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An analysis of China's energy policy from 1981 to 2020: transitioning towards to a diversified and low-carbon energy system

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Abstract

Looking back at four decades of China's energy policy (1981-2020), three momentous shifts can be said to have taken place. From the Sixth **Five-Year** Plan (1981) to the Ninth **Five-Year** Plan (2000), the focus was exclusively on improving energy efficiency. Subsequently, from the Tenth **Five-Year** Plan (2001) to the Eleventh **Five-Year** Plan (2010), energy security also became a major objective, as awareness of the gradual depletion of fossil fuels grew. From 2011 onwards (Twelfth and Thirteenth **Five-Year** Plans), China's energy policy has also aimed to ward off climate change. This policy evolution suggests that the Chinese economy has initiated a low-carbon energy transition since 2011. Nevertheless, this transition cannot be considered sustainable because the local government are reluctant to apply stringent institutional limitations to wealth-creating processes within their jurisdiction and because China's energy consumption is not decoupled from its economic growth and total environmental costs of renewable energy are not taken account. In seeking to usher in a sustainable energy system, the Chinese government needs to overcome three challenges: 1/ an institutional challenge; 2/ an economic challenge and 3/ an environmental challenge

Key words

Energy Policy

Energy transition

Low carbon transition

China

Five-year plan

1. Introduction

The rapid development of China's economy has led to rising energy consumption, particularly since the 2000s when the Chinese economy began to specialize in heavy industries. Primary energy consumption thus rose from 412 Mtoe (million tonnes of oil equivalent) in 1981 to 3384.4 Mtoe in 2019. As of today, energy consumption still relies for the most part on coal, which represented 57.6% of the Chinese energy mix as of 2019 (British Petroleum, 2020). Coal combustion is largely responsible for air pollution in China (Chen and Xu, 2010; Tong et al., 2018), putting public health at risk (Tilt, 2019; Gao et al., 2017) and also contributes significantly to CO₂ emissions. Since 2006, China has constantly topped international rankings for CO₂ emissions. In 2020, the country emitted nearly 9.9 billion tonnes of CO₂ – 30,7% of global emissions (see Fig 1). In a 2014 agreement signed with US President Barack Obama, Chinese President Xi Jinping pledged that China's carbon emissions would reach its peak before 2030. In June 2015, this target was confirmed in the Intended Nationally Determined Contributions (INDC) that China submitted to the United Nations (UN). In September 2020, at the UN General Assembly, China re-emphasized its commitment to weigh in on climate change by stating its goal of achieving carbon neutrality by 2060. In October 2021, before the COP 26 (Conference of the Parties), at Glasgow, the Chinese government submitted to the UN its new Intended Nationally Determined Contributions (INDC) which include a peak of carbon emissions before 2030; a carbon neutrality by 2060 but also a decrease in carbon intensity by 65% by 2030 and a 25% share of non-fossil energy sources in the energy mix by 2030. During to the COP 26 (Conference of the Parties), US President Joe Biden and Chinese President Xi Jinping signed a new agreement confirming their cooperation on climate change. Both countries recognize so the gravity and urgency of the climate crisis.

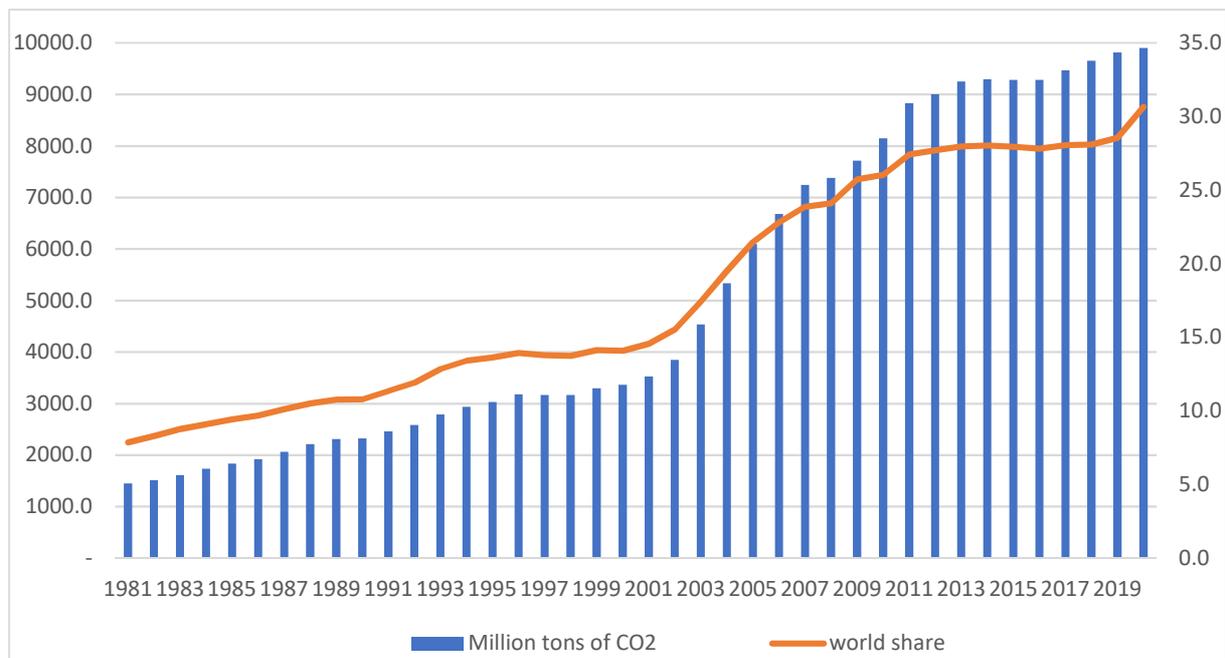


Fig. 1. The global dynamics of China's CO2 emissions, million tonnes of CO2 and % of total emissions, 1981-2020 Source: Author's calculation based on data from BP (2021) Statistical Review of World Energy, 70th Edition

Unsurprisingly, in its efforts to meet these environmental targets, the Chinese government is paying special attention to the energy sector. This sector, like the rest of the economy, has undergone a series of reforms since 1980. The analysis of energy policies within the Five-Year Plans (FYP) of the last four decades (i.e. from the Sixth to the Thirteenth Plan) can account for the environmental focus that has developed over the years. FYPs are the most important government document of China and are economic planning documents that lay out the guidelines and main targets of China's development strategy. Every FYP has its unique characteristics due to the specific period when it is composed and approved. They have been formulated by the Chinese government since 1953, when the first plan was drafted. To date, fourteen FYPs have been issued. The Fourteenth Plan (2021-2025) was officially adopted on the 11th of March 2021, at the close of the National People's Congress (NPC) session.

The contents and major targets in the FYPs are changed significantly according to the economic development and social growth conditions. Each FYP contains either a section or chapter related to national energy policy (Yuan and Zuo, 2011). By analyzing the change in energy related contents in the FYPs, notably the target of energy efficiency or carbon intensity, the energy mix or investments in renewable energy, the changes in energy policy are examined. The examination of accomplishments

and targets learnt in previous FYPs provides an important historical framework for understanding China's current efforts to transition to a low-carbon transition. Indeed, since the advent of the 21st century, energy transition can be defined as a process aimed not only to improve energy efficiency so as to limit the growth of energy needs but also to diversify the country's energy system. On the one hand, a diversified energy system helps secure the country's energy supplies, while on the other hand, it is helpful to reduce CO₂ emissions (Smil, 2017). This transition is often characterized as a low-carbon transition with regard to its target of reducing CO₂ emissions.

Looking back at the last eight FYPs (from the Sixth to the Thirteenth Plan) (1981-2020), one breaks up China's energy policy into three phases: an exclusive focus on energy efficiency (1981-2000); a growing concern for energy security alongside a continued interest in energy efficiency (2001-2010); the integration of climate change as a third in climate change policy (2011-2020). This third goal highlights the start of China's energy transition in 2011. Analysing China's energy policy on the basis of the last eight FYPs confirms most of the research carried out on the evolution of Chinese energy policy and on the set up of a low-carbon energy transition in China (Zhang, 2010; Jiang et al., 2010; Yuan and Zuo, 2011; Li and Wang, 2012; Andrews-Speed, 2012; Zhang et al., 2017; Li and Taeihagh, 2020; Xu, 2021). However, the present article dates the beginning of this transition to the Twelfth FYP.

The Chinese energy system has therefore shifted from intensive reliance on coal to a more diversified system that notably relies on the development of renewable and low-carbon energy. The transition to a more diversified energy system does not allow for a sustainable energy transition. In this article, we consider that a sustainable energy transition process must be based on strong sustainability¹, i.e. that “critical environmental capacities and qualities cannot be substituted, but must instead be sustained, as prerequisites for social and economic activities and functions » (Haskell et al., 2021, p.1). For

¹ Weak sustainability includes the view that trade-offs between three dimensions of sustainability, social, economic, and environmental, are both possible (United Nations, 2015).

China's energy transition to usher in a sustainable energy system, the Chinese government must first enforce all the laws, standards and targets included notably in the five-year plans to local governments. It must also reduce its energy and coal consumption by decoupling it from its economic growth and limit the environmental costs of renewable energy in order to maintain its natural resources. So, the Chinese government needs so to address challenges of three different kinds: institutional, economic and environmental.

This article is structured as follows. Section 2 provides an account of China's current energy situation. Section 3 presents the three phases of China's energy policy evolution over the past four decades. Section 4 discusses the three main challenges that the Chinese government must address if the energy transition initiated in 2011 is to lead to a sustainable transition of the Chinese energy system. Section 5 summarizes research findings and puts forward some policy implications.

2. China's energy situation

As of today, China is the world's largest producer and consumer of energy. In 2019, China accounted for nearly 18% of the world's population, consumed 24% of the world's energy, of which it produced 20%. China's energy consumption, in particular its total final consumption, which is the sum of the consumption in the end-use sectors and for non-energy use, increased very sharply from 2001 onwards— a much faster rate than the global average or that of non-OECD (Organisation for Economic Co-operation and Development) countries. This consumption increases from 488,8 Mtoe (Million tonnes of oil equivalent) in 1981 to 800,5 Mtoe in 2001 to 2093,1 Mtoe in 2020. Consumption growth has shown clear signs of slowing down in recent years: from +14% in 2003, it dropped to +6% in 2010 and +1,7% in 2019 (Calculations based on data from the International energy Agency -IEA-, 2021).

Rising energy demand from the 2000s onwards is the direct consequence of strong industrialisation, particularly in heavy industries. Since the 2010s, however, energy demand appears contained. This can be explained by a lower rate of economic growth, by sector-specific developments in the Chinese economy (a growth of the service sector leads to a drop in energy consumption) and by a continuous improvement in energy intensity.

Since the 1990s, the gap between energy demand and production has widened in China (Nolan et al., 2014). This materialised in the form of falling levels of self-sufficiency and rising fuel imports. The country's rate of self-sufficiency for coal dropped from 100% (1981) to 94% (2019); and from 123% in 1981 to 30% in 2019 for oil. Meanwhile, its gas self-sufficiency rate rose from 100% in 1981 and peaked at 111% in 2002, before dropping to as low as 59% in 2019 (International Energy Agency, 2021). The Chinese government is therefore compelled to rely on imports. China successively became a net importer of oil in 1993, of natural gas in 2007 and of coal in 2009. The government also found itself having to increase and diversify its national energy supply. Figure 2 shows a strong increase in natural gas, multiplied over 14 times between 1981 and 2019. As for coal, its production increased almost six-fold between 1981 and 2019. Coal production went through several distinct phases in recent years: a dramatic increase between 2000 and 2011; a stagnation from 2012 to 2015; a decrease in 2016; followed by another surge from 2017, with nearly 1958 Mtoe of coal extracted in 2019. The country boasts almost half of the world's coal-fired power plant capacities. It also continues to open new power plants on its territory and relaxed its moratorium on the construction of coal-fired power plants in 2017. According to a 2019 study by the Global Energy Monitor NGO (Non-governmental Organisation), China has already devised a construction program for new coal plants equivalent to the total capacity of the European Union's coal fleet. This corresponds to nearly 148 gigawatts of generation capacity currently under construction or yet to be launched (Shearer et al., 2019).

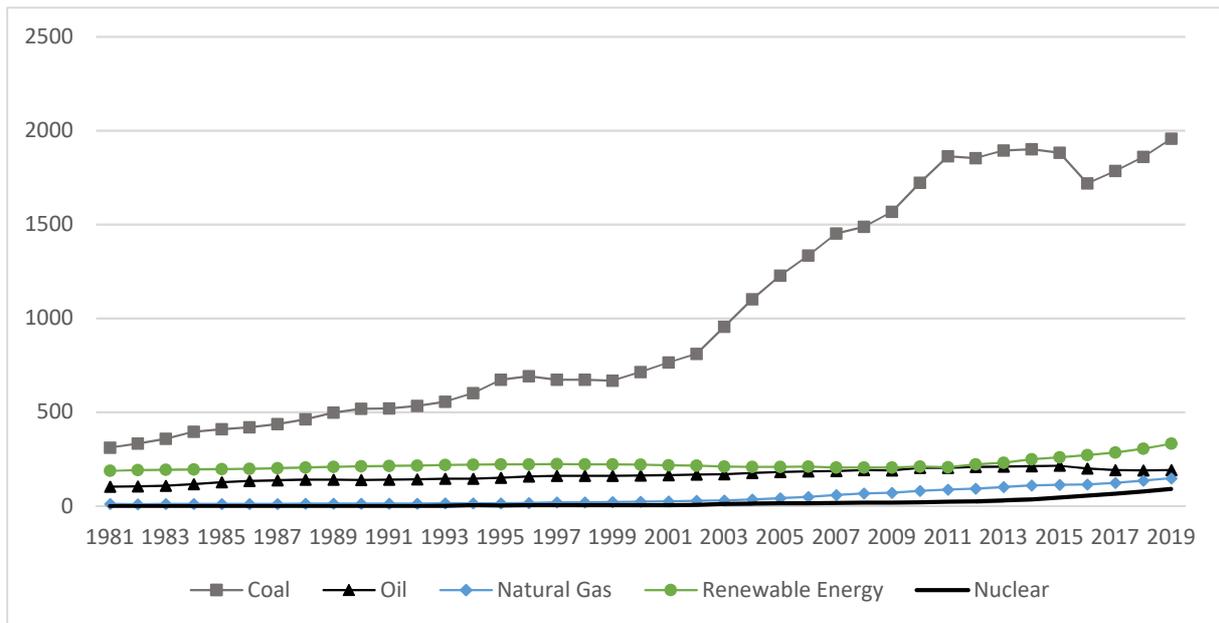


Fig. 2 Production of China's main energy sources, from 1981 to 2019, in Mtoe. Source: Based on data from the International Energy Agency (2021)
Note: Mtoe: Million tonnes of oil equivalent

China has now become the world's leading producer of coal,-the fifth-largest producer of oil and the seventh-largest producer of natural gas. The Chinese government is nevertheless acutely aware of the country's dependence on fossil fuels and its consequence: high CO₂ emissions (Liu et al., 2021). Hence the central government's insistent promotion of renewables (Li et al., 2019), as revealed by the "law on renewable energy" promulgated in 2006, revised in 2010 and supplemented in 2014; through massive subsidies granted by a "Renewable Energy Fund"; and even through strong investments in renewable energy projects (hydroelectricity, wind, solar, geothermal energy and biomass) (see Fig. 3). These investments have allowed China to assume a leading role in the photovoltaic and wind power sectors. Production from these energy sources grew from 207 Mtoe to 332 Mtoe between 2011 and 2019 (see Fig. 2). China's electricity generation highlights a more diversified production system that favours renewables, with a sudden boom in wind and solar power, even if coal still represented more than 66% of its electricity production in 2019 (vs. 37% worldwide) (British Petroleum, 2020).

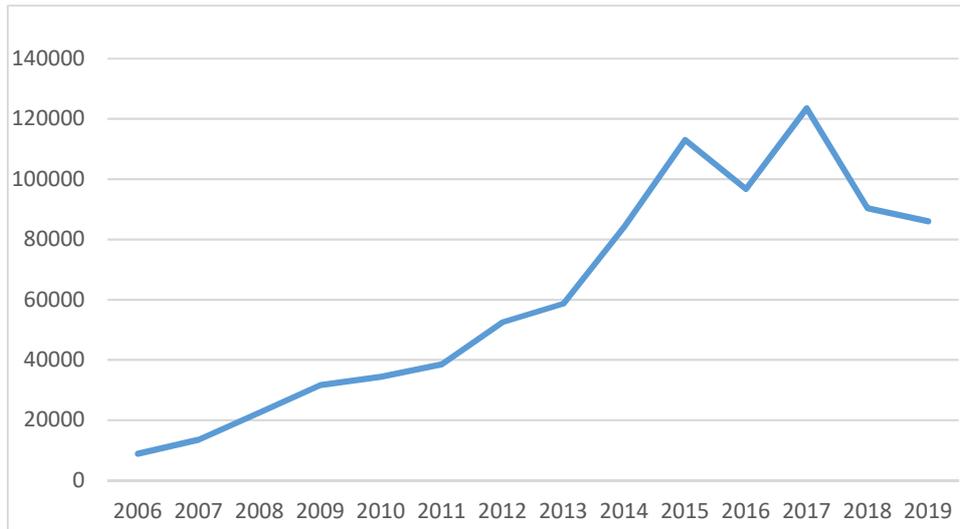


Fig. 3. Investments in renewable energy projects in China, 2006-2019, Millions \$. Source: Climatescope 2020, Bloomberg NEF, <https://global-climatescope.org/>

This diversification of energy sources has allowed for a slow but gradual evolution of China's energy mix. In 2020, coal represented 56.6% of its energy mix, and renewables only as little as 13.3% (see Fig. 4).

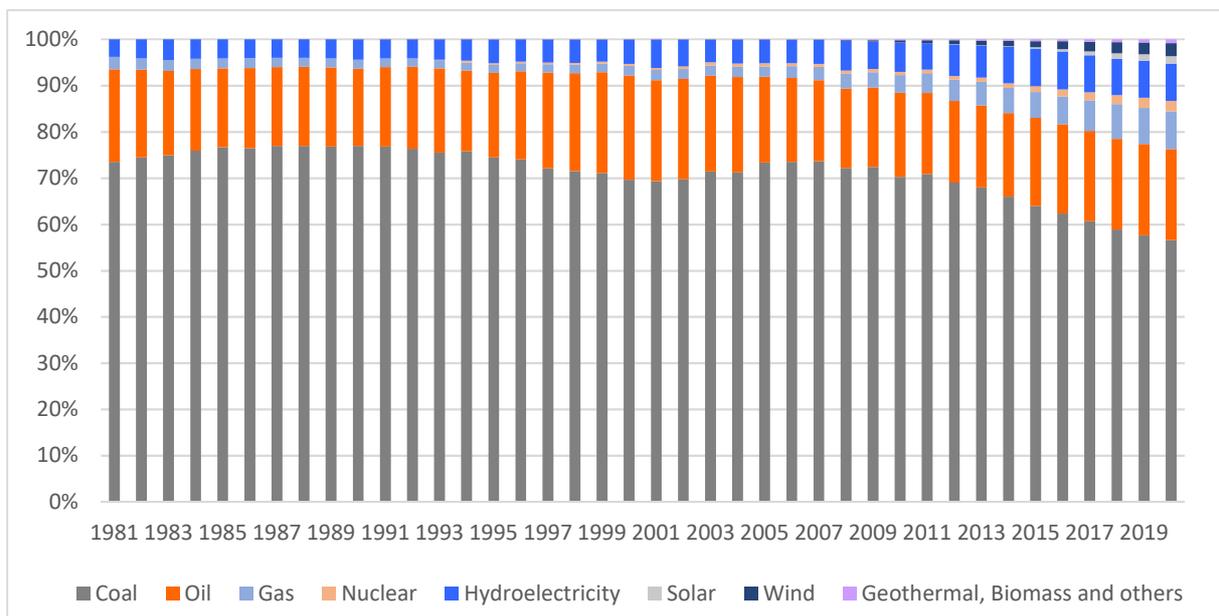


Fig. 4. Energy mix based on primary energy consumption, 1981-2020, in %. Source: Author's calculation based on data from British Petroleum (2021)

3. The three phases of China's energy policy: 1981-2020

3.1 All out on energy efficiency: 1981-2000 (Sixth to Ninth FYPs)

During this period, the Chinese government wished to establish a more efficient energy sector. One of the main characteristics of the economic policies implemented under Mao was to replicate industrial capacities in order to make each province self-sufficient. Local governments were called upon to set up their own industries. These were mainly small and medium-sized industries using machinery that was largely energy inefficient. Modernising the economy was therefore a priority once China opened up in 1978. Energy savings and energy efficiency were the order of the day.

For the first time, the Sixth FYP (1981-1985) listed energy efficiency among its objectives. It specified that the energy consumption per unit of product will decrease 2.6–3.5% per year after various energy conservation measures are implemented. (State Council, 1981). The goal was to produce more while using fewer resources and less energy in order to promote economic growth (Zhang, 1995). In this context, between 1981 and 1995 the Chinese government made critical investments to maximise energy savings (see Table 2) and set up programs granting preferential funding for companies that achieved energy savings (Sheehan and Sun, 2007). The share of investments dedicated to energy efficiency exceeded 10% of investment in the energy supply for three years (1982-1984) under the Sixth FYP. This was the result of a significant effort on the part of the Chinese government (Levine et al., 2009). This share of investments subsequently fell to 7.1% in 1995.

Table 1

Capital Construction Investment in Energy Conservation, 1981-2003, in billions of current Yuans. Source: NBS, China Statistical Yearbook, various years; SPC, Handbook of Comprehensive Resource Utilization, 1991; Energy Research Institute

Year	Energy Supply Investment	Energy Conservation Capital Construction Investment	Energy Conservation Technical Investment	Updating Investment	Total Conservation Investment
1981	71,54	2,99	4,53		7,53
1982	84,19	4,30	5,80		10,10
1983 ^[a]	97,44	6,77	6,07		12,84
1984 ^[a]	117,61	6,25	7,33		13,58
1985 ^[a]	138,75	5,66	6,64		12,31
1986	150,92	5,65	7,78		13,42
1987	162,67	6,29	7,80		14,09
1988	160,45	6,11	7,66		13,77
1989	151,98	5,30	5,44		10,74
1990	163,64	5,30	5,42		10,72
1991 ^[1]	173,55	9,19	6,08		15,26
1992 ^[1]	183,14	7,97	6,51		14,48
1993 ^[1]	186,11	6,29	6,16		12,45
1994 ^[1]	197,45	5,70	9,00		14,70
1995 ^[1]	215,27	5,38	9,87		15,25
1996	247,25		8,24		
1997	292,84		10,27		
1998	288,20		10,38		
1999 ^[b]					
2000	283,96				
2001	261,69				
2002	264,89				
2003	282,41				

Note: [a] Only the sum of investment for the period 1983-1985 and 1991-1995 was available. The total was divided equally among each period.

[b] Data from 1999 is not available

The energy policy delineated in the Seventh FYP (1986-1990) also aimed to improve energy efficiency with a decrease to the energy consumption per 1000 RMB of national income from 1.29 tce (tonne of coal equivalent) in 1985 to 1.14 tce in 1986, but also to introduce energy savings, particularly in oil use. At the same time, the government promoted increases in coal, oil and gas production (State Council, 1986).

Despite the target of cutting the energy consumption per 1000 RMB of GDP from 0.93 to 0.85 tce at the end of that period, the Eighth FYP (1991-1995) was highly focused on economic growth. It therefore emphasised meeting energy needs by promoting domestic coal production (opening new mines and improving existing ones), developing hydroelectric and thermal power plants, and exploring for oil and especially gas, including offshore gas (State Council, 1991). As the gas production target was not reached during within this FYP, the following Plan made provisions for gas imports.

The Ninth FYP (1996-2000) retained an emphasis on expanding fossil fuel production to meet the demand. The first law on energy savings was promulgated in 1998 and revised in 2007. As a counterpoint to the promotion of fossil fuels, whose efficiency was lauded, it was in this Plan that the phrase "sustainable development» made its first appearance. The text contains several references to the problem of environmental degradation. The issue of conserving water, soil, animal and plant species is also mentioned. A control system for water quality and air quality was set up, along with quantified goals for the treatment of solid waste and gaseous emissions (State Council, 1996). Towards the end of this first phase (1981-2000), the environmental issue gained prominence in the form of pollution mishaps at the local level.

These various measures led to a strong reduction in energy intensity over the period studied. The objective announced by Deng Xiaoping to quadruple Chinese GDP while only doubling energy consumption (i.e. halving energy intensity) was achieved. Between 1990 and 2001, energy intensity was more than halved, dropping from 21.2 to 9.8 (see Figure 5). Despite strong economic growth, the country's rising energy consumption did not outpace its economic growth. Nevertheless, this increase in energy consumption caused an increase in the use of fossil fuels. Preference for fossil fuels was maintained, so much so that their proportion exceeded 94% of the energy mix by 2000.

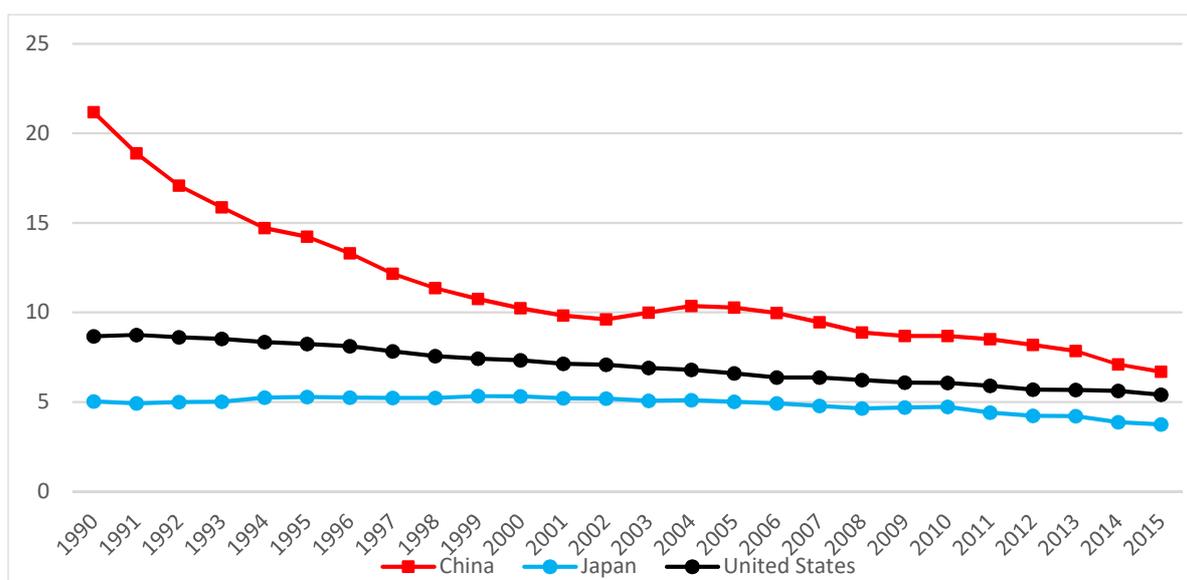


Fig. 5 Energy intensity index for China, 1990-2015, MJ/GDP in USD, 2011 PPP. Source: Author based on World Bank data, <https://donnees.banquemondiale.org/inducteur/EG.EGY.PRIM.PP.KD?locations=CN>

3.2 An energy policy with a two-fold objective: energy efficiency and energy security: 2001-2010 (Tenth and Eleventh FYPs)

The start of this period (2003-2005) was characterized by rising energy intensity (see Fig. 5). As a result of its burgeoning heavy industries, China was then dealing with recurring power outages and increasing energy dependence on oil and natural gas imports, at a time when the price of raw materials was surging across the board. In that situation, the Chinese authorities revised their energy policy, and prioritized energy security over all other objectives (Yuan and Zuo, 2011).

The Tenth FYP (2001-2005) thus focused on supplying energy to meet a growing demand, notably linked to the strong industrialisation of the Chinese economy. In practice, this led to a growth in national production on the one hand, and an increase in oil and natural gas imports on the other. As a result of this strong energy demand, the share of coal in China's energy mix rose from 69.3% to 73.4% in the course of the Tenth FYP.

This Plan also outlined the construction of a strategic reserve system for oil and sought to diversify the energy supply with significant investments in renewables (State Council, 2001). In 2001 the Chinese government launched the first Plan dedicated to new and renewable energy sources. Due to increasing demand, the energy sector was taking on a strategic role. In 2003, the Chinese government created an

Energy Bureau within the National Development and Reform Commission (NRDC) and an Energy Leading Group within the State Council. In the Tenth FYP, the Chinese government continued to include energy intensity targets and a list of priority technologies. These were rebranded as "energy-saving policies". But, for the first time since 1980, the goals set in the FYP were not achieved. Instead of the expected 15-17% reduction in energy intensity, there was an 11% increase during in the course of that period. At that stage, China acknowledged the need to engage in proactive and restrictive policies to make its energy targets achievable.

In November 2005, the Chinese government published a report that set an energy intensity fall target of -20%, which was included in the Eleventh FYP (2006-2010) but which it failed to attain by a small margin (fall of 19.06%) (Lo and Wang, 2013). This FYP focused mainly on reducing energy intensity and pursuing the diversification of the energy supply, with little regard for environmental issues. One of the flagship initiatives of this Plan in terms of intensity reduction was the "Top 1000 Enterprises Energy Conservation Action Program". It was established in April 2006 to pressure the 1008 most energy-intensive companies into cutting their energy intensity (Ke et al., 2012). These companies accounted for 33% of national energy consumption and 47% of industrial consumption in 2004. The program was intended to save 100 million tonnes of coal equivalent (Mtce) during the Eleventh Plan (Zhang, 2010). This goal was achieved.

In addition, in compliance with its overarching goal of diversifying energy supply, the Eleventh FYP also aimed to:

- expand existing national oil reserves and establish new ones (State Council, 2006).
- develop nuclear power, with the construction of new nuclear power plants as a priority. The plan for the medium- and long-term development of nuclear energy was announced in 2007. Its objective was to develop nuclear capacities with 40 million kW of installation capacity and an annual electricity production of 260-280 billion kWh by 2020 (National Economic and Trade Commission, 2007).
- develop investments in renewable energy. Figure 3 shows that between 2006 and 2010, these investments nearly quadrupled, surging from \$ 8.9 billion to \$ 34.5 billion. The 2006 law on renewables is evidence of the government's willingness to rely on these energy sources. In July 2009,

the central government launched the Golden Sun Program to foster the solar sector. It aimed to subsidise 50% of investment costs for a solar energy capacity of over 500 MW until 2011, with a subsidy rate of up to 70% for solar power projects in remote areas (Zhang, 2010).

Finally, the law on energy savings, which came into force in 1998, was revised in 2007. Although there was still progress to be made (Zhou et al., 2010), it clarified the responsibilities of the many public bodies involved. In order to improve its administrative capacity to achieve the Plan's targets, the Chinese government mobilised its local bodies across the country at every level. Each province was subsequently in charge of passing down guidelines to the multiple administrative sub-divisions (prefectures, counties etc.).

During this period, the country's energy policy reflected a twofold objective: reduce energy intensity and diversify energy sources to ensure energy security. The question of climate change was adumbrated for the first time in the Eleventh FYP (2006-2010), but not its resulting damages. In 2007, China set up an institution, the National Leading Group on Climate Change (NLGCC), entrusted with the task of implementing its National Plan on Climate Change at the local level, and for coordinating the various actions of provincial and municipal governments. In October 2009, the NDRC published a White Paper, "China's Policies and Actions on Climate Change". Nevertheless, it was not until the following FYP that climate change was treated as a major concern.

3.3 An energy policy to initiate an energy transition: 2011-2020 (Twelfth and Thirteenth FYPs)

The phase that began 10 years ago not only focuses on improving energy efficiency and energy security, but also incorporates strong environmental concerns, notably in relation to climate change. The Twelfth FYP (2011-2015) was thus considered a "green revolution" for China (Geal et al., 2011). In this Plan and for the first time, the fight against climate change is presented as a major challenge to the Chinese economy, on an equal footing with local pollution. An entire chapter discusses it. For the first time, this FYP introduces a carbon intensity target (Li and Wang, 2012). The terms "green

growth" and "green development" are increasingly present, gradually replacing the phrase "sustainable development". This Plan set three climate and environmental targets for 2015:

- Reducing energy intensity by 16% compared to 2010,
- Reducing carbon intensity by 17% compared to 2010,
- Increasing the share of non-fossil sources in primary energy consumption from 8.6% (2010) to 11.4% (2015) (State Council, 2011).

These three targets were achieved with a rate of 18.2%, 20% and 12% respectively.

In addition, there was now a consumption cap expressed in absolute terms: total energy consumption was not to exceed 4 billion tonnes of coal equivalent (Gtce Giga-tonnes coal equivalent), which implies a marked slowdown in demand. Moreover, renewables were set to account for 20% of resources used to generate electricity. In the end, all the targets of the Twelfth Plan were reached. Much like the successful Top Thousand Enterprises Energy Conservation Action Program (Top 1000), a Ten-Thousand Enterprises Energy Conservation Program (Top 10,000) was set up through the Twelfth FYP (Lo, 2014). The program encompassed 14,641 companies with the goal of saving 250 Mtce during this Plan (Lo and Wang, 2013). Energy intensity also continued to decline over this period (see Fig. 2).

Furthermore, in 2014 several carbon markets were set up on an experimental basis in two provinces (Guangdong and Hubei) and five municipalities (Beijing, Tianjin, Shanghai, Chongqing and Shenzhen) (Zhang et al., 2014; Lo, 2016). Two additional markets in the provinces of Fujian and Sichuan were created in 2016. In February 2021, a national market took over from these regional markets. The Chinese government thus sought to limit the rise in CO₂ emissions through initiatives such as the Top 10,000 Program, but also, more recently, through market-related reforms like stronger competition in the electricity market or the creation of the national carbon market (Zhang and Andrews-Speed, 2020).

The Thirteenth Plan was presented as that of a "new era" (National Economic and Trade Commission, 2016a). It included "green development" as one of its five pillars (the others being innovation, openness, coordination and inclusive development). Hailing the advent of an "energy revolution", the Thirteenth Plan (2016-2020) reflected the willingness to improve energy efficiency and diversify energy sources in favour of renewables and low-carbon energy (National Economic and Trade Commission, 2016b).

It outlined aims to:

- reduce energy intensity by 15% by 2020;
- reduce carbon intensity by 18% by 2020;
- provide funding for innovation in low-carbon technologies;
- reach a 15% share of non-fossil energy sources in the energy mix (this objective was reached in 2020 with a share of 15.6% in the energy mix);
- cut the share of coal in the energy mix to 58% by 2020 (the first mandatory objective on coal which was reached in 2020 with a share of 56.6% in the energy mix), with an energy consumption target below 5 billion tonnes of coal equivalent.

In seeking to reduce coal use, the Chinese government implemented a specific policy to improve the performance of coal-fired power stations. In practice, this resulted in a newer and better-performing thermal fleet with a large proportion of highly efficient power stations in terms of fuel consumption per unit of energy produced. These new plants, known as "supercritical" and "ultra-supercritical", currently account for 19% and 25% of the Chinese fleet respectively. They facilitate reductions in coal consumption and CO₂ emissions per unit of electricity produced.

The Ten Thousand Enterprises Energy Conservation Program, inscribed in the Twelfth FYP, achieved its objectives and was transformed into a Top 30,000 Program in the Thirteenth FYP.

Political discourse reflected this change of course: as when China's former prime minister, at the 2009 World Economic Forum, stressed his country's goal to develop a "low-carbon" economy (*ditan* in Chinese). Put forward by Hu Jintao in 2007, the notion of "ecological civilisation" was made a

primary objective of the party in 2012 when Xi Jinping came to power. It later became a constitutional principle of the People's Republic in 2018. This trend was confirmed by the US-China joint statement on climate change in September 2014, followed by the ratification of the COP 21 climate agreement in September 2015. President Xi Jinping made additional commitments: in December 2014, he pledged that China would reach a peak in CO₂ emissions around 2030; in September 2020, he pledged to reach carbon neutrality by 2060.

Renewable energy became increasingly important from 2008 onwards and, above all, more diversified starting with the Twelfth FYP. The share of coal in the energy mix decreased, rising from 70.8% (2011) to 56.6% (2020) (see Fig. 2)². Energy diversification policies are bearing fruit, as shown by the development of natural gas and hydroelectricity, the most important renewable resources. Wind and solar power are also experiencing a substantial growth despite grid connection problems. The share of non-fossil sources (renewables and nuclear) in the energy mix thus increased from 7.4% in 2011 to 15.6% in 2020. This share exceeds the target set in the Thirteenth FYP. Thanks to this development of renewable energy sources, China became the world's leading producer of hydroelectricity in 2019 (30.1% of global production). In 2018, it had already topped the world in the production of wind power (28.7%), solar photovoltaic power (31.9%) and electricity from biomass (17.5%).

Thus, China's ongoing efforts to reduce energy intensity (continuously declining since 2005, see Fig. 5) coupled with a willingness to diversify energy sources in favour of renewable and low-carbon energy since 2011, have enabled the country to embark on a low-carbon energy transition (see Fig. 6). This energy transition relies on a transformation of the Chinese energy system from a carbon-based system to a low-carbon system. However, this low-carbon energy transition cannot reasonably be equated with a sustainable energy transition, as the latter would require the Chinese government to respond to three challenges.

2 This share is certainly decreasing but still relatively high compared to other economies: 15.8% for the US, 3.5% for France and 28% globally (British Petroleum, 2017).

Years	1981	2000	2001	2010	2011	2020
Plans	Sixth	to Ninth	Tenth	to Eleventh	Twelfth	to Thirteenth
Energy policy's objectives	Energy efficiency		Energy efficiency Energy security		Energy efficiency Energy security Climate change ↓ Energy Transition	

Fig. 6. Three historical phases of China's energy policy.

4. Three challenges to a sustainable energy transition in China

4.1 An institutional challenge: applying standards and laws at the local level

China's legislative and regulatory framework for environmental protection was established incrementally over the past four decades.

In 1979, a (provisional) law on environmental protection was promulgated. In 1989, after a 10-year trial period, the law was revised and a final version of the Environmental Protection Law came into force. This law serves as the main legal basis for China's environmental protection system. A new in-depth review of the national environmental law was announced in 2014 and came into force on 1 January 2015. It is the most comprehensive review conducted since the law's enactment in 1989. It acknowledges the need to reconcile economic activity and environmental protection. The new law incorporates major advances compared to the previous legal framework. It grants authorities leeway to shut down companies deemed to have seriously infringe environmental regulations, and in some cases even to confiscate assets, whereas previously they could only impose fines. The new law protects whistleblowers on environmental issues, and the list of people who can bring complaints before the courts for non-compliance with ecological standards was extended to include victims of pollution and

NGOs. It prohibits polluting factories from being set up near protected ecological zones. With this latest revision, China therefore acquired a relatively complete and advanced legal framework for environmental protection. In addition, other pieces of legislation and policies dealing with the environment, energy and renewables are put in place by various ministries and local governments, which somewhat complicates the legal system (Liu, 2019).

Local governments are involved in implementing national policy goals including those for energy conservation (Zhang et al., 2011, Zhao et al., 2014). Since the Eleventh FYP, the central government require the energy conservation target for local governments and key central government departments. In late 2006, the State Council approved and distributed a scheme disaggregating the Eleventh FYP's national energy-saving target into energy-saving targets for each province (Zhou et al, 2010). The State Council further required local governments to disaggregate provincial targets to cities and counties. Provinces or cities can go beyond the measures instituted at the national level and set up more favorable local energy or environmental regulations (Zheng and Kahn, 2013 ; Yu et al., 2016).

However, this institutional framework is met with resistance from local governments which are reluctant to apply stringent institutional limitations to wealth-creating processes within their jurisdiction (Kostka and Nahm, 2017). The Chinese government therefore had to introduce new means of control at the local level to enforce its directives. Thus, the performance of provincial officials is no longer evaluated solely on the basis of economic growth, but also on the respect of ecosystems and decrease of energy intensity. A "target responsibility system" for local governments was introduced in 2007. Studies have shown that this system failed to meet its objectives during the Eleventh FYP (Sun, 2018). Four changes were introduced in 2011: 1/ a 4-point cut in the energy intensity objective between the Eleventh and Twelfth FYPs (the target set in the Twelfth FYP was 16%); 2/ an annual assessment instead of a single assessment at the end of the Plan, meant to deter slackness on the part of local government officials; 3/ a redistribution of the provincial energy intensity reduction objectives to reflect the economic development of the provinces; and 4/ the introduction of sector-specific energy saving objectives (Lo and Wang, 2013). A new reform of the system was then launched during the Thirteenth FYP to further improve its efficiency (Lo, 2020).

4.2 An economic challenge: decoupling economic growth from energy and coal consumption

The connection between economic growth and energy consumption has been investigated in numerous studies. The first related to the United States (Kraft and Kraft, 1978), then to other developed countries such as Italy, the UK, Germany, France, Canada and Japan (Yu and Choi, 1985; Erol and Yu, 1987), and finally developing or emerging countries (Masih and Masih, 1996; Glasure and Lee, 1997; Asafu-Adjaye, 2000; Yang, 2000). Some studies also focused on China. They explored either the causal links or the decoupling between economic growth and energy or electricity consumption in China (Shiu and Lam, 2004; Yuan et al., 2007; Lin and Liu, 2016). The question of decoupling arises when GDP grows less quickly than energy consumption (Shiu and Lam, 2004). Figure 7 shows four phases of decoupling: 1/ in the late 1980s; 2/ during the Asian crisis of 1997-2000; 3/ during the global economic crisis of 2007-2010; and 4/ in 2012-2016. The study conducted by Lin and Liu (2016) on the 1996-2011 period sheds light on phases 2 and 3. The study by Zhao et al. (2018), on the 1992-2012 period, distinguishes phases of strong and weak decoupling, which are broadly correlated with the major decoupling periods displayed in Figure 7. By focusing on the last ten years, we can see that from 2012 there is a significant decrease in the growth rates of energy consumption and coal consumption, with the latter even declining between 2014 and 2016. A decoupling therefore appears during this period. Various factors might explain this phenomenon: the decline of Chinese growth; the evolution of its economic development model in the form of a shift towards a service economy; and the development of renewables.

The double priority of growth and environmental protection is still recent and may be subject to occasional adjustments for the sake of economic growth. This was the case during the trade war with the US in 2018-2019. The current health crisis also seems to have temporarily halted China's steps towards energy transition. According to the latest report from the Global Energy Monitor et al. (2021), China commissioned 38.4 Gigawatts (GW) of new coal-fired power stations in 2020, which accounts

for 76% of new coal power plants worldwide. There are currently 88.1 GW of coal-fired power stations under construction in China, nearly half of the world’s total, with an additional 158.7 GW in the pipeline. According to the Global Energy Monitor et al. (2021), this significant rate of construction of coal power plants is the highest since 2016. China has seen a growth in its coal sector since its provinces have been using coal construction projects to revive local economy following the Covid economic slump. These increasingly numerous projects were backed by the central government, which relaxed restrictions on building permits for new coal power plants and increased lending to develop the national economy, including for coal-intensive megaprojects. There is therefore a stark contradiction between the carbon neutrality objectives announced for 2060 and these current and planned coal plant construction projects (considering their average lifespan is about 40 years).

Due to the strong economic recovery in 2021 and extreme weather conditions, China is experiencing power shortages. To cope with this situation, the Chinese government ask coal-fired power plants to increase their production, authorize the reopening of mines in the north of the country and increase its coal imports since the summer of 2021. In view of this matter, the question of whether China’s energy situation may qualify as “decoupling” is debateable (see Fig. 7).

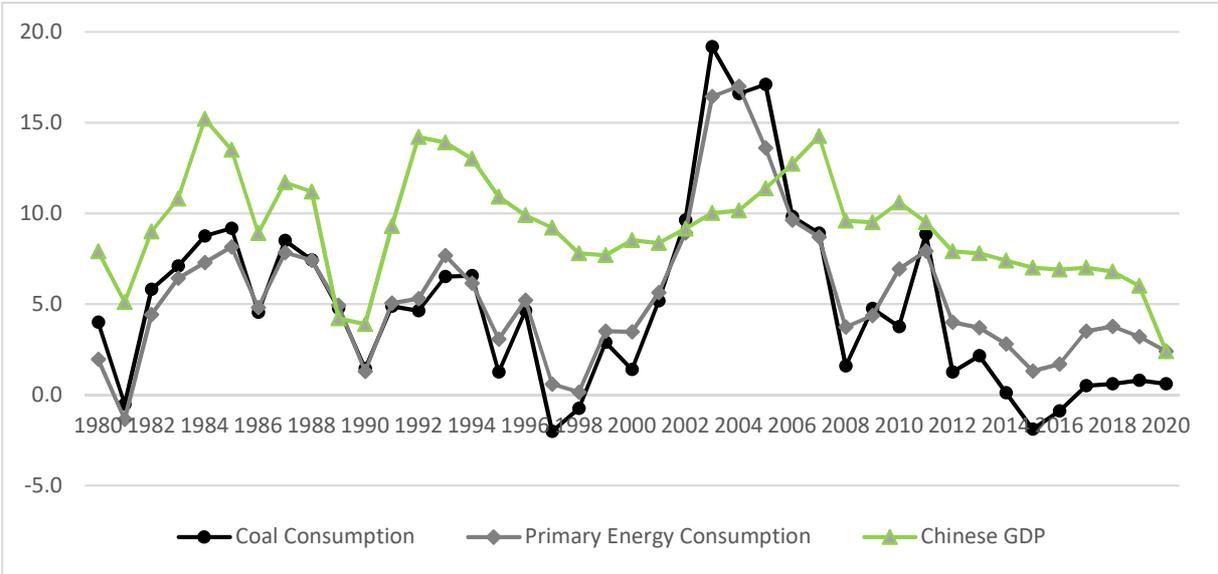


Fig. 7. Chinese GDP, Primary Energy Consumption, Coal Consumption, annual growth rate, 1980-2020. Source: Author based on British Petroleum data (2021)

4.3 An environmental challenge, or the environmental costs of renewable energy

Since the early 2000s, renewables have benefited from investments, subsidies and advantageous feed-in tariffs for electricity, which allowed China to become the largest producer of solar panels and wind turbines (Wang et al., 2018). Significant investments made to encourage electricity production from renewables were not made in distribution networks (Sandalow, 2018). Such policies have so led to production capacities in excess of capacities of distribution networks, particularly in wind and solar power. As a result, much of the energy output was simply squandered. In 2018, the Chinese government stepped in to reduce subsidies for these two forms of energy production. It should also be noted that these intermittent renewable energy sources (solar and wind) solely concern the decarbonisation of the electricity system, which in 2017 accounted for only 6.6% of China's electricity mix.

Another factor puts the development of renewables into perspective: the problem linked to the consumption of rare metals and rare earth elements and to the pollution resulting from their extraction and recycling. Indeed, the focus placed on renewables energy in the context of a low-carbon energy transition fails to consider the total environmental cost of producing renewable technologies: from extraction to the production of photovoltaic cells, electric car batteries, wind turbines, and the recycling of metals and other components. Once these costs are taken into account, it appears that while renewables facilitate reductions in CO₂ emissions and low-carbon energy transitions, they do not allow for a clean or sustainable energy transition. No energy is clean (Harjanne and Korhonen, 2019). Renewable energy sources imply an environmental cost which should not be overlooked. Studies on the life cycle assessment of renewable energy in terms of CO₂ emissions are beginning to be conducted, particularly for China. For example, to minimize life-cycle emissions in solar PV production in China, the carbon pricing policy and the diffusion of innovation or the adoption of well-performing technologies are often considered as the most effective policies to achieve a low-carbon production of electricity (Xu et al., 2018 ; Liu et Lv, 2019 ; Liu and van den Bergh, 2020).

5. Conclusion and policy implications

Looking back at the last eight FYPs spanning a period of four decades (1981-2020), the extent to which China's energy policy was transformed becomes apparent. Between 1981 and 2000 (from the Sixth to the Ninth FYPs) there was a single goal: to improve energy efficiency. Modernising industrial capacities and the objectives of decrease of energy consumption allowed to improve energy efficiency during this first historical phase of Chinese energy policy. Between 2001 and 2010 (Tenth and Eleventh FYPs), another objective was drawn up due as a response to the depletion of fossil fuels: energy security. A reduction in energy intensity (although the targets were not reached in the two FYPs) and a diversification of energy supply (increased coal production, oil and gas imports and development of nuclear power and renewable energy) have been at the heart of this historic second phase of Chinese energy policy. Since 2011 (Twelfth and Thirteenth FYPs), environmental degradation and the fight against climate change are once again influencing the energy policy, now more focused on the development of renewable and low-carbon energy sources. Over the past ten years, China has initiated an energy transition. Indeed, Chinese current energy policy aims not only to improve energy efficiency but also to diversify the country's energy system in order to its secure energy supply and reduce its CO₂ emissions.

However, this transition towards a low-carbon energy system may not qualify as a step towards a clean or sustainable energy system because the local government are reluctant to apply stringent institutional limitations to wealth-creating processes within their jurisdiction and because China's energy consumption is not decoupled from its economic growth and total environmental costs of renewable energy are not taken account. If China is to build a sustainable energy system, its government must rise up to a threefold challenge:

- 1/ an institutional challenge concerning the application of rules and laws by local authorities;
- 2/ an economic challenge leading to the decoupling of economic growth and coal consumption;

3/ an environmental challenge that considered the total environmental cost (extraction, use and recycling) of renewable and low-carbon energy sources.

The upcoming Fourteenth FYP will be crucial in speeding up energy transition and put China on the tracks towards a sustainable energy system. In March 2021, the Chinese government published the main targets of the country's Fourteenth FYP (2021-2025):

- reducing energy intensity by 13.5% by 2025;
- reducing carbon intensity by 18% by 2025;
- increasing the share of non-fossil energy sources in the energy mix from 15.8% to 20%.

Based on these conclusions, I lay out three policy implications for a shift towards a sustainable energy transition.

1/ The effectiveness of the target responsibility system reform is crucial for local authorities to apply the laws and standards set by the government. The latter must verify its effectiveness as quickly as possible.

2/ Decoupling economic growth from energy consumption can only prove effective if the Chinese government keeps improving energy efficiency and expanding its service sector, but also, crucially, if it manages to prevent the construction of new coal-powered plants and deter the use of fossil fuels. At the April 2021 Leaders' Summit on Climate, initiated by US President Joe Biden, the Chinese government made announcements in support of such measures, to the effect that China would limit the growth of coal consumption throughout the Fourteenth FYP, and gradually reduce it over the Fifteenth FYP. Time will tell what objectives are set for coal consumption at the end of 2021 in the context of the sector-specific energy plan.

3/ The first two policy implications are currently being worked on; the Chinese government should pursue this direction and verify the correct implementation of its measures. The last policy implication involves reviewing the underlying ideology of the present energy transition. This entails considering

all the environmental costs of renewables – whether having to do with design, manufacturing, use or recycling. Renewable and low-carbon energy are not clean. The energy transition must be based on strong sustainability: the three stocks of capital (technical, human and natural) are complementary, not substitutable. The Chinese government should rethink its methods for extracting rare earths and critical metals and align them with environmental protection. It could also develop a recycling sector for the components used in the manufacture of these renewable energy. This consideration of the environmental costs at every stage of the production of renewable and low-carbon energy sources might give the Chinese economy a competitive in the years to come.

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