Situation analysis and development suggestion regarding carbon emission peaking

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Abstract. The determination of positive, reasonable and realizable carbon emission peak target is the strategic selection for addressing climate change, which is in favor of the reversed transition of economic development mode to green low-carbon pattern. China definitely proposes to achieve the carbon emission peaking by about 2030. This paper sorts out the global carbon emission peaking conditions, including the carbon emission peaking time of major developed countries, and the prediction on China's carbon emission peaking time. In addition, this paper also illustrates the fundamental laws of carbon emission peaking, including the overseas basic conditions, analysis of China's carbon emission situation, and the key factors that affect China's carbon emission peaking. Finally, this paper provides the suggestions regarding the promotion of China's carbon emission peaking.

1. Introduction
The global warming issue resulted from the massive emission of greenhouse gas has already become the great challenge encountered by the healthy and sustainable development of human society. The determination of positive, reasonable and realizable carbon emission peak target is the strategic selection for addressing climate change, which is in favor of the reversed transition of economic development mode into green low-carbon pattern. On December 19th, 2017, China officially started the national carbon emission trading system, which was not only China's significant measures to realize the carbon dioxide emission peaking commitment by 2030, but also the important component for peaking the global greenhouse gas emission. At present, the greenhouse gas emission of many countries in the world has reached the peak, and some countries also commit the peaking time. As predicted by the World Resource Institute, the number of peaking countries in the world will be increased to 57 by 2030, and the covered greenhouse gas emission amount will account for 60% of the total amount in the world.

President Xi Jinping reaffirmed in the speech delivered at the Opening Ceremony of The Paris Conference on Climate Change, "In its Intended Nationally Determined Contributions, China pledges to peak CO2 emissions by around 2030 and strive to achieve it as soon as possible". The realization of national carbon emission peaking target, not only needs to take the lead to realize the zero growth of carbon dioxide within the iron and steel, building materials and other high energy consumption industries during the period of "13th Five-Year Plan", but also needs to take the lead for the economically developed regions to reach peak by around 2020. Meanwhile, the carbon emissions for economically developed regions are promoted to reach peak, which not only contributes to accelerating the formation of green low-carbon transformational development mode and reversed
transmission mechanism, but also contributes to synergetically promoting the high quality development of the economy and the high-level protection of ecological environment.

2. Carbon emission peaking time

At present, 49 countries have already reached the peak in the world, and the total amount of greenhouse gas emission has still been rising, but the emission amount of some countries has already reached the peak. The number of peaking countries in 1990, 2000 and 2010 was 19, 33 and 49 separately, and most of them belonged to the developed countries. The emission proportions of these countries account for 21%, 18% and 36% of the global emissions respectively. During the period of 1990–2000, although the number of peaking countries had been increased by 14, the emission growth amount of non-peaking countries had been much higher than that of peaking countries. Therefore, the emission amount of peaking countries accounted for 18% of the global total emission amount, instead of the previous 21%.

As per the emission reduction commitment of all countries, the number of peaking countries will reach 53 and 57 by 2020 and 2030 separately. As per the emission proportion calculation of all countries in the world in 2010, the emission amount of peaking countries will account for 40% and 60% of the global total amount in 2020 and 2030 separately.

Among the 14 peaking countries during the period of 1991–2000, except for Costa Rica, all the other countries were European countries, most of which came from the Western Europe and Northern Europe. During the period of 2001–2010, there were 16 peaking countries, most of which were distributed in Northern America, Southern Europe, Oceania, and Southern America, including the major emitters Brazil and USA that peaked in 2004 and 2007 separately. 4 countries are committed to reach the peak by 2020, namely, Japan, South Korea, New Zealand, and Malta respectively. In addition, 4 countries are also committed to reach the peak by 2030, namely, China, Mexico, Singapore, and Marshall Islands respectively.

2.1. Major developed countries that have already peaked carbon emissions

As shown from the relevant statistic data, the major developed countries have already peaked the carbon emission. As shown in Table 1, the Germany, France, UK, Denmark and other countries had already peaked the carbon emissions before 21st century, and the USA, Japan, Norway and other countries had peaked the carbon emissions during the period of 2000–2010. The USA, Japan and Denmark had simultaneously peaked the carbon emissions and energy consumption in 2007, 2004 and 1996 separately. The carbon emissions and energy consumption peaking times of the Germany, France and UK are staggered. The carbon emissions were peaked earlier than energy consumption: the Germany's carbon emissions were peaked in 1980, which was 5 years earlier than the peaking time of energy consumption. The France's carbon emissions were peaked in 1979, which was 26 years earlier than the peaking time of energy consumption. The UK's carbon emissions were peaked in 1971, which was 25 years earlier than the peaking time of energy consumption. The France, Denmark, UK, Germany and other countries realized the long-term continuous low-speed economic growth mainly through the rapid enhancement of non-fossil energy consumption proportion, so as to realize the earlier peaking of carbon emissions and energy consumption [1-4].

Table 1. Peaking time for carbon emissions and energy consumption of developed countries

| Country | Peaking time of energy consumption | Peaking time of carbon emissions | Remarks                  |
|---------|----------------------------------|---------------------------------|--------------------------|
| USA     | 2007                             | 2007                            | Concurrent Peaking       |
| Japan   | 2004                             | 2004                            |                          |
| Denmark | 1996                             | 1996                            |                          |
| Germany | 1985                             | 1980                            | Staggered peaking, carbon emissions peaking at first |
| France  | 2005                             | 1979                            |                          |
| UK      | 1996                             | 1971                            |                          |
| Norway  | Non-peaking                      | 2010                            |                          |
2.2. Prediction on China's peaking time of carbon emissions

Since China declared to peak the carbon dioxide emission by about 2030 and try to reach the peak at the earliest in the U.S.-China Joint Announcement on Climate Change dated in November 2014, many research institutes and relevant experts in China has started to carry out a great number of positive studies by centering around China's carbon emissions and energy consumption peaking issues. The research results may be classified into two types: firstly, it is thought that China will peak the carbon emissions by about 2030. As shown from the research and analysis of State Grid Energy Research Institute, by 2030, the total amount of China's primary energy consumption will be controlled at 5.1~5.9 billion tons standard coal, and the proportion of non-fossil energy will be within the range of 23%~25%. When the carbon emissions will be peaked by 2030, the total emissions will be within the range of 10~11 billion ton [4]. As shown in the report World and China Energy Outlook 2050 released by CNPC Economics and Technology Research Institute, China's energy consumption will be peaked by around 2035, and the fossil energy consumption will be peaked by 2030, while the carbon dioxide emission will be peaked by about 2030 [6]. Secondly, it is thought that China's carbon emissions will be peaked by 2025 or even earlier. As predicted by the report China Energy Outlook 2030 released by China Energy Research Society in 2016, the total amount growth of China's energy demand in the future will become slower, and the annual average growth rate within the period of 2016~2030 will be 1.4%. The energy production structure will be continuously optimized, and the non-fossil energy output proportion in 2030 is expected to reach 27%, and the carbon emission may be peaked in 2025 [7].

As proposed in the report Energy Economy Outlook during the "13th Five-Year Plan" and by 2030 released by Center for Energy and Environmental Policy Research Beijing Institute of Technology, China's coal consumption amount will be peaked by around 2019, and then declined year by year. It is expected that China's petroleum demand will moderately grow, and the annual average growth rate will be about 1.7%. The proportion of non-fossil energy demand will exceed the proportion of petroleum, and the carbon emission is expected to be peaked by 2025, while the 20% proportion target of non-fossil energy will also be realized in advance. As shown from the research results released by Jiang Kejuan’s Research Team of Energy Research Institute, National Development and Reform Commission, China is likely to peak the carbon emission during the period of 2020~2022, and the earlier carbon emission peaking mainly relies on the economic structural adjustment, strengthened energy conservation, the development of renewable energy and nuclear power, the utilization of carbon capture and storage technology, the advocacy of low-carbon lifestyle and consumption, instead of the restriction on economic development [8].

3. Basic laws of carbon emissions peaking

3.1. Basic overseas information

The time for a region peaks the carbon emissions and energy consumption, is closely related to local economic and social development stage and the development method. As shown from the relevant researches of developed countries that have already peaked the carbon emissions, the peaking of carbon emissions and the peaking of energy consumption have their own objective laws, and the time cannot be deliberately or casually set. The basic statistical laws involve five major economic and social development indicators [9, 10]:

Firstly, it is the level of urbanization and industrialization. Whether the level of urbanization and industrialization reaches a certain level, is the basic premise that a region peaks the carbon emissions. After entering into the late industrialization, namely, when the urbanization rate reaches above 75%, the city will not need a large quantity of rebar and cement to carry out the housing and infrastructure construction, and the consumption demand of the relevant heavy industry products and energy will also be greatly reduced. The high-end manufacturing industry and modern service industry develop very fast, and the carbon emission begins to drop. Then, the peaking is likely to occur.
Secondly, it is the economic growth rate (GDP annual growth rate). Generally, the carbon emission is peaked, when the regional economic growth rate becomes much slower, namely, no more than 3%. Then, the energy consumption growth rate required by economic growth is also greatly reduced.

Thirdly, it is the per capita GDP. Generally, the carbon emission is peaked, when the per capita income level is much higher, most of which is above US$ 20,000. Then, the proportion of product consumption with the higher energy consumption is very small. With the implementation of energy conservation measures, the per capita energy consumption begins to decline. When the carbon emission is peaked, the USA's per capita carbon emission is about 22 tons, and the corresponding per capita GDP is US$ 25,000. The Germany's per capita carbon emission is 14 tons, and the corresponding per capita GDP is US$ 24,000. The France's per capita carbon emission is about 10 tons, and the corresponding per capita GDP is US$ 2.3.

Fourthly, it is the proportion of tertiary industry. Generally, the carbon emission is peaked after the proportion of tertiary industry reaches above 65%. The proportion of secondary industry with the higher energy consumption gradually declines, and the regional economic growth mainly relies on the tertiary industry.

Fifthly, it is the total population. Generally, the carbon emission is peaked after the total population is peaked and not increased any more.

3.2. Analysis of China's carbon emission situation

At present, the features of China's large economic volume, more energy consumption and high total carbon emission amount are obvious, and the carbon emission amount accounts for about 27% of the global carbon emission amount [11]. Only the total emission amount of carbon dioxide produced during the energy activity and cement production process has already approached to the total national carbon emission amount of OECD. On one hand, the realization of 2°C temperature rise target, requires the global peaking at the earliest, while the global carbon emission peaking is greatly dependent on China's carbon emission peaking time. Under the background that the global emission space becomes increasingly scarce, the international pressure of China's carbon emission reduction is also undoubtedly increasing. On the other hand, considering that the strong carbon emission control may bring the tremendous coordinated benefits within the air pollution control, water resources consumption reduction, human health and other fields, the active response to climate change and promotion of carbon emission peaking at the earliest have already become the inherent requirements of China's sustainable development. At present, China's economic, industrial and energy development has already stepped into the new normal situation, and the carbon emission control also encounters the new situation. It is necessary to identify the key factors of carbon emission peaking and timely carry out the relevant work arrangements, as per the strengthened carbon emission peaking situation research and judgment.

Generally, China's carbon emission peaking encounters the following new situations:

The economic and energy development enters the new normal situation, which creates the favorable conditions for China's carbon emission peaking. Under the background that the global market demand growth became slower and generally stagnant, and the domestic economic encountered the much greater downward pressure, the Chinese government started the industrial structure adjustment, and economic growth quality improvement, and other new normal situation adaption path in 2014, exerted the force from both sides, i.e., the supply-side and demand-side, accelerated the growth of new industry, new commercial activity and new power, and obtained the preliminary results. As per the data from National Bureau of Statistics, the GDP in 2015 had a year-on-year growth of 6.9%. The tertiary industry accounts for 50.5% of the GDP, which broke through 50% for the first time. The industrial sector capacity reduction has achieved the initial effects, and the growth of high-tech industry was obviously speeded up. Under the drive of speed transition and shift change of economic development, and enhancement of quality efficiency, China's energy development also entered the new normal situation of "Low-Speed Growth and Fast-Speed Transition". Meanwhile, with the gradual implementation of the "Capacity Reduction, Reducing Excess Inventory,"
Deleveraging, Lowering costs, and Strengthening Points of Weakness’, the supply-side reform and other tasks during the "13th Five-Year Plan" period, the total amount of energy consumption control and low carbonization process of energy structure will be further accelerated. It is required to take the above factors into consideration, and notice that the whole-year energy intensity and carbon intensity reduction target have already been outperformed in the first half year of 2016. It is predicted that the situation of China's carbon emission control work during the period of "13th Five-Year Plan" and within a much longer period, would become better, which created the favorable conditions for China to peak the carbon emissions at the earliest.

China entered the significant opportunity period of energy low-carbon transition, which provided the significant motive for peaking the carbon emissions. Since the "12th Five-Year Plan", under the support of positive planning target and policy, China's coal consumption has achieved the effective control, and the low-carbon energy industrial development and infrastructure construction has been continuously accelerated, while the clean and low carbonization process of the energy has been obviously accelerated. Due to the interaction of the economic downturn in recent years, the increased force of implementing the air pollution control tasks, and the rapid development of alternative energy, and many other factors, China's coal consumption has continued to fall. In 2015, the coal consumption declined by 3.7% on a year-on-year basis, which exceeded the 2.9% of last year. The development of non-fossil energy was further accelerated, and the non-fossil energy consumption is increased by 7.2% on a year-on-year basis, while the total installed capacity of non-fossil energy reached about 520 million KW. In 2015, the proportion of China's non-fossil energy in the primary energy rose to 12%, and the proportion of coal declined to 64.5%. Considering that the capacity reduction, destocking, the relative abundant power, and other conditions would still continue for a certain period of time, China would usher in the good opportunity for further adjusting the energy structure and enhancing the proportion of excellent energy.

As indicated by the relevant measurement, China's carbon emission may be peaked by about 2030 or even earlier. As per the scenario study, if the existing policies and measures continue and are gradually intensified, China's energy consumption may be controlled within 5 billion tons standard coal in 2020, and the carbon emissions per unit of GDP will decline by 48%, compared with that in 2005. In addition, the 40%~45% target of Copenhagen will be outperformed. The carbon emissions related to China's energy consumption may be peaked by 2030, and the carbon dioxide peaking level will be controlled at about 110 tons. Compared with the carbon intensity in 2005, the carbon intensity in 2030 will drop by about 68%. The total carbon emission amount in 2050 will drop back to the emission level before 2010. If the period of good opportunity for the current economic, industrial and energy low-carbon transition is grasped, and the emission reduction efforts of each department are intensified, the carbon emissions related to China's energy consumption will be expected to peak by about 2025 at the earliest, and the peaking level of carbon dioxide will be controlled at about 10.5 billion tons. Compared with that in 2005, the carbon intensity in 2030 will drop by about 70%. In addition, the total carbon emissions by 2050 will drop back to the carbon emission level before 2005, which approaches to China's better allocation plan under the "2℃ Temperature Control Target".

3.3. Key factors that affect China's carbon emission peaking
With reference to the general laws for carbon emission peaking of developed countries, and in combination with the present status of China's economic and social development, there is still a tough journey for peaking China's carbon emissions. In combination with the research results of experts and scholars, the key factors that affect the peaking of China's carbon emissions include the following four aspects:

The first aspect is the impact of economic growth. In order to peak the carbon emission at the earliest, it is required to promote the unhooking between economic growth and carbon emission as soon as possible, i.e., the decline rate of carbon intensity shall exceed the growth rate of GDP. As per the judgment of international mainstream research, China's growth rate will fall into the range of about 3.5%~5.5%. The actual annual average decline rates of China's carbon intensity during the "11th
Five-Year Plan" and "12th Five-Year Plan" period were 4.7% and 4.69% separately. Within the future 10~15 years, the reasonable expectation level for annual average decline rate of carbon intensity will be within the range of 4%～5%. Therefore, the time slot for peaking the carbon emission in China is likely to occur within the period of 2025~2030. From the perspective of China's reality, under the lower growth rate of GDP, the high carbon industries with lower added-value will be firstly affected. Therefore, the greater decline and adjustment space may be given to the carbon intensity. Objectively, the present carbon emission control situation gets better. Although it is related to the continuously intensified force of relevant policies, the local degree of emphasis upon the carbon emission control is far from enough. The carbon intensity may be greatly reduced, which is still affected by the economic downturn. The future 10~15 years are the key period of China's low carbon transition. With the change to economic situation or economic growth and pressure increase, the local impulse for developing the high carbon industry will rise again, so as to ensure the growth rate of GDP. If the carbon emission cannot be strongly restricted, it is not only hard to peak the carbon emission at the earliest, but also affects the successful achievement of China's peaking target of carbon emission by around 2030.

The second aspect is the impact of industrialization and urbanization. For one thing, the industrial sectors take the lead to peak the carbon emission, which are the necessary conditions for China to peak the carbon emission at the earliest. At present, China has already entered the medium-term industrialization development stage, and the output of major high energy consumption products will be peaked and begin to drop, while the energy demand of industrial sectors will become stable, which is the favorable factor for controlling the carbon emissions. However, at the same time, the task of China's industrial transformation is still tough. The supply-side reform, "capacity reduction" and other priority tasks cannot be completed overnight. In the first half year of 2016, the two sectors, namely, iron and steel, and coal, completed 30% and 29% of the capacity reduction target task separately, while the output of cement and flat glass were still increased by 3.2% and 1% respectively. However, the driving effect of new driving forces and new industry formats upon the economic growth still needs to gradually appear, and the promotion of growth method innovation, economic development quality and benefits enhancement would still encounter great challenges. For another, the reasonable control of building and traffic energy consumption growth is also the key factor for ensuring the earlier peaking of carbon emission. At present, China is still under the process of accelerating the urbanization, and the future urbanization will become the main driving factor for driving the growth of carbon emissions. In fact, there is still a big gap between the current building and traffic energy consumption level of China and that of developed countries, and the greater growth space of energy consumption and carbon emission still exists. However, at the same time, China's degree of concern regarding low carbon development during the urban planning process is still very low, and the application of new-style low-carbon technology is still very limited, while the low carbon consumption pattern is still far behind. If these issues fail to be properly solved, it will greatly promote the growth rate of urban energy consumption and carbon emission, so as to offset the emission reduction effects of the industrial departments and postpone the peaking time of carbon emission.

The third aspect is the impact of energy low carbon transition. There are the following several key factors for peaking China's carbon emissions at the earliest: Firstly, in order to promote the earlier peaking of carbon consumption, it is required to reserve the space for the development of low carbon energy (including the natural gas and non-fossil energy). Secondly, in order to promote the large-scale utilization and fast development of non-fossil energy, especially the renewable energy, the new growth in energy demand after 2020 will be fundamentally satisfied by non-fossil energy, and the non-fossil energy is promoted to be transformed into the alternative energy, and even the dominant energy, from the auxiliary energy. Thirdly, it is required to continuously improve the proportion of power, gas and other clean energy in the final energy consumption, and speed up the construction of intelligent energy system. Generally, the realization of energy increment is almost satisfied by the non-fossil energy, which is the top priority of these factors. However, it is not easy to ensure the large-scale utilization and rapid development of non-fossil energy. Certainly, the remaining hydropower resources that are available for China's development and utilization, have already become limited, and the future growth
of non-fossil energy is mainly dependent on the wind, solar and nuclear power. Although the wind power and solar power have the greater potential, the actual utilization amount is much less than expected, subject to the stability, the long-distance traffic consumption and other issues. In recent years, the situation of wind and solar power abandonment everywhere has become from bad to worse. In addition, the nuclear power also faces the uncertain development prospect. As per the present planning target, the installed nuclear power capacity will reach 58 million KW by 2020. It is expected that the installed nuclear power capacity will reach 130~140 million KW by 2030, which means that 8 plus million KW level nuclear power plants are required to be commissioned every year within 10 years, namely, 2020~2030. Then, considering the safety issues involved in the nuclear power development, the challenge is not small. In summary, if China's non-fossil energy development in 2030 is lagging behind the expectations, and the installed capacity is reduced by 100 million KW, then the coal consumption and carbon dioxide emission will be increased by about 200 million tons and 400 million tons separately. If so, it will be hard to peak the carbon emissions in advance [12, 13].

Technical factors will be the important factors for China to peak the carbon emission reduction and carbon emissions. As predicted by some scholars, China may reach the present living standard of developed countries before 2030, and the per capita energy consumption of China will be much lower than that of developed countries, all of which come from the rapid development of new energy, energy conservation and low carbon technology. Since China promoted the large-scale energy conservation during the "11th Five-Year Plan" period, China's energy conservation technology and application has made progress in leaps and bounds. The technical energy conservation indicator will be greatly improved, and the unit consumption of many products has already approached to that of the developed countries. During the period from "12th Five-Year Plan" to "13th Five-Year Plan", the continuous and strong energy conservation policy has been ongoing. It is predicted that China's control effects of energy conservation upon the growth of energy consumption will still be obvious within a certain period of time in the future. As the negative emissions technology, the carbon capture, utilization, and storage (CCUS) will also become the significant technology for China's further emission reduction.

4. Suggestions for promoting the peaking of China's carbon emissions

The promotion of peaking the carbon emissions at the earliest is not only the significant method for China to fulfill the commitment of Intended Nationally Determined Contributions, and win the initiative of global climate governance, but also the core contents and inherent requirements for China to construct the ecological civilization and fulfill the green development concept. In addition, it is also required to take initiative to adopt measures from many aspects, and speed up the economic and social low carbon transition.

Firstly, it is required to perfect the legal standards and institutional system. As per the general requirements of China's carbon emissions peaking target, it is required to actively promote the issuance of Act on Addressing Climate Change and the relevant compatible laws and regulations, and promote the transition from carbon emission intensity control to the double control of both intensity and total amount, so as to provide the adequate legal supports for the response to climate change and low carbon development, and regulate the relevant works by rules.

Secondly, it is required to strengthen the carbon emission control of key industries. Starting from the first peaking demand of industries, it is required to strengthen the carbon emission management of the building materials, chemical industry, iron and steel, power and other high energy consumption industries, and building, traffic and other key sectors, it is required to formulate and release the total carbon emissions control target of key sectors and industries based on the in-depth research and demonstration, research and propose the implementation scheme, and issue the carbon emission control policies and measures.

Thirdly, it is required to accelerate the low-carbon transition of energy system. It is required to promote the relevant sectors to comprehensively implement the policies and measures that support the low-carbon energy development, strengthen the collaborative optimization of energy system, and
accelerate the energy price reform. In addition, it is also required to break the institutional obstacles, and ensure the achievement of non-fossil energy development phased objectives.

Forthly, it is required to strengthen the innovation of development mode and technical revolution. Centering around the peak target and problem-orientation, it is required to propose the innovation pattern and path that are applied to the development of low-carbon economy in variable regions, and carry out the significant low-carbon technical demonstration works including the CCUS.

Fifthly, it is required to strengthen the basic capacity building. It is required to steadily promote the greenhouse gas emission review and evaluation, perfect and improve the basic data statistic system, and to further drive the low-carbon technical catalogue compilation and low-carbon product certification. At the same time, it is also required to strengthen the extensive propaganda and guidance for addressing climate change, and improve the public low-carbon living, consumption concept and practice capacity.

Sixthly, it is required to strengthen the international exchange and cooperation. It is required to further carry out the practical cooperation with the European and USA, and other developed countries and international agencies, and fully utilize the technical backward advantages to promote the introduction, demonstration and promotion of significant low-carbon technology. Meanwhile, it is required to grasp the good opportunity of "The Belt and Road", strengthen and deepen the South-South cooperation for addressing the climate change, and accelerate the "Go globally" pace within the energy and low-carbon fields.

5. Conclusion

Through the above combing and analysis, it may be considered that China is likely to peak the carbon emissions in 2030. However, this must be supported by the appropriate polices, including the adjustment of industrial structure and energy structure, transformation of development pattern, the promotion of clean energy and active enhancement of carbon sink capacity. As for the specific province (city), it is required to actively formulate the peaking time, path and level by "adjusting measures to local conditions" under the national overall arrangements, and peak the carbon emissions by about 2030 under the support of appropriate policies [14].

At present, China has entered a rapid economic development period. Although China has been generally in the post industrialization period, the local region has still been in the period of medium-term industrialization. Therefore, it is of critical significance to successfully realize the carbon emission target and adjust the energy structure. It is necessary to improve the adjustment of energy structure, unswervingly change the present status that coal ranks the top of national energy utilization. Within a short period of time, it is feasible to develop the natural gas and other energies with the lower carbon intensity. However, in the long run, it is necessary to implement the energy innovation, strive to develop the clean energy, and establish the clean energy economy. In addition, it is also required to actively turn around the situation that the development of clean energy is restricted due to the excess production capacity, which will realize the unhooking between the economic development and high carbon energy consumption in the real sense.

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