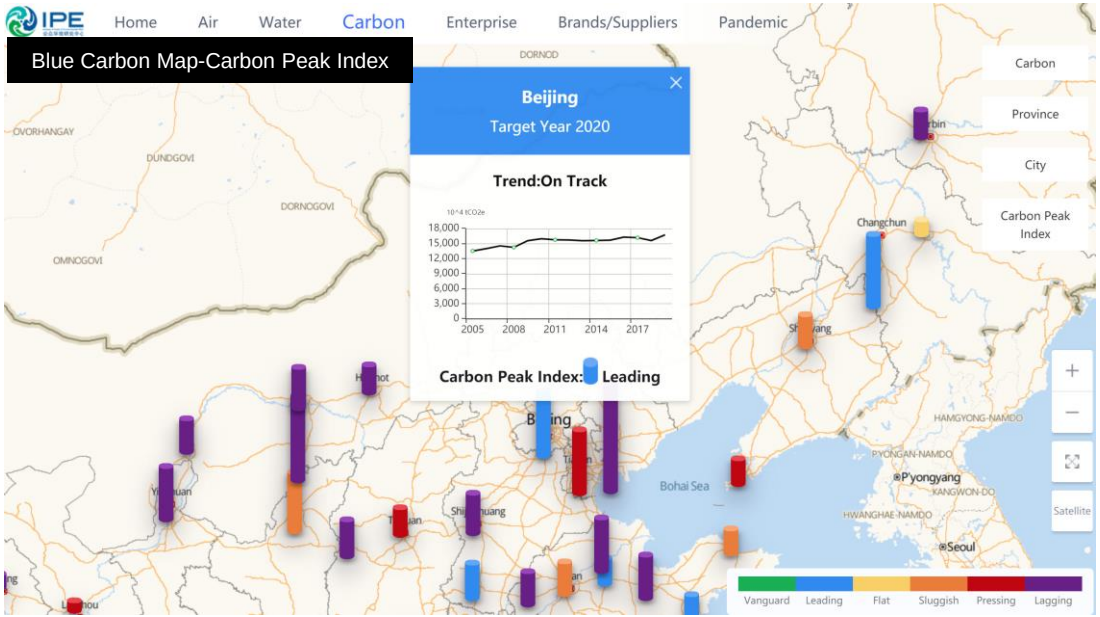
“Leading” City

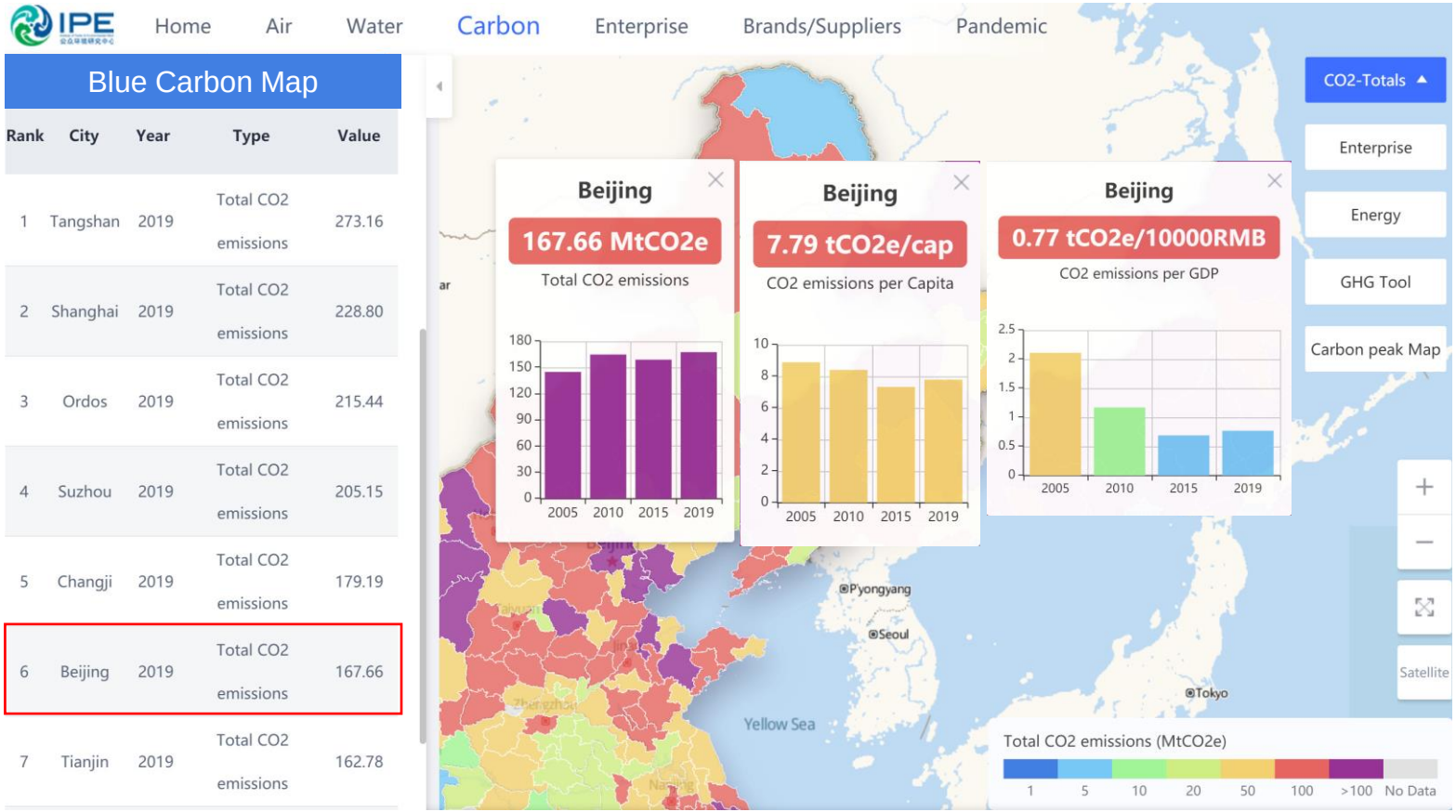
Beijing

Beijing is also one of the first cities to propose a carbon peak target. It also proposed to peak carbon emission by 2020 at the first China-US Climate Smart/Low Carbon Cities Summit in 2015.

The major changes have taken place in Beijing's energy structure, the proportion of coal has been declining, and the proportion of natural gas has been rising. However, due to the continuous growth of purchased power (mainly coal power), the low-carbon energy structure is not yet set.

Based on the long-term carbon dioxide emission sequence of Beijing from 2005 to 2019, the emission peaking trend shows that Beijing is in a plateau period and is expected to reach the peak before 2025.

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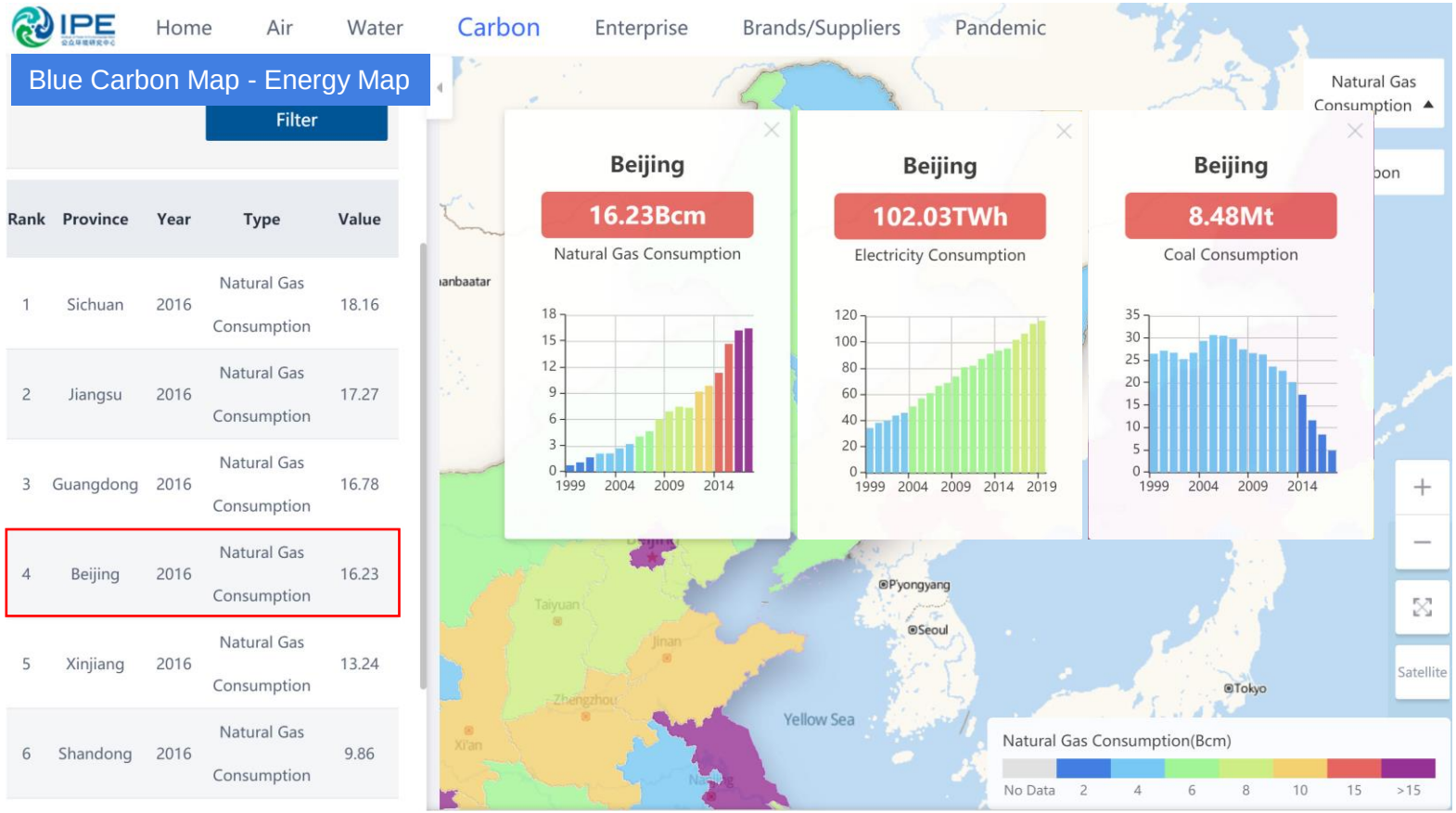
Blue Carbon Map
Rank City Year Type Value
1 Tangshan 2019 Total CO2 emissions 273.16
2 Shanghai 2019 Total CO2 emissions 228.80
3 Ordos 2019 Total CO2 emissions 215.44
4 Suzhou 2019 Total CO2 emissions 205.15
5 Changji 2019 Total CO2 emissions 179.19
6 Beijing 2019 Total CO2 emissions 167.66
7 Tianjin 2019 Total CO2 emissions 162.78
Beijing
167.66 MtCO2e
Total CO2 emissions
Beijing
7.79 tCO2e/cap
CO2 emissions per Capita
Beijing
0.77 tCO2e/10000RMB
CO2 emissions per GDP
2005 2010 2015 2019
CO2-Totals
Enterprise
Energy
GHG Tool
Carbon peak Map
Satellite
Pyongyang
Seoul
Tokyo
Yellow Sea
Total CO2 emissions (MtCO2e)
1 5 10 20 50 100 >100 No Data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Blue Carbon Map - Energy Map
Filter
Rank Province Year Type Value
1 Sichuan 2016 Natural Gas Consumption 18.16
2 Jiangsu 2016 Natural Gas Consumption 17.27
3 Guangdong 2016 Natural Gas Consumption 16.78
4 Beijing 2016 Natural Gas Consumption 16.23
5 Xinjiang 2016 Natural Gas Consumption 13.24
6 Shandong 2016 Natural Gas Consumption 9.86
Natural Gas Consumption
Beijing
16.23Bcm
Natural Gas Consumption
Beijing
102.03TWh
Electricity Consumption
Beijing
8.48Mt
Coal Consumption
Pyongyang
Seoul
Tokyo
Yellow Sea
Taiyuan
Jinan
Zhengzhou
Xi'an
Satellite
Natural Gas Consumption(Bcm)
No Data 2 4 6 8 10 15 >15

For cities that have not yet reached the peak, how to set the target year and carbon emissions peak for cities?

The procedure of setting a city's carbon peak target (time and amount) is shown on the right. Combining the national target to achieve carbon neutrality by 2060 and peak carbon emissions before 2030, and factors such as population, GDP, etc., the city's future carbon dioxide emission trends (increase, decrease, peak or plateau period, etc.) are therefore judged and then the peak time and peak emission volume can be set. At the same time, it is necessary to meet the goal of reducing carbon intensity 65% by 2030 from a 2005 base year and the goal of reducing absolute emissions about 60% by 2030 from a 2010 base year as set forth in the "IPCC Special Report on Global Warming of 1.5°C". On this basis, cities can also propose earlier peak year and more ambitious absolute emissions reduction target based on their own conditions.

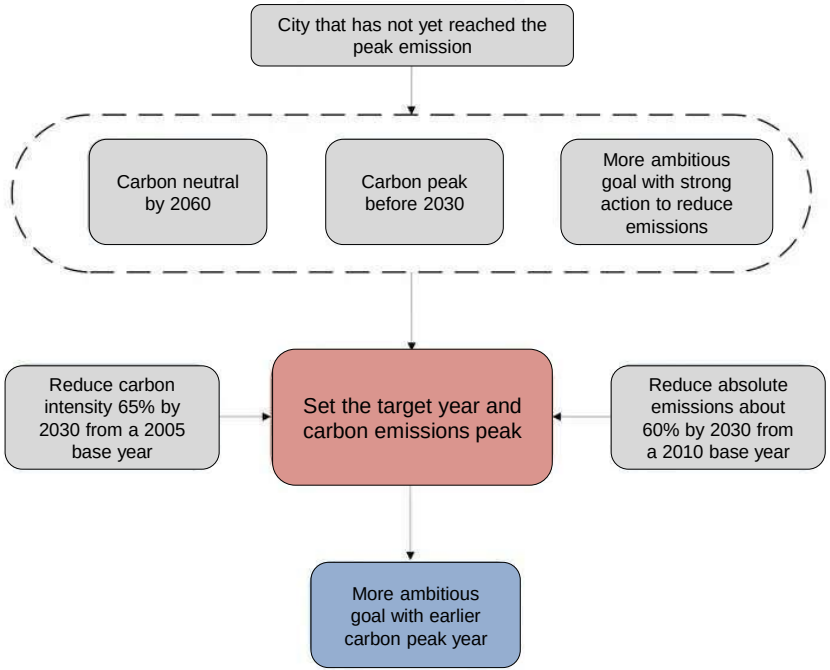


Figure 4 City carbon peak planning flowchart

Conclusion

We recommend cities across the country to:

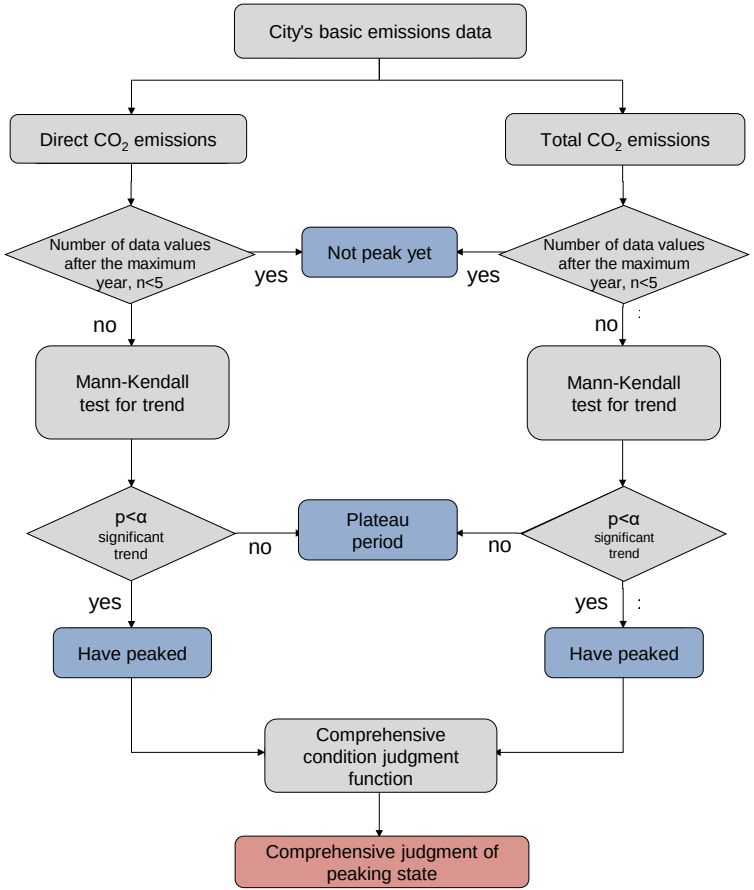
- Set and announce the carbon peak target as soon as possible
- Carry out the peaking action, evaluate and release the progress every year
- Publish carbon intensity per unit of GDP at the same as quarterly GDP
- Set and publish emission reduction paths after peaking especially for leading cities
- Establish a combined mandatory and voluntary corporate carbon disclosure system
- Encourage companies to set targets for emission reduction, peaking carbon emission and carbon neutrality

In the context of carbon peak and carbon neutrality, environmental protection under the guidance of the “14th Five-Year Plan” requires the establishment of a new dual-wheel model for pollution prevention and carbon emissions reduction. With the help of innovative solutions to strengthen GHG accounting, carbon disclosure and confirmation, all regions and enterprises shall be urged to accelerate the coordinated development of pollution and emissions reduction.

Appendix：

Judgment method of City Carbon Peak

According to statistical methods, whether the city has peaked carbon emissions is judged based on the city's historical carbon emissions data. For example, based on the city's direct carbon dioxide emissions and total emissions (direct emissions + indirect emissions) data from 2005 to 2019, using the conditional judgment function and the Mann-Kendall test for trend, the model which shows the status of the city's carbon dioxide emissions peaking process is constructed.



Are there 5 years after the year of maximum emission?

According to international experience (United Nations Environment Programme and World Resources Institute), domestic 5-year planning and Gilbert statistical principles, if the number n of data (years) of the city's emission time series X after the maximum year is n<5, the city's direct/total carbon dioxide emissions have not reached the peak. This is because the city still needs a testing period after reaching the peak to prove that it is not a false peak, and the trend test cannot be performed when the data sample (years) is too small.

If it is to judge whether the carbon emission peaked in 2005-2019, the maximum value should be in 2014 or before, otherwise it is considered that the city has not reached the peak.

If the number of data (years) is met, the Mann-Kendall trend test is used to determine whether there is a significant downward trend in emissions after the peak year?

Under the significance level α=0.05, when n≥5, if the probability p corresponding to n and S is less than the significance level α, the null hypothesis is rejected and the trend is considered significant. This means that the city's direct/ total carbon dioxide emissions have a significant downward trend after the maximum year, and the city is considered to have reached its peak. If the probability p is greater than or equal to the significance level α. This means that the city's direct/total carbon dioxide emissions after the maximum year have no significant trend, so it is considered to be in the plateau period.

Mann-Kendall trend analysis test method, the calculation formula of its statistic S： $S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \mathrm{sgn}(x_j - x_i)$

Among them, x_j is the j^{th} data value of the city emission time series X after the maximum year; n is the data amount (years) of the city after the maximum year; sgn is a sign function; the statistic S roughly obeys the normal distribution. The mean is 0, and the variance is:

$$\mathrm{Var}(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{n} t_i(i-1)(2i+5)}{18}$$

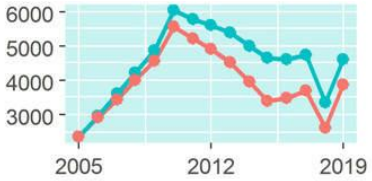
Among them, t_i is the number of data points in the i^{th} group, and the amount of data in each group in this article is 1 (ie, annual carbon emissions).

Standardized statistics, calculated according to the following formula： $Z_c = \begin{cases} \frac{S-1}{\sqrt{Var(S)}}, & S > 0 \\ 0, & S = 0 \\ \frac{S+1}{\sqrt{Var(S)}}, & S < 0 \end{cases}$

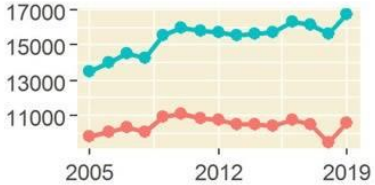
According to the condition function, make synthetical judgement on direct emissions and total emissions, and finally determine whether the city's carbon emissions have reached the peak.

Taking **Shenzhen, Beijing and Suzhou** as examples

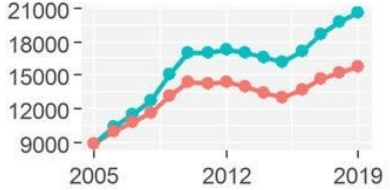
Results of carbon peak trend in typical Chinese cities



Shenzhen



Beijing



Suzhou

Note: The green line is the total emissions, the red line is the direct emissions; the green background indicates the city has reached the peak, the yellow background means it is in the plateau period, and the gray background shows it has not peaked.