Green energy transition:

The case study on China

INTRODUCTION

Modern world is the product of industrialization and it is industrialization that all countries have sought to achieve as their highest priority.

Since the 19th century, distinct types of industrial revolutions have taken place, as a result of different combinations of strategic production functions.

These marked unprecedented phases of human development and led to the occurrence of the so-called "Great Divergence" between the West and the "rest", based on economic, social and political disparities. This period accounted for the current distribution of wealth and power that has seen the West in a favorable position until the second half of the 20th and the beginning of the 21st centuries when, thanks to incredible efforts made to industrialize underdeveloped areas, the first signs of the "Great Convergence" were starting to be seen, as China employed catch-up strategies to bridge the gap with the Western leaders.

With the funding of New China in the 1950s and the beginning of reforms and opening-up, Chinese economic development went into overdrive, continuously shrinking the huge gap with Western countries that developed during the first and second revolutions.

Ever since, China underwent its reform and opening-up, making great efforts to catch up with the industrial civilization of other countries; enjoying economic boom and a growing world status, role and influence[1].

The Chinese incredible economic growth over the last three decades has taken place at an unprecedented speed, leading the country to become the second largest economy in the world in the past and, possibly, the first one in the coming decade.

As a result of such growth, China is considered a major rising power that continually increases its impact on global governance, by the economic, political and environmental points of view. The downside of this apparently idyllic condition is the fact that the Country is also the global largest greenhouse gas emitter since 2007, burning half of the coal consumed in the world.

For this reason, China faces great pressure both inside and outside the international negotiations to become more ambitious in its transition to the green development. However, balancing the Country's energy needs to fuel its continuous economic growth

[1] Angang H., *China: innovative green development*, page 94, Springer, second edition 2017

with the resulting potential impacts of climate change presents an enormous policy dilemma, not only for China, but also for the entire world.

On the domestic front, despite the fundamentals for long-term economic growth have not changed, and the economic development prospects are as broad as ever[2] , the need to improve the quality and efficiency of such growth and transform the economy has become a priority.

The Chinese leaders are fully aware of these challenges, as demonstrated by the adoption, during the 18th Conference of the Communist Party's Central Committee, of a general policy of Ecological Civilization. This placed ecological goals at the same level of importance as existing policies on economic, political, cultural, and social development.

With the grand vision of Ecological Civilization, the issue is then how China explores concrete, constructive, and realistic solutions in the 13th Five-Year Plan and beyond, in order to succeed in transitioning to a low-carbon, green economy. To achieve this aim, the Country needs to cap nationwide coal consumption and cut coal consumption in absolute terms in severely polluted regions. It should make unprecedented efforts to keep energy consumption and carbon emissions under control in key energy-consuming industries and cities in the context of government decentralization and unprecedented urbanization[3].

Moreover, China will need to strengthen and expand flagship programs and initiatives and supportive economic policies; harness market forces to promote industrial upgrading and energy conservation and further increase the widespread use of renewable energy.

The present Thesis aims at analyzing China's transition to a green development through the study of the country's historical, economic and political realms.

This is divided in two main parts.

In the first one, the historical development of the Chinese industry is examined, in order to understand the energy sector and how the Country has gotten to become the world's GHG largest emitter.

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[2] Central Committee of the Communist Party of China Beijing, China, *the 13th five-year plan for economic and social development of the people's republic of China 2016–2020,* Translated by Compilation and Translation Bureau

[3] Zhongxiang Zhang, *Climate mitigation policy in China*, Climate Policy, 15:sup1, S1-S6, 2015. Available at http://www.tandfonline.com/doi/full/10.1080/14693062.2015.1096477

Then, by using the Kaya identity, a way for China to reduce its emissions is explained, highlighting how the carbon intensity of energy could be the major dependent variable affecting CO_2 emissions and implying that carbon emissions reduction may be better achieved by inter-fuel substitution and adoption of technologies with lower CO_2 intensity.

This part ends with the fourth chapter, which lists various pros and cons for China to invest in the green sector and concludes by affirming the importance of a sustainable development, considered as a "no regrets" decision.

The Dissertation continuous with the second part, which furnishes an overview on the most important political, economic and social decisions that have characterized the Chinese change of strategy. Indeed, from a country that was heavily dependent on fossil fuels, it is currently trying to decarbonize its economy.

The transformation of those China's priorities that reflect in policy and economy is illustrated throughout their evolution since the 1950s.

Finally, the obstacles to the effective green transition are summarized and a series of political and economic solutions are proposed.

PART I – How the Green Path has become an inevitable choice for China

CHAPTER 1

The change in energy needs – before and after the economic boom

1.1 Industrial Revolution worldwide

From the Great Divergence to Great Convergence

Modern world is the product of industrialization and it is industrialization that all countries now seek to achieve as their highest priority.

Different types of industrial revolutions result from distinct combinations of strategic production functions. The first industrial revolution created the "steam age" (1760-1840) and marked the transition from agricultural to industrial civilization, from the muscle power to the use of coal as the prime energy source. Thereafter, in the "electric age" of the second industrial revolution (1840-1950), heavy industries - such as electricity, steel, railways, chemicals and automotive - arose and oil started to be used as the new energy source. This revolution promoted the rapid development of transportation, both within and between countries, and a globalized international political and economic system gradually emerged. After two World Wars, the third industrial revolution gave rise to the "information age" (1950-2000)[4].

Exchange of information and resources became more rapid and most countries and regions were involved in this globalization process.

Industrial revolutions were unprecedented phase of human development, which led the capitalist model to expand worldwide and capital to reach every corner of the world.

The driving force of the capitalist development model is the single-minded pursuit of profit from capital, which relies on expanding the scale of access to natural resources and energy to achieve further expansion of production and thus to obtain maximum profit. The capitalist development model, however, has a fundamental and

[4] Mathews J.A., *Greening of Capitalism. How Asia is driving the next great transformation*, Chapter 2 Stanford University press, 2015

irreconcilable contradiction between infinite capital expansion and limited natural resources. This contradiction has temporarily relieved in the early development of capitalism through continuous wars and colonial plunder of the Western-oriented countries.

However, with rapid advances in technology and completion of the global expansion of capital, traditional approaches have been unable to inject the new required resources by the ever-expanding capitalist system.

After World War II, Western societies entered a model based on consumerism, in which the excessive growth of consumption drove high production and profit, resulting in higher degradation of natural resources, pollution and emissions. In applying this capitalist model, known as the "black model" of development in China, Western counties have promoted the development of civilization and achieved some national success. Nevertheless, this has led to huge and invisible costs for the whole world, that is mainly reflected first in Western countries' consumption of energy and resources - at rates several times higher than their proportion of the world's population - and second in their emissions of the greenhouse gases and pollution during their 250-year industrial history, which largely expanded human ecological deficit.

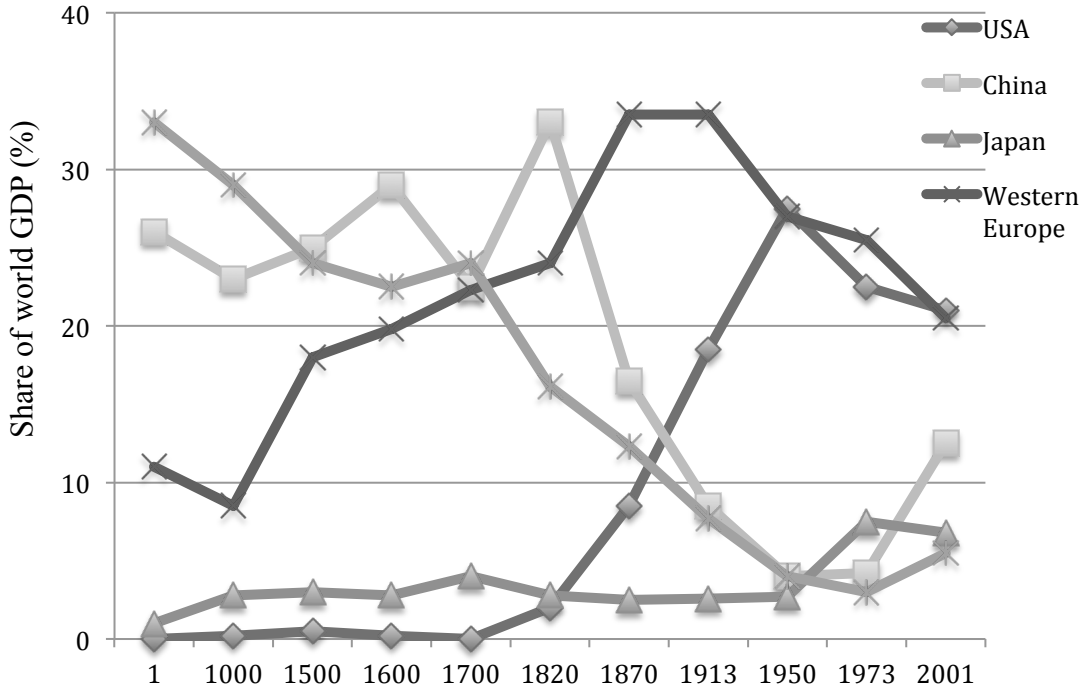
According to figures from the U.S. Department of Energy database, from 1800 to 1900 northern countries were responsible for over 90% of global carbon dioxide emissions; of that proportion, 70% was due to European countries, and the United States accounted for 23.6%, while from 1900 to 2000, northern countries were responsible for 50-90%.

Another factor resulting from the industrialization process is the lift of close to one billion people, in Western Europe, North America and Japan, out of the "Malthusian trap" that pinned income to population and set them on a trajectory of rising per capita wealth and for the occurrence of the so-called "great divergence" between the West and the "rest", based on economic, social and political disparities.

This period accounted for the current distribution of wealth and power that has seen the West in a favorable position during the last three hundred years.

Between 1760 and 1860, population and per capita income doubled in England. This was the first sustained breakout from the abovementioned Malthusian trap[5], named after the English political economist T. Malthus, who had asserted that, as income increases, so population would do at a greater rate until it would outgrow its resource base, triggering a famine. This is just what happened throughout history. A tragic demonstration of this theory occurred in China during the Qing dynasty, under which food production systems were rationalized and intensified, leading to improvements in agricultural productivity. This, nonetheless, was followed by explosive increases in population (from 100 million in 1750 to 283 million in 1890)[6] and repeated period of famine. Clearly, China had not broken out of the Malthusian trap, contrary to Britain that, through industrialization and its access to fossil fuels, had done it.

However, by the second half of the 20th and the beginning of the 21st centuries, thanks to incredible efforts made to industrialize underdeveloped areas, the first signs of the "Great Convergence" were starting to be seen, as China has been employing catch-up strategies to bridge the gap with the Western leaders.



[5] Mathews J.A., *Greening of Capitalism. How Asia is driving the next great transformation*", pp. 2-3, Stanford University press, 2015

[6] See Pomeranz (2000) on the Great Divergence.

Figure 1 Major world economies' fluctuations over the past two thousands years
Source: Maddison 2001

With the funding of New China and the beginning of reforms and opening-up period, Chinese economic development went into overdrive, continuously shrinking the huge gap with Western countries that developed during the first and second industrial revolutions.

Economic globalization, the transfer of production, manufacturing and exports and the transfer of resource consumption, pollution emissions and natural assets' depletion started to reflect the inequality and injustice that exist in terms of income and cost between northern and southern countries.

As a victim of this major global transfer, China has undergone a continually rising proportionate net depletion of natural capital: it surpassed the EU in 2005, the United States in 2008 and Russia in 2009. China has now the highest level in the world.

1.2 The Chinese industrial development

1.2.1 Historical highlights - from ancient times to Communist party's takeover

Since ancient times in China there has been a unity between nature and humanity. Having respect for nature, protecting nature, and conforming to the laws of nature have long been mainstream elements of traditional Chinese culture.

However, Since the New China started to develop as the world's fastest-growing economy and the world's most populous country, it has been undergoing the greatest urbanization and industrialization in human history, placing enormous pressure on the country's fragile environment.

China's energy industry developed rapidly as the country underwent the change from an impoverished, self-sufficient nation of smack resources to a country that was a major producer of resources.

The first eco-environmental degradation occurred during the Qing and Han dynasties (2 AD), following which there were few forests in the Guanzhong area but serious problems of soil erosion and flooding. The population doubled from 10 to 20 million, during the Qin Dynasty, and to 60 million in the second year of the Emperor Yuanshi, which marked the beginning of feudal society. The arable area was considerably

extended and, in addition, appropriation of forestry land led to China's forest coverage rate being reduced to 41%. This resulted in the destruction of forests, grasslands and other areas of natural vegetation and serious soil erosion.

Then, during the following millennium, China alternated periods of natural restore and deterioration, according to different policies and population growth.

There was considerable population growth, agricultural expansion and a population spread to peripheral areas of the country.

This development was an important foundation upon which an independent and relatively complete industrial system was built.

It also represents a historical starting point for China's transformation into a world industrial superpower.

1.2.2 Historical highlights - from 1949 to the economic opening-up

While the Western predecessors took centuries to modernize and build up industries, China has undergone an equivalent process in just a few decades[7]. The speed of the process added further complexity to the already challenging task of managing domestic energy intensive development and global climate change mitigation. Moreover, the country started to face three deep-seated sustainability problems that had implications on the country's willingness and ability to respond to climate change[8]:

1. China's population growth increased the pressure on already notoriously scares and unevenly distributed resources. Estimates of the size of China's population by the middle of this century fluctuate by a few hundred million, making it extremely difficult to estimate China's future resource needs.
2. Growth has come at a high social and environmental cost. Due to its uneven distribution and rapid pace, economic growth has not improved living standards for all citizens. This unbalanced economic development added pressure on already limited resources and concurrently deepens already wide chasms between those who has a lot and who has very little.
3. A combination of China's socialist heritage and capitalist enthusiasm created a basis for large scale exploitation of human and natural resources.

[7] Handling K., Han G, Olsson M., *A balancing act: China's role in climate change,* page 35, The Commission on Sustainable Development, 2009

[8] ibid.

The consumption of goods such as water and petrol began to be subsidized by the government, giving cheap prices for consumers and a large turnover for producers, a system that in itself inherently supports over-exploitation.

Between 1949, which marked the beginning of the country's economic rise, and 1978, China basically achieved its initial goals of industrialization that were advanced in the 1950s and 1960s. The country established an independent and relatively complete industrial and economic system, laying the foundation for the development of industrialization and achieving the highest economic growth in history.

The aim of the Chinese Communist Party was transforming China into a modern, powerful, socialist nation in the long run and, in economic terms, these objectives translated into industrialization, improvement of living standards and narrowing of income differences.

Industrialized countries' traditional development presented two distinct features whether in Europe, in the United States and in Japan, despite their different national and development conditions. One was that high-speed growth is sustained by high consumption of resources (especially non-renewable resources); the other was that the high-speed growth is stimulated by high consumption of the means of subsistence (the traditional model). China, instead, had different conditions and could not realize modernization by following the traditional model, because of numerous reasons[9].

- First, when Europe, the United States and Japan launched industrialization, they took an active part in international trade and linked themselves with the world market, accumulating industrial capital and opening up the international market through war and colonization. On the contrary, China had endured a hundred years of suffering before opening its doors and its exports product mix, principally primary goods, playing an unfavorable role.
- Second, industrialization has come very late in China, with a subsequent large gap with industrialized countries to bridge in production technology, development and resource use.
- Third, China's per capita resources were less than a fraction respect in Europe and United States.

[9] Angang H., *Green development: the inevitable choice for China,* 2006

- Fourth, China is an extremely populous country.
- Lastly, it was impossible to realize past models of capital accumulation by waging wars and plundering resources from other countries, as the industrialized economies did. China must rely on internal reform and development.

The form of the economic model and the policies that expressed it during the whole Chinese history reflected both the latest policy emphasis and the structural foundation built up in the earlier periods.

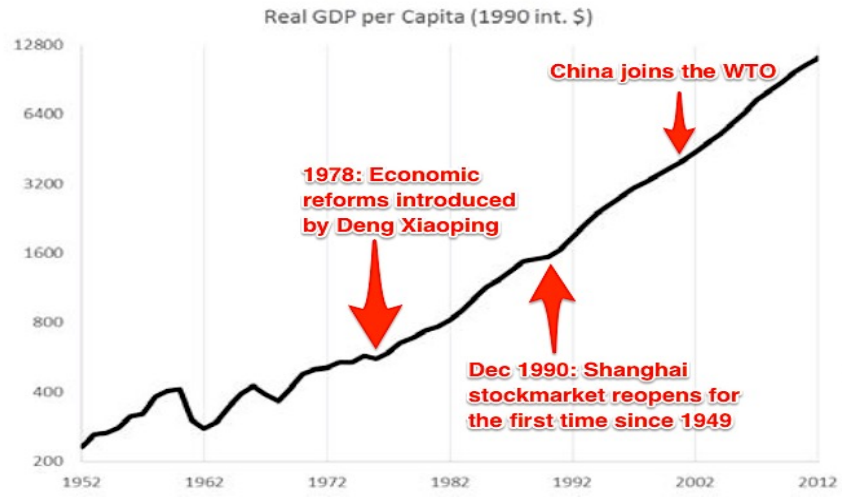


Fig 2: Real GDP per Capita

Source: https://www.weforum.org/agenda/2015/07/brief-history-of-china-economic-growth/

The first two decades following the founding of the People's Republic of China were marked by the alternation between substantial growth of per capita GDP and output and sharp reversals. The strategy of placing the priority on the development of heavy industry, by setting an artificially low cost of such development was implemented, while the price of capital, foreign exchange, energy, raw materials, agricultural products and labor were depressed.

The period of the First Five-Year Plan was important for China's resource and energy development. With the help of the Soviet Union, the country undertook 156 projects, in which the energy industry, vital to re-industrialization efforts, was given the highest priority (33.3%); as the source of raw materials, the metallurgical industry was given the fourth-highest priority (12.8%).[10] The major projects were also major consumers of

[10] Hu A., *China: Innovative Green Development,* pp. 86, Springer, second edition, 2017

China's energy, resources and raw materials, and the growth rate in energy consumption during this period was much higher than the economic growth rate - the energy consumption per unit of GDP from 1953 to 1957 showed an increase of 32.4% - due to significant investments in the black industry.

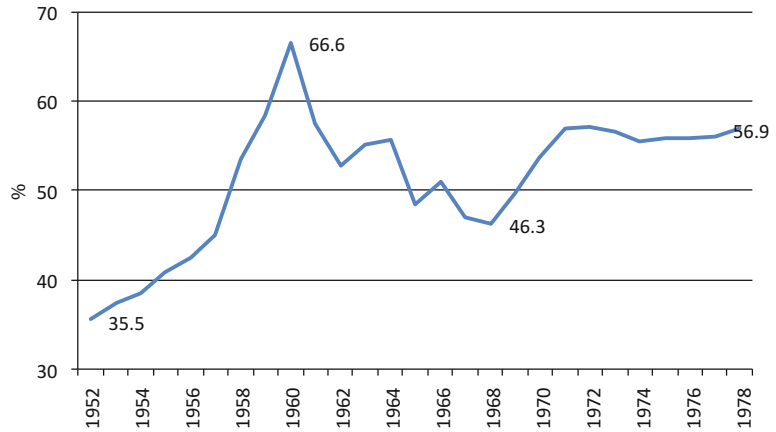


Figure 3: The Chinese heavy industry as a proportion of total industrial output value (1952-1978)
Sources: China Industrial Economic Statistics Yearbook (2007); the data for 1953-56 and 1958-62 derive from China Financial Statistics (1952-96)

The small blast furnaces, coke ovens and coal mines everywhere around the country represented an excessively expensive mode of economic development: compared with 1957 levels, the cost of energy per unit of GDP showed an increase of 138% by 1960, which is the highest figure in the country's history.

During the following period, the Chinese economy grew at a great pace, thanks to the high consumption of resources, which however led to high levels of pollution and emissions.

1978 was the defining year in shifting the country from its unsteady early economic trajectory on to a more sustainable path and from an increase to a decrease in energy intensiveness.

The Third Plenary Session of the 11th Central Committee of the Communist Party laid the groundwork for future growth by introducing reforms that permitted farmers to sell their products in local markets and began the shift from collective farming to the household responsibility system.

A year later, the Law on Chinese Foreign Equity Joint Ventures was introduced. This permitted foreign capital to enter China and help boosting regional economies, although

it took until the mid-1980s for the government to gradually ease pricing restrictions and allow companies to retain profits and set up their own wage structures. This not only boosted GDP from 6% to 9.4% per year between the 1953-1978 and 1978-2012, but also increased the pace of urbanization as workers were drawn from the countryside into higher-paying jobs in cities.

These progresses were slowed down during the Sixth Five-Year Plan, when a reduction of the industrial energy consumption per-unit consumption was implemented by 12.3-16-3%, leading to a fall by 23.5% of energy consumption per unit of GDP[11].

This trend continued even during the Seventh Five-year Plan, which proposed an increased production capacity based on efficiency and a further decrease of energy consumption per unit of GDP by 11.6%.

The Eight plan placed the focus on both development and conservation, requiring prominent savings; over its course, the reduction in energy use was aimed at the equivalent of 100 million tons of standard coal and the energy consumption per unit of GDP of 8.6% (the actual decline was 25.5%).

However, despite the efforts, China has become the world largest emitter of Greenhouse gases, identified by the Intergovernmental Panel on Climate Change (IPCC) as sources of "anthropogenic" climate change.

From the beginning of the reforms in the 1980s[12] to the late 1990s energy consumption grew only half as fast as GDP.

What China managed to reach, instead, was a unique development path where national and per capita incomes grew while energy intensity was falling. This trend was, however, reversed from the turn of the century, when the Country entered a phase of increasing energy and CO_2 intensities.

China, Latin America, East Asia and India started their development path by emulating the Western countries, that is by implementing a conventional resource-intensive and fossil-fueled model. China's energy industry developed rapidly as the country underwent the change from an impoverished, self-sufficient nation of small resources to

[11] Angang H., *China: innovative green development*, page 94, Springer, second edition 2017

[12] Handling K., Han G, Olsson M., *A balancing act: China's role in climate change,* pp. 26, The Commission on Sustainable Development, 2009

a country that was a major producer of resources. At the same time, the industrial products rose in quality and in proportion of the total world output.
The development of the Chinese resources was the starting point for the transformation of the Country into a superpower and it was an important foundation upon which an independent and relatively complete industrial system was built.

During the period of the Ninth Five-Year Plan, large-scale industrial restructuring were undertaken. The growth pattern shifted from high to low capital investments and from high-energy consumption and high pollution emissions to low energy consumption, low emissions and high growth. China was able to achieve an 8.63% economic growth rate despite an energy-consumption growth rate of only 1.10% and a decline in energy intensity of 26.7%.

1.2.3 Reforms and opening-up toward the Asian Great Superpower

Since China's reform and opening-up, along with the greatest industrialization and urbanization in history, rapid economic growth has produced considerable consumption of energy and resources, high emissions of industrial pollution and damage to the environment[13].
China has taken a detour and implemented successful and cheap early reforms to become a great superpower; but these economic policies have ignored the country's ecology and have given importance to short-term profits.

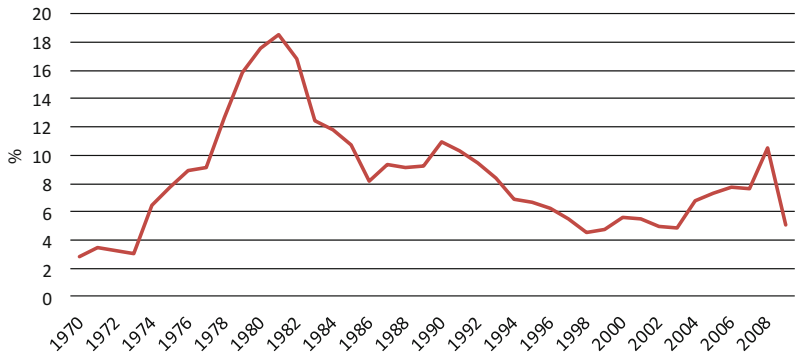


Figure 4: Proportion of natural capital depletion in GNI (1970-2009)
Source: World Bank, WDI (2010)

[13] Hu A., *China: Innovative Green Development,* pp. 89, Springer, second edition, 2017

In this period, though the efficiency of energy use has increased, the overall depletion of natural capital began to decline after a peak in the 1980s. In addition, green investment dropped significantly, from 2.3% at the beginning of reform and opening-up to about 1% in the early 1990s.

China experienced the largest, most widespread and severe ecological destruction in history.

Continuing with the "business as usual" way of growth was becoming more and more costly by several points of view, most important of which was an increase in pollution and a worsening of the population's health conditions.

The clash between humanity and nature constitutes one of the core contradictions within modern China's social productive forces, which is stressed by the recent and rapid expansion of the ecological deficit[14].

There are several factors that influence the current situation: first of which is the impressive increase in population rate (from 540 million in 1949 to 1.3 billion today); second, the expansion in the area of land under cultivation[15]; third, the scale and speed of deforestation, soil erosion and desertification; fourth, the rapid industrialization, urbanization and modernization that are responsible for most of environmental pollution. Finally, the frequency of natural disasters and the associated-direct and indirect economic losses are becoming more and more severe.

As well as industrialized developed countries, China has inevitably experienced a process of "protection after destruction", "treatment after pollution" and "reduction after emission"[16].

The issue of climate protection has reached the apex of the global agenda at a time when China faces tremendous development and energy security challenges[17].

Since the 1970s, a growing worldwide environmental awareness started to develop.

In December 1970, Zhou Enlai, a Chinese politician, affirmed: "We do not aim to become a superpower. For the sake of future generations, we are not desperate to

[14]Angang H., *China: innovative green development*, page 2, Springer, second edition, 2017

[15] Angang H. Yi W., *Survival and development, Situation Analysis Research Group of the Chinese Academy of Sciences,* Beijing, Science Publishing House, 1989.

[16] Mathews J.A., *Greening of Capitalism. How Asia is driving the next great transformation*, pg. Chapter 2, Stanford University press, 2015

[17] Handling K., Han G, Olsson M., *A balancing act: China's role in climate change,* The Commission on Sustainable Development

achieve this. Industrial problems are new problems for us, and industrialization inevitably causes such problems". After three decades of nearly 10% annual economic growth, China has come to a crossroads in its efforts to develop into a harmonious and globally responsible society.

In August 1973, the Country held its first conference on environmental protection, as part of establishing an official policy, where it discussed overall planning, rational distribution, comprehensive utilization of resources, the conversion of harms to benefits and the reliance on people. After the meeting, China set up a central environmental protection agency with regional branches to oversee management of the environment, while, since the mid-1990s the Country has followed a clear, sustainable development strategy, a mode that can meet the needs of people in the contemporary world without impairing the ability of future generations to meet their own needs.

Subsequently, the Asian country entered a period of shrinking natural deficit, as efficiency improvements were made in energy-utilization, pollution control and ecological environmental protection. The proportion of losses of natural assets as part of GDP showed a significant decrease of about 5%. Whereas, due to an increased capacity of prevention and mitigation, the proportion of natural disasters resulting in a direct loss to GDP dropped significantly.

	Nominal GDP (1)	Loss of natural assets (2)	Losses trough natural disasters (3)	Investment in human capital (4)	Green investment (5)	Balance of domestic natural account (5+4-3-2)	External natural capital input (6)	Real GDP (World Bank calculation) (1 − 2 + investment in education)	Green GDP (author's calculation) (1 + 5 + 4 − 2 − 3 + 6)
1978	100	13.5	4.0	7.3	2.3	-7.9	-1.0	89.1	91.1
1979	100	17.3	4.0	7.7	2.3	-11.3	-1.0	85.5	87.7
1980	100	19.3	4.0	8.1	1.9	-13.3	-1.1	83.9	85.6
1981	100	20.5	4.0	8.1	1.6	-14.8	-1.1	83.0	84.0
1982	100	19.3	4.0	8.3	1.6	-13.3	-1.2	84.5	85.5
1983	100	14.8	4.0	8.5	1.5	-8.8	-1.7	88.9	89.6
1984	100	13.7	4.0	8.5	1.3	-7.8	-2.6	90.0	89.6
1985	100	11.9	4.0	7.6	1.1	-7.1	-2.8	91.5	90.1
1986	100	8.9	4.0	7.9	1.2	-3.9	-1.9	94.6	94.2
1987	100	10.0	4.0	7.4	1.2	-5.4	-2.3	92.3	92.2
1988	100	9.5	4.0	7.2	1.0	-5.2	-1.4	93.5	93.4
1989	100	9.7	4.0	8.0	1.0	-4.8	-1.0	93.8	94.2

1990	100	10.8	4.0	8.4	1.0	-5.5	-1.7	92.7	92.8
1991	100	9.6	5.6	8.2	1.2	-5.9	-1.4	93.7	92.7
1992	100	8.5	3.2	8.1	1.3	-2.3	-0.9	94.7	96.8
1993	100	7.5	2.8	7.6	1.3	-1.4	-0.6	95.5	98.0
1994	100	5.9	3.9	7.4	1.1	-1.3	-0.6	97.2	98.1
1995	100	5.4	3.1	7.2	1.1	-0.2	0.4	97.7	100.2
1996	100	5.1	4.1	7.6	1.1	-0.6	0.4	98.0	99.8
1997	100	4.5	2.5	7.9	1.2	2.0	0.5	98.7	102.5
1998	100	3.2	3.6	8.5	1.6	3.3	0.2	100.3	103.5
1999	100	3.2	2.2	9.0	1.6	5.2	0.6	100.5	105.9
2000	100	4.0	2.1	9.4	1.9	5.3	1.8	99.9	107.0
2001	100	3.9	1.8	9.8	1.8	5.9	1.5	100.3	107.3
2002	100	3.4	1.4	10.4	2.1	7.7	1.4	101.1	109.1
2003	100	3.7	1.4	10.6	2.1	7.6	2.3	100.9	109.9
2004	100	5.5	1.0	10.5	2.0	6.0	4.0	99.0	109.9
2005	100	5.8	1.1	10.7	2.0	5.8	4.4	98.8	110.2
2006	100	5.8	1.2	10.7	1.9	5.6	4.9	98.8	110.5
2007	100	5.7	0.9	10.7	2.0	6.0	5.2	99.0	111.2
2008	100	7.6	3.9	11.2	2.2	1.9	6.3	97.2	108.1
2009	100	4.3	0.8	11.7	2.3	9.0	4.5	100.5	113.5

Table 1 : China's green GDP accounting (1978-2009). Unit %

Note: the data in this table were calculated by Angang Hu, author of *China: Innovative Green Development*
Source (2) from the National Disaster Reduction Committee, 2010; (3) from the World Bank, WDI; (4) from the National Bureau of Statistics, R&D investment in 1978– 1990 is the proportion of innovation funds and science and technology in GDP; (5) from the China Water Yearbook 2010, State Forestry Administration, 2010; (6) from the National Bureau of Statistics

China's coal dependence and the dramatic increase in energy use since the turn of the century have created domestic worries about how to fuel China's future growth as well as international concerns about escalating carbon emissions. Energy security has reached the top of the Chinese political agenda and is framing the view of the nation's climate policy options.

The environmental degradation has reached a point where it limits growth potential and adds to social instability, at the same time as it causes millions of premature deaths annually and contributes to a 40% increase in birth defects within the last decade alone. This is the reason why the leaders are currently debating how future economic development could be redirected toward social reforms, environmental protection and resource conservation without compromising the stable economic growth that would be paid for these reforms.

1.2.4 From a massive to an integrative energy-consumption

After the success of restoring the national economy in the early period of New China, it started to learn from the Soviet experience and implemented industrialization under the slogan "one industrialization, three reforms"[18] in which the government launched industrialization but excluded the private sector (private capital and individual ownership), giving priority to the development of heavy industry and artificially depressing its costs, such as the price of capital, foreign exchange, energy, raw materials, agricultural products and labor.

Then, in almost three decades[19] of Maoist rule, China built an extremely energy-intensive and economically inefficient industrial structure.

Under Mao Zedong and the Communist Party, China introduced a centrally planned command economy. This system involved the abolition of household agriculture in favor of collectivities as well as a move toward centrally allocated industrial inputs and outputs in accordance with a plan developed by the State Planning Commission. Economic resources were directed out of agriculture and into energy-intensive heavy industries like steel and cement, which doubled the share of economic output while tripling the amount of energy required to produce each unit.

Market forces were largely eliminated by industry and commerce as the government set wages and allocated skilled workers to jobs[20].

Economic modernization continued and by the middle of the 1980s, power generation became the government's main priority, accounting for the largest share of investment in the energy sector. With little exploration activity, investments in oil and natural gas rose marginally, as did output, and growth in primary energy production was achieved through the expansion of coal supply.

Going against what China's resource base could support, this approach provoked a serious energy inefficiency and production losses.

Additionally, the 1980s Deng's reforms introduced fiscal decentralization and a gradual expansion of rural property rights, which in essence redistributed land tenure from the

[18] Angang H., "China: innovative green development", page 10

[19] Handling K., Han G, Olsson M., *A balancing act: China's role in climate change,* page 61, The Commission on Sustainable Development 2009

[20] Meidan M., *The structure of China's oil industry: Past trends and future prospects*, Oxford Institute for Energy Studies, 2016

commune to the household level. This created a dramatic increase in agricultural productivity at the same time as the strengthened property rights provided incentives for productivity gains and competition-driven efficiency[21].

The reforms moved to include also rural industry when township and village enterprises began replacing the former commune and brigade enterprises, becoming the engine of growth during the 1980s and 1990s and transforming the industrial structure from heavy and energy intensive industry to light industry with higher economic outputs in relation to energy input.

As a response to the 1998 financial crisis, China began a development stage where rapid urbanization and industrialization led to expansive infrastructure development and the consequent boost of demand for heavy industrial products.

This shift came at the turn of the century, as the Country rapidly developed its energy-intensive, heavy industries.

Over the 2000–2013 period, China's growth strategy was characterized by the following features[22]:

- roughly double-digit annual GDP growth (on average);
- high investment share of expenditure, with exceptionally low proportions of expenditure on domestic consumption and services;
- high levels of investment in heavy industry sectors such as steel and cement production, which require large volumes of energy (both direct fossil fuel inputs in the production process and electricity consumption, with the latter supplied predominantly through expansions in coal-fired power generation);
- high profit share of income;
- strong dependence on exports to external markets, in which falls in net-exports were largely replaced by additional, government-stimulated domestic investment.

One consequence of this growth model was an extraordinary expansion in coal consumption. Between 2000 and 2013, China's coal consumption nearly trebled,

[21] ibid.

[22] China Council for International Cooperation on Environment and Development [CCICED], 2014; Garnaut et al., 2013; 2014

growing at a compound rate of more than 8% per year[23] and leading the country to become a net importer of coal from 2009 (by the end of this period half of the coal consumed globally was being consumed in China) .

This model, despite the numerous benefits it brought, led the Chinese people[24], experts[25] and leaders[26] to recognize its unsustainability — for economic, financial, social and local environmental reasons, in addition to its incompatibility with global climate goals.

The economy's reliance on coal-fired power and heavy industrial production, and its growing vehicle use in urban areas, have led to acute rises in outdoor air pollution, that has become a scourge for public health. In the most comprehensive study of ground monitoring data to date, particulate matter pollution measuring less than 2.5 micrometers in diameter (PM2.5) in China has been estimated to contribute to 1.6 million premature deaths per year, i.e. 4,000 deaths per day[27] (equivalent to more than 10% GDP. Other environmental impacts are mounting, too, including water pollution and water scarcity, soil pollution and solid waste[28] .

Furthermore, the old model of growth is unsustainable in a conventional economic sense. As demand in many parts of China's construction and heavy industrial sectors passes saturation points, continued political-economic incentives to invest in these areas have resulted in widespread excess capacity and diminishing returns on capital, undermining their competitiveness and resulting in weak productivity growth[29]. Given the extent of excess capacity in real estate and heavy industry, much of the investment was not allocated to profitable projects and the total debt in the Chinese economy quadrupled from an estimated $7 trillion in 2007 to $28 trillion by mid-2014[30].

Natural resource constraints, environmental deterioration and high levels of dependence on imported energy are also undermining China's economic performance and imposing mounting economic costs.

In 2012-2013, this led the Chinese then-incoming generation of political leaders to articulate the need for fundamental structural change and policy reform — a 'new

[23] National Bureau of Statistics [NBS], 2015a1
[24] Pew Research Centre, 2013; Wike & Parker, 2015
[25] International Monetary Fund [IMF], 2015; World Bank & DRC, 2013
[26] President Xi (quoted in Anonymous, 2013) and Premier Li (quoted in Anderlini, Mitchell and Wildau, 2015).
[27] Rohde & Muller, 2015
[28] CCICED, 2014; World Bank & DRC, 2014
[29] CCICED, 2014; IMF, 2015
[30] Dobbs, Lund, Woetzel, & Mutafchieva, 2015

normal' — in order to respond to these challenges and steer China's development path onto a more sustainable and desirable course[31].

This 'new normal' is understood by the leadership and policy elite as embodying a shift toward economic growth of a higher quality and lower rate, with a particular emphasis on four sub-themes: services, innovation, reduced inequality and environmental sustainability[32]. "Services" and "innovation" can be read as proxies for the changing structure of Chinese industry and investment towards services and higher-value-added manufacturing; "reduced inequality" refers to rebalancing the economy toward domestic consumption and initiatives to reduce urban-rural and inter-regional inequalities and "environmental sustainability" is both a product of the other measures and a distinct aim referring to changes in the energy supply and other environmental and climate policy initiatives.

China's economy has grown rapidly; its urbanization rates have increased substantially in recent years and are expected to increase even further. In addition, it has become the world's largest industrial producer, topping the world ranking in the production of major industrial products and China's industrial added value ranks second in the world. Fossil fuels, and in particular coal, play an important role in meeting this energy demand.

[31] Green F., Stern N, *China's changing economy: implications for its carbon dioxide emissions,* "LSE Research Online", 2016, Available at 10.1080/14693062.2016.1156515

[32] This summary definition of the 'new normal' concept is based on Stern's discussions with Chinese leaders and policymakers at the China Development Forum in March 2015. These four sub-themes are also apparent from key documents produced under China's new leadership over the last two years, such as those cited in the previous paragraph (cf Hu, 2015)

CHAPTER 2

The Chinese Energy Mix

Throughout the 1950s a predominant rural population used coal and biomass as energy source. Yet, during the Mao Zedong era (1949-1976), as the country embarked on an industrialization process and sought energy independence, its commercial energy industry grew rapidly. The Chinese oil industry was shaped: the corporate structures, the ambiguous relations between party, state and industrial actors, as well as the underlying principles guiding the industry, all originated during the Maoist era and remained after this time. Moreover, China made significant advances in energy exploration, extraction and transportation and conservation techniques.

Although its technological level was lagging behind that of developed countries, its most notable success was the development of hydroelectricity capacity. At the end of 1976, the aggregate installed capacity accounted for 36% of Chinese power production, a share higher than in other major of the 1968 and 1978 design, and coal production and oil output were expanding regularly while energy production grew at a staggering annual rate of 13% [33].

By the end of the Maoist era, China had become the world's third largest consumer energy, with industry accounting for 60 % of the Chinese energy demand, the transport sector for 7 % and residential and commercial sectors for 28 %.

On the eve of the 1978 reform and opening up, China was the fourth largest energy producer in the world, after the USA, Saudi Arabia and the Soviet Union. Its energy mix was more diversified than it had been in 1949, consisting of 75% coal, 17.5% oil, and 5.5% natural gas and 2% hydropower.

[33] Meidan M., *The structure of China's oil industry: Past trends and future prospects*, Oxford Institute for Energy Studies, 2016

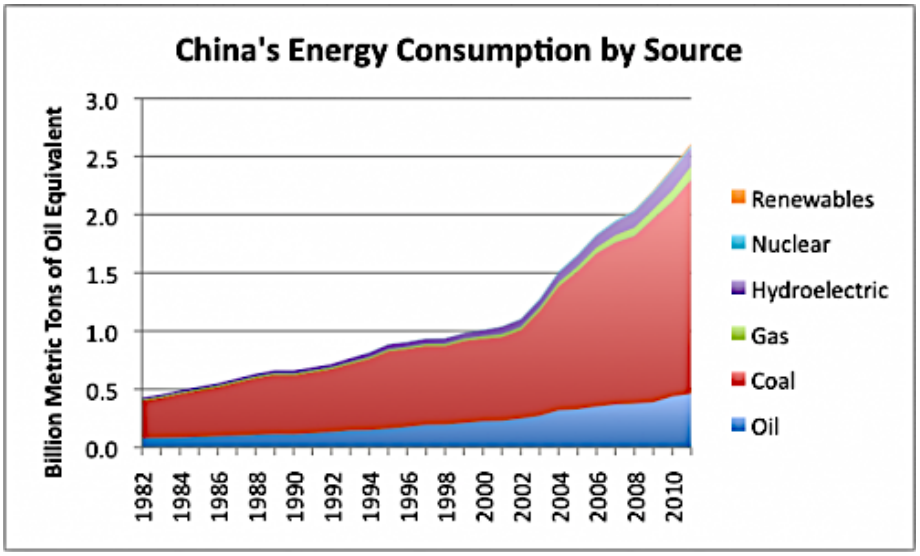


Figure 5: China's Energy Consumption by Source

Source: BP's Statistical Review of World Energy data. Available at https://www.bp.com/en/global/corporate/about-bp/statistical-review-of-world-energy-2012.html

In 1978, Deng Xiaoping, China's paramount leader after the death of Mao Zedong, initiated economic reforms that gave rise to decades of high economic growth rates and substantial change in energy production and consumption patterns throughout the country[34].

Today, China's total energy consumption increased from 1.470 million tons of coal equivalent (Mtce) in 2000 to 4.260 Mtce in 2014. Coal has dominated China's energy consumption since 2000, accounting for about 70% of total energy consumption up to 2009. From 2010 its share started to decline and dropped to 66% by the end of 2014. The share of oil in total energy consumption has been stable over this time period (between 18% and 19%).

In addition to fossil fuel production trends, the increase in demand for oil products, natural gas and electricity over the past two decades is striking. Coal use has been increasing steadily since the late 1990s, predominating the market, but oil and gas demand boosted as well.

[34] Meidan M., *The structure of China's oil industry: Past trends and future prospects*, Oxford Institute for Energy Studies, 2016

The combined government policy requirements for improving air quality and lowering CO_2 emissions have begun to drive an adjustment of the energy mix in China, with the aspiration of achieving a greener and more efficient energy system.

A series of reforms that emphasized relaxing central planning, introducing gradual market mechanisms and encouraging limited foreign participation in the economy have been implemented and a trend to replace coal by natural gas and non-fossil fuels (including hydro, nuclear and renewables) has began. For example, the contribution of natural gas to total energy consumption increased from 2.2% in 2000 to 6.2% in 2014 and the share of other energy sources increased from 6.4% to 10.7% over the same period.

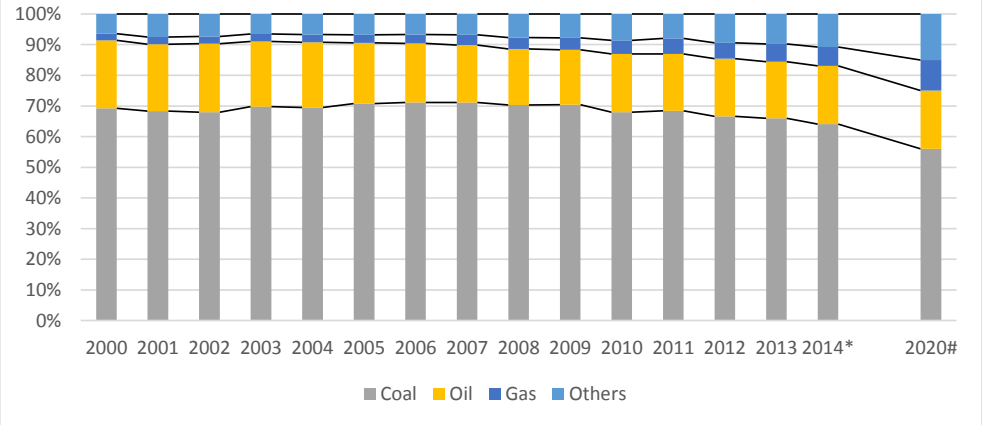


Figure 6: Share of energy sources in total energy consumption between 2000 and 2020

Source: National Bureau of Statistics website12 for data between 2000 and 2013; Own estimates for 2014 data based on National Bureau of Statistics (2015). Own estimates for 2020 data based on State Council (2014). Assumptions are made based on the future share of oil in total energy consumption remaining at 2014 levels (19%).

Energy security concerns have driven China to ambitious carbon mitigation policies. It is one of its overriding priorities, being strictly linked with economic development, poverty alleviation and social stability. Indeed, because the legitimacy of the Chinese Communist Party depends on its ability to deliver continued reform and development, the government's focus on energy security is not merely an economic necessity, but a matter of political survival.

Since 1994, domestic oil supply has not keep pace with demand and China has covered half of its oil demand by imports. As long as demand from transportation and petrochemicals increases, China's dependency on imported oil will increase to about 80% in 2030. But the Country is also increasing its dependence on coal imports as

domestic mining and transportation of coal and transmission of electricity from coalfields in the west cannot meet developing eastern countries' growing demand.

2.1 The Coal Challenge

"China's economic miracle is fuelled by cheap coal, like the western world's industrialization during the 20th century was driven by oil. The dominance of coal is one of the key reasons for China's exceedingly high energy intensity; coal is at the heart of China's carbon emissions and health related pollution problems" [35].

Coal plays a leading role in the energy industry of China. It accounts for more than two-thirds of the primary energy mix, followed by oil for one-fifth, hydropower for over 6% and gas for almost 3%.

Around half of all coal is used for power generation, accounting for nearly 80% of the total 4.980 TWh/year generated in the last decade (total generation from natural as and oil production was less than 2% while nuclear accounted for 1.2%) and the rest for the production of iron and steel.

China is the world largest producer and consumer of coal and it is also the largest user of coal- derived electricity.

Coal production

China is the largest coal producer in the world. It ranks first in terms of coal top quality and second in terms of total coal reserves behind the United States .

Most of its coal reserves are very far from the most populated coastal areas and this make coal availability and dislocation a serious problem. Hence, China has become a net importer of coal, due to the lack of efficient industrial sectors and transport infrastructure that make it difficult to carry coal from the northern to the southern regions.

Energy demand in China has increased exponentially during the last decades, with electric demand roughly doubled in 2013. In particular, Chinese coal demand had boosted so fast that it exceeded its production, which led to increased investments abroad.

[35] K. Hallding, G. Han and M. Olsson, the Commission on Sustainable Development, *A Balancing Act: China's Role in Climate Change*

The country's largest open-pit coalmine is located in Haerwusu, in the Inner Mongolia Autonomous Region. It started its production activity in 2008 with a forecasted output of 7 million tons in the fourth quarter of the year and it is estimated that it will operate approximately for 79 years.

The Asian superpower is also building coal-fired plants in other countries, such as Kenya, where the plant will be built by the state-owned Power Construction Corporation of China and other 11 African countries of which the combined capacity of the units is 42.5 GW – over eight times the region's existing coal capacity. In addition, Pakistan is committed to build as many as 12 new coal-fired power plants over the next years as part of a large infrastructure investment project that China and its partners are funding. About $33 billion will be spent on 19 energy projects that include coal-fired power plants, transmission lines, and other infrastructure as part of the China-Pakistan Economic corridor.

Since the 1980s a series of laws, measures and plans to face electricity shortage and failure of domestic oil production problems, were implemented at the national level stimulating coal production as the primary fuel. This increased at an average of about 6% per year between 1990 and 2012.

However, after the derogation of the Thirteenth Five-Year Plan (2016-2020), domestic coal production has been cut (dropping by 9% in 2016), as well as the percentage of coal in the energy mix. Declines in production were announced in July 2016, when the commission in charge of the state-owned enterprises (SASAC), ordered companies under its supervision to cut coal mining capacity by 10% in 2 years and by 15% in 5 years. Furthermore, the National Energy Administration (NEA) took strong actions to curtail the continued rapid construction of coal-fired power plants, issuing a directive curbing construction in many areas of the country. This was followed up in January 2017 when the NEA canceled a further 103 coal power plants, eliminating 120 GW of future coal-fired capacity, despite the resistance of local authorities.

Coal consumption

Nowadays, China burns 50% of the world's total coal consumption, more than the amount of the U.S., Russia and India combined. Due to the fast expansion of heavy industry and increased electrification of households and factories, coal consumption

increased by 40% since the beginning of the century, reaching the same amount as the total combined power demand of Germany, France and the UK.

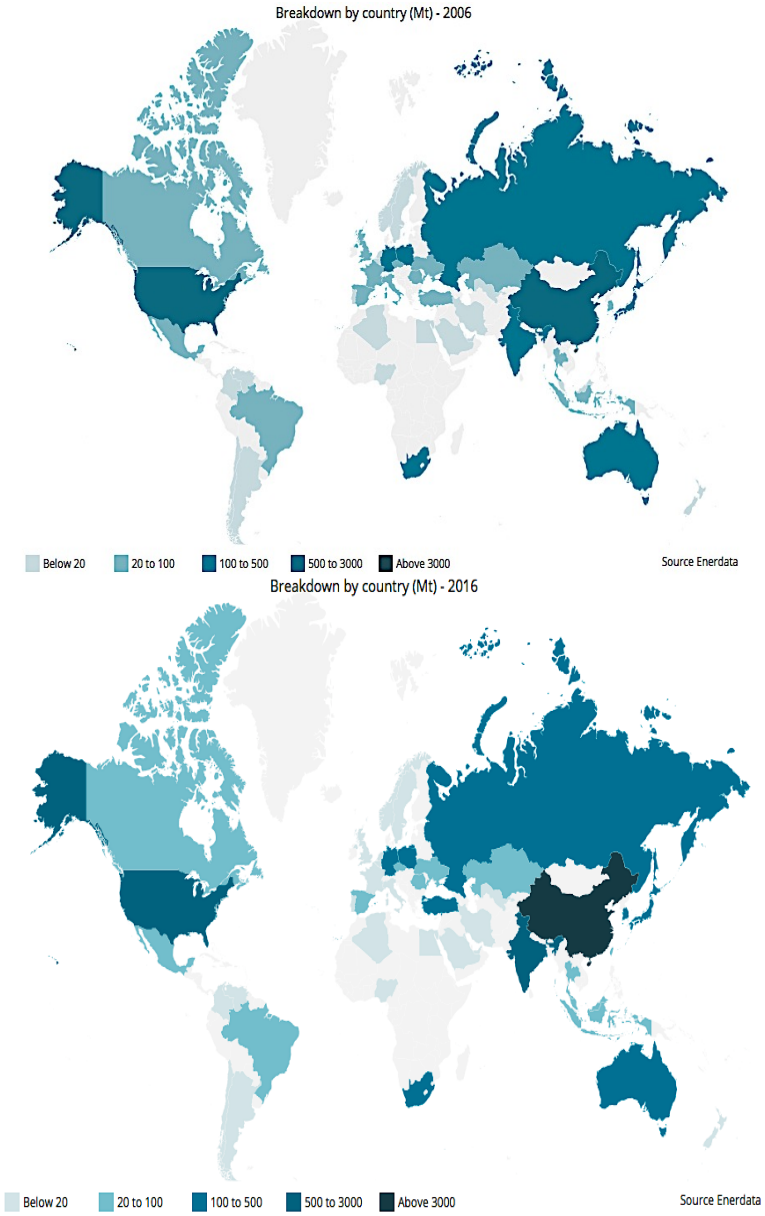


Figure 7: World Coal Consumption 2006-2016

Source: Enerdata

China's coal-fired generation capacity is expected to increase by 19% over the next years. Indeed, although the country has canceled some coal-fired capacity due to lack of demand growth, it still intends to increase its coal-fired power plants to almost 1.100 GW, which is three times the capacity of the United States.

About half of the coal is used directly in industry, for boiler, coking ovens or for on-site generation. Residential use has decreased from 20 to 4% during the last twenty years

because of the increase in the use of gas and electricity for household use and a little less than half of China's coal is used for generating power on the grid.

Efforts to reduce emissions

As soon as the coal sector continued to grow (the IEA projects overall growth by 25% up to 2030), it became clear that unchecked local mining had and would have had severe environmental, human safety and market consequences.

Coal is the dirtiest of the fossil fuels. It has a low energy content in relation to CO_2 release and it leads to harmful consequences both for the environment and people. Specifically, coal consumption is responsible for 90% of the SO_2 emissions, 70% of the dust emissions, 67% of the NO_x emissions, and 70% of the CO_2 emissions.

In 2013, China's CO_2 emissions from fossil fuel combustion, which accounts for about 85% of the total, was originated for 83% by coal, 14% by oil products and 3% by natural gas.

Although the shares of oil and natural gas are on the rise, the reliance of China on coal is one of the highest of all countries.

Official statistics report an average of 6000 miners' death every year because of mining accidents, in addition to other large numbers caused by mining-resulting diseases (the World Bank estimates around 350,000- 400,000 premature deaths a year), like cancer and birth defects.

Therefore, the development and deployment of clean coal technologies are crucial to promote sustainable development in China.

The leadership has well understood its importance and, through heavy investments in the R&D and the application of relevant technologies, it has pushed for renewal of the coal energy sector and invested for increasing its efficiency.

Since 2005, all new power plants are required to be built using new technologies and higher environmental precautions. The so-called ultra supercritical facilities have been launched and are starting to be built, reaching more than 45% efficiency, which in essence is equivalent to a 50 % efficiency improvement compared to the beginning of the century.

In 2007, it ordered the closure of more than 500 furnaces under 100 MW.

Another initiative was that of heating some 134,000 households with renewable energy or natural gas during the 2017 winter. Taiyuan, capital of China's coal hub Shanxi province, has imposed the ban of sale, transport and burning of coal by individuals and companies. The aim was cutting the use of coal by 2 million tons, or about 90% of the total consumption of the city for more than 3 million.

A similar change took place in many households in a slew of northern Chinese cities. The country burns around 300 million tons of coal for heating every year, that is around 7% of annual coal consumption according to China's National Bureau of Statistics.

The decision arose in September 2016, when researchers found that the winter heating policy had cut people's lifespan by more than three years due to cardiorespiratory disease such as lung cancer, compared with residents of southern cities.

Thus, China's Ministry of Environment selected Beijing, Tianjin and cities in Hebei province to begin switching to cleaner heating[36].

However, the ban has been relaxed soon because of a growing outcry from people left without a reliable energy supply due to gas shortages and surging prices since the onset of winter. Indeed, delays in setting up pipelines and severe supply shortages have left many people out in cold and, while coal has been banned in villages and communities, many residents have yet to be provided with an alternative.

The environmental campaign has helped push demand for gas to new highs, but a lack of storage and transport infrastructure means supply is failing to keep pace. As a result, the government would help energy companies to increase imports of natural gas via cross-border pipelines and liquefied natural gas terminals. Gas imports in the first 10 months of the year rose by 24.9% from the same period of 2016[37].

For now, not even supercritical coal power provides a long-term solution to the climate dilemma.

There are a few clean coal technologies currently being developed in China. The first type refers to high efficiency combustion and advanced power generation technologies (Fluidised Bed Combustion and supercritical boilers) and IGCC (Integrates gasification combined cycle) that are already in wide application. The second type is coal

[36] https://qz.com/1093898/chinas-putting-the-brakes-on-coal-for-heating-millions-of-homes-this-winter/

[37] http://www.businessinsider.com/china-is-relaxing-the-coal-ban-because-of-winter-temperatures-2017-12?IR=T

transformation technologies such as gasification and liquefaction technologies which are being prototyped and are in the demonstration phase. And the third type is Carbon Capture and Storage (CCS) technologies which are still being researched.

The latter technology has been studied in order to fill the gaps left by coal plant and to continue burning it without its current harmful impact. It could be not only a potential low-carbon coal alternative, but also offer commercial prospects for the Chinese energy business.

Unfortunately, this technology will not be available for full-scale application before 2020 or commercially competitive against other low-carbon alternatives before 2030.

2.2 The Oil and Gas Industry

The Oil industry was, first and foremost, shaped in the early 1950s by Mao's decision to industrialize the country and embrace the Soviet economic model.

Shortly after the Korean War broke out in 1950, the Coordinating Committee for Multilateral Export Controls declared an oil embargo on China, leading the country to rely on eastern European and Soviet exports. This led Mao to promote self-sufficiency by developing the country's oil resources.

Then, during the Sino-Soviet discord in 1959, Moscow decided to withdraw its assistance from the Chinese petroleum sector and the subsequent shortage of expertise and oil supplied, prompted Beijing to accelerate efforts to develop its domestic oil reserves and become self-sufficient[38]. That same year the country's first oilfield, Daqing, was discovered and priority was given to the allocation of machines and equipment. In addition, a semi-autonomous economic and political unit was set up, in charge of providing facilities and a welfare system to employees in and around the oil production sites. As a result, the share of oil in the Chinese energy mix grew and oil became an important pillar of the Chinese energy industry and economy.

China is now the world's largest oil consumer and importer. While this gives the country significant clout in the global oil market, its weight is compounded by the fact that in 2013 it was also the world's fourth largest oil producer, after Saudi Arabia, the USA and Russia.

[38] Meidan M., *The structure of China's oil industry: Past trends and future prospects*, Oxford Institute for Energy Studies, 2016

China's oil sector has been dominated by three large state-owned oil companies that have been developing the country's domestic reserves, building and operating pipelines, managing increasingly sophisticated downstream, and filling its strategic petroleum reserves. These companies employ millions of workers; enjoy ministerial status and close connections to the top leadership. Over the years, as China's demand has exceeded production, these companies have also become major investors in the global upstream and established their presence in global refining and oil trading.

Yet, despite China's growing international reach, its oil sector remains heavily dominated by the Chinese state.

From a majority stake in the oil companies, through price setting and diplomatic support for outbound investments, the government maintains significant influence over commercial decisions. At the same time, the technical knowhow and market expertise of the National Oil Companies offer them an important role in policy-making. This relationship is poorly understood, but it is now set to evolve further, alongside government efforts to gradually liberalize the energy sector and reform its state owned giants.

Concerning gas industry, the transition between 2013 and 2014 represents a milestone for China's gas market[39]. In June 2013, a market-oriented gas pricing reform was implemented in order to alleviate the losses caused by the price distortion and to make imported price fit into the cost-plus pricing mechanism. On May 2014, the decade-long negotiation with Russia on gas supply finally reached an agreement. Gazprom will provide 38 Bcm/ year from East Siberia to China's Bohai Bay region for a period of 30 years from 2018[40]. The long-term large-scale pipeline gas supply to the coastal regions is aimed to help to alleviate the gas shortage in China's wealthy regions, but could also have a significant impact on the potential LNG supply to the Bohai Bay gas markets[41].

Six months later, the Altai deal, between Beijing and Moscow, was signed.

This will benefit China' resources diversification and Russia's export market and reliance on Europe.

[39]Li X., *Natural gas in China: a regional analysis,* The Oxford Institute for Energy Study, 2015

[41] Paik (2015)

On the demand side, the annual growth of gas suddenly dropped to 8.3% in 2014 after a decade due to several factors. First, the growth of China's primary energy consumption had decreased to its lowest level since 2000 with an annual growth rate of 2.6%, because the Chinese economy has entered into the "new normal" phase, which has a lower growth rate but represents a more sustainable pathway. Second, the competitiveness of gas has diminished due to the plunge of oil and coal prices in the context of the recent gas pricing reform. However, while gas has suffered on a pure price competitive basis, the effort to mitigate severe environmental pollution, caused by the excessive use of coal, is of huge significance.

Oil and Gas production

China's oil production underwent three main stages: the first was the discovery of Chinese oilfields in the late 1950s and early 1960s, which allowed significant increases in production. The second was in 1979, when production slowed down unexpectedly and the third took place when production showed signs of renewed strength in 1983-4.

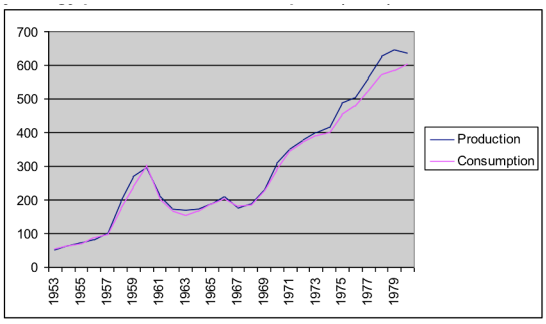


Figure 8: Primary energy production and

Source: *Energy in China,* Ministry of Energy, the People's Republic

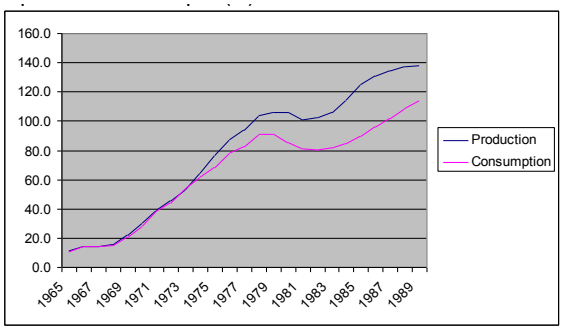


Figure 9: Oil production and consumption

Source: BP *Statistical Review 2011* of China, Beijing: 1989, pages 78-9

The largest oil field in China is located 210 km southeast of Hong Kong in the Pearl River Mouth Basin offshore. It was discovered in January 1987 but water depth, the presence of heavy oil and a very strong bottom-water drive were among the technical challenges that had to be resolved before the oil could be extracted.

Despite China is the fourth largest oil producer outside the Middle East, with the current energy needs it covers a great percentage of its oil demand from imports. Indeed, producing only 4 million barrels per day, China relies massively on the international

market for its oil supply (7.59 million barrels of crude oil per day in 2016, with an increase of 13.6% over 2015, according to the Chinese Customs) and this dependence is not expected to decrease. Rather, it is predicted to increase up to 12 million barrels a day by 2020 and, by 2030, 80% of China's crude oil supply is supposed that will be imported.

Differently, demand for natural gas is met partly by shale gas production, partly by imports by pipeline and in the form of liquefied natural gas (LNG), as well as from domestic sources including tight gas, coal-bed methane and others.

Water scarcity is the main obstacle to meeting production targets.

For this reason, by 2010 total imports had reached 9.3 billion cubic meters. Australia (48%) and Indonesia (18%) account for the majority of LNG supply, albeit China has the largest technically recoverable shale gas resources in the world, amounting to some 25.1 trillion cubic meters[42].

Pipelines also play an important role for the natural gas trade of China. Turkmenistan is the largest supplier of natural gas, accounting for more than half of total imports.

In 2014, China signed an agreement with Russia to import natural gas worth USD 400 billion over a period of 30 years (to deliver about 38 billion cubic meters of gas per year from 2018). But the most recent pact is the one between China's biggest state oil company Sinopec and Alaska.

Alaska LNG is designed to carry natural gas from fields in the North Slope through an 800-mile (1,287 km) pipeline to south central Alaska for in-state use and to a liquefaction plant to produce up to 20 million tons of LNG per year for export.

Sinopec will buy some of the LNG and may supply engineering work for the project's construction, Bank of China will provide funding and China Investment Corp may take an equity stake, while the Alaska Gasoline Development Corp (ASDG) will remain a majority shareholder.

Alaska aims to shore up its oil and gas sector, which has struggled to compete with lower-cost shale projects in states such as Texas. Securing a Chinese customer, lender and investor would help Alaska overcome a multi-billion dollar budget deficit and create jobs. The LNG will meet China's growing appetite for cleaner-burning fuels as the government tries to wean the country off coal to reduce air pollution.

[42] IEA, 2012b

Oil and Gas consumption

China is the world's top crude oil consumer and importer.

Oil accounts for just over one-fifth of China's energy demand, a share that has only marginally increased since the early 1990s. Its production has shown a steady boost between 1990 and 2012, growing at about 1.8% per year, while natural gas production has increased by 9.3% per year on average.

China's oil demand has doubled over the past decade, with a particularly significant boost between 2000 and 2005 when demand for oil reached one-quarter of the total. For each day of 2016, the Country consumed 11.5 million barrels of oil, over a half million barrel increase from 2015, according to the annual report released by China Petroleum and Chemical Industry Association (CPCIA)[43].

Industry is the biggest oil consumer, but in addition to the boom of heavy industry and power shortages, oil demand was stimulated by an increase in the number of vehicles on the road transportation.

Natural gas, differently, accounts for 6% of energy demand.

A number of studies have addressed the natural gas consumption in China from national perspective. However, for a country as large as China in terms of population and geographic extent, any analysis of natural gas market development needs to capture its regional variations.

China's regions have very distinctive features in terms of gas supply and demand.

First, natural gas resources are unevenly distributed and often remote from the demand centers. Second, different regions have distinctive gas consumption patterns.

China has tried to extend the use of natural gas both through expanded domestic production and through increased imports since 1990s and today, it is the fastest growing major fuel, with demand quadrupling in the past decade.

[43] https://www.export.gov/article?id=China-Oil-and-Gas

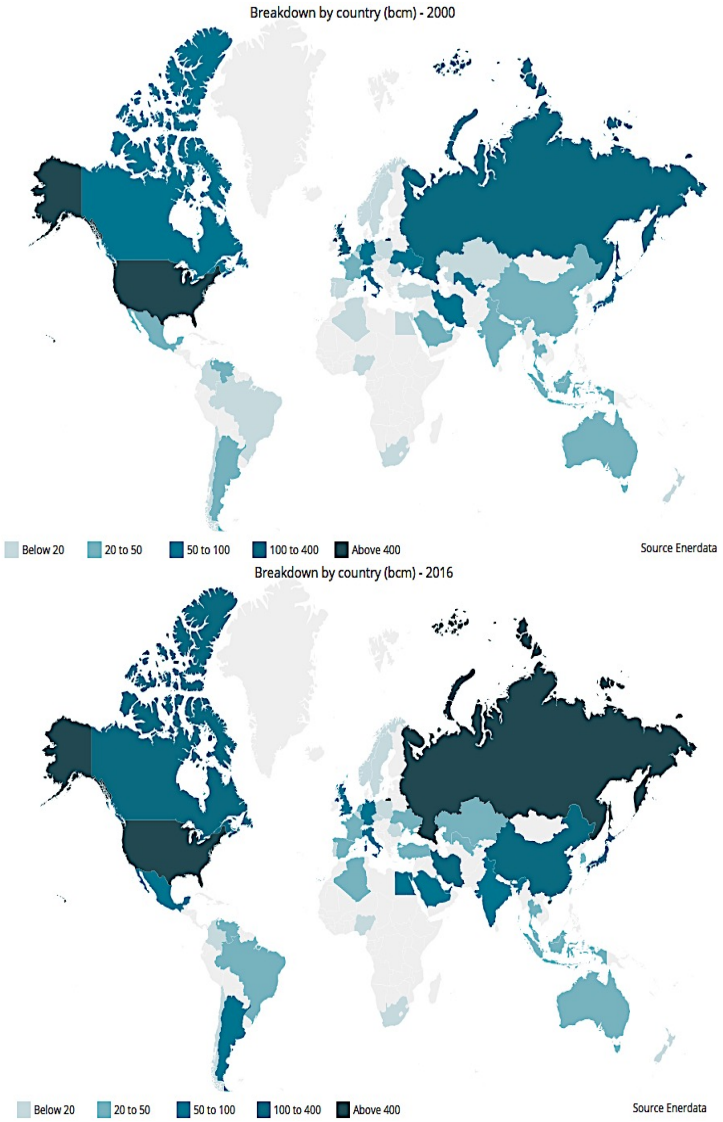


Figure 10: World Oil consumption 2006-2016

Source: Enerdata

In 2016, China's consumption of natural gas grew by 6.4% , reaching 224 billion cubic meters[44]. Of this quantity, 150 billion cubic meters had been produced domestically, highlighting a rise in imports that is expected to increase steadily in the long run, with a view to the government's plan to replace coal with cleaner and more efficient natural gas in power generation.

[44] https://www.export.gov/article?id=China-Oil-and-Gas

2.3 The Nuclear Industry

Due to increasing concern about air quality, climate change and fossil fuels shortages, the government has prioritized the development of nuclear power during the recent years. Indeed, although nuclear plays a marginal role in the national energy mix, it is important in coastal areas that are remote from the coalfields and where the economy is developing rapidly. In fact, most nuclear power plants are located on the coast and they generally use seawater for cooling a direct once-through cycle. The *New York Times* has reported that China is placing many of its nuclear plants near large cities, and there is a concern that tens of millions of people could be exposed to radiation in the event of an accident. China's neighboring Guangdong and Lingao nuclear plants have around 28 million people within a 75-kilometers radius that covers Hong Kong.

China ranks fourth worldwide for total nuclear power capacity installed and third for nuclear power generated.

In March 2008, the newly formed *Sate Energy Bureau* (SEB) set a target of doubling the nuclear share of power generation from 2.5 to 5% by 2020. Nevertheless, there were interruptions and delay due to the Fukushima accident in 2011. The challenges to nuclear energy in China mainly include public awareness and acceptance, lagging behind in relevant technologies and lack of nuclear waste treatment.

China's National Development Reform Commission has indicated the intention to raise the percentage of China's electricity produced by nuclear power from the current 2% to 6% by 2020 (compared to 20% in the USA and 74% in France), with the aim to maximize self-reliance on nuclear reactor technology, manufacturing and design, although international cooperation transfer are also encouraged. China is also involved in the development of nuclear fusion reactors through its participation in the ITER project, having constructed an experimental nuclear fusion reactor, as well as research and development into the thorium fuel cycle as a potential alternative means of nuclear fission.

China has two major nuclear power companies, the China National Nuclear Corporation operating mainly in the north-east region and the China General Nuclear Power Group, operating mainly in south-east China. Nuclear power contributed fro 3% of the total

production in 2015 and is the fastest-growing electricity source, with 29% growth rate over 2014.

From A Large Greenhouse Gas- Emitting To A Low-Carbon Nation

Since the 1990s, China has been a major producer of greenhouse gas emissions, and its proportion of the world's carbon dioxide emissions has rapidly increased: 8.08 % in 1980, 11.3% in 1990, 19.16% in 2005, when it surpassed the U.S. as the largest emitting country. This high ranking is mainly due to the size of its population and current economy, but also because of the large share of coal in its energy mix, as it has far greater coal reserves than those of oil and gas.

Today, China is the world's largest emitter of carbon dioxide and organic wastewater discharge, as well as the nation with the largest annual loss of natural assets. It is faced not only with enormous pressure from the international community to reduce greenhouse gas emissions, but also with very serious ecological challenges, including desertification, rocky desertification, serious soil erosion, and degradation of ecosystem functions. It can no longer follow the former Soviet-style model of heavy industrialization with its high-energy consumption, pollution emissions and low resource efficiency; also, it cannot imitate the modern mode of high consumption, high expenditure of resources and pollution emissions applied in Western countries. The only viable way forward is be inventive and to innovate the path of green development.

China's policymakers are putting a new emphasis on energy efficiency, conservation, renewable energy, and the shift toward natural gas as the principle primary energy source, in the place of coal and oil[45].

The decrease in the annual trend of 2015 is unprecedented and is a sign of decoupling from economic growth. Annual GDP growth was also slowing down, but remained still positive (from 10% per year before 2012 to about 7% per year 2013-2015). A key factor for this change in CO_2 emissions was the decline in coal consumption, caused by the shift from manufacturing to a more service-oriented economy. Moreover, for the 10th consecutive year, China added more newly installed hydropower capacity than the rest of the world combined.

[45] Cao and Bluth, 2013

Toward sustainability, the Chinese government has taken measures such as legislation for energy conservation and renewable energy development, shutting down of low-efficiency small plants in the energy-intensive industries, further raising of energy efficiency standards for transports and buildings, and granting incentives to alternative fuel and hybrid vehicles and imposition of energy consumption taxes.

China, in particular, is emerging as a leader in building renewable energy industries and advancing the frontier of resource efficiency technology. After all, the conventional view has been that it would be the most advanced countries that would be supplying the technologies needed to clean up the planet. The fact that in many ways it is the latecomers like China that are taking the lead, while the advanced countries remain locked in by their carbon investments, is at odds with this conventional view.

As the 21st century continues, we clearly recognize that the world's fourth industrial revolution, the so-called green industrial revolution, has arrived, with its goals of substantially improving resource productivity, reducing pollution emissions and decoupling economic growth and carbon emissions.

During the first decade of 21st century, China became an instigator and then a participant, innovator and practitioner of this global green industrial revolution. It took on board green development planning, implemented a green development strategy and took a series of innovative measures to achieve the goal of green modernization.

The question is one of survival as human development reaches a new crossroads: which path will the World follow? What role will China play? The only correct answer is to resolutely develop an ecological civilization.

CHAPTER 3

Decoupling economic growth and carbon emissions – the Kaya identity

Since the Industrial Revolution, modern economic growth has caused high levels of pollution and resource usage, as all economic activity requires energy and, to the extent this energy comes from fossil fuels, its use results in emissions of carbon dioxide[46].
Human activities in this growth model are driving the Earth's system beyond its safe operating space[47] and the past few decades, in particular, have seen explosive growth in GHG emissions. Suffice it to think that, as reported by the Intergovernmental Panel on Climate Change[48], half of all CO_2 emitted from 1750 to 2010 have been produced in the last 40 years[49].
This serious problem affects the world as a whole and, as such, global combined efforts have become a priority to slow down the current environmental degradation and mitigate global temperature. To achieve this goal, green growth has become the ultimate solution for climate change thanks to a combination of factors, such as low levels of carbon emissions, material resource use and a low environmental footprint[50].

As the second largest global economy and the biggest annual carbon emitter in the world, China is highly responsible in this fight and it must implement major efforts towards CO_2 reduction to solve the global climate change problem.
The Country's endeavor to mitigate carbon emissions was initially driven by international pressure; however, since the beginning of the 21st century, the country's increasing awareness about the unfeasibility and unsustainability of its current growth pathway led to the shift of low-carbon motivation based on the country's own interests.
In this chapter, China's future options for decarbonization are discussed, through the use of the Kaya identity first and of three of the main current scenarios at a second stage.

[46] Deutch J., *Decoupling economic growth,* "Joule", Elsevier Inc.,2017
[47] Rockstro¨m et al., 2009
[48] IPCC, 2014
[49] Yongsheng Zhang, *Reformulating the low-carbon green growth strategy in China, Climate Policy*, 15:sup1, S40-S59, 2015, Available at 10.1080/14693062.2015.1094726
[50] World Bank & DRC, 2012

3.1 Reducing carbon intensity

The former US President Obama, before leaving office, highlighted the importance of "decoupling" energy sector emissions from economic growth[51].

Decarbonization can be expressed as a product of two factors: specific carbon emissions per unit energy and energy requirements per unit value added, often called energy intensity. Nowadays, the economic system witnesses a gradual reduction of both factors, outpaced, however, by the rate of economic growth, which would ultimately result in an overall global increase in energy consumption and carbon dioxide emissions. However, in the article "The Irreversible Momentum of Clean Energy", President Obama, contrarily to projections, reported that during his presidency (2008 – 2015), CO_2 emissions from the energy sector decreased by 9.5% while the economy grew by over 10%, according to statistics of the 2017 Economic Report of the President[52].

To analyze this ''irreversible trend'' and ''decoupling'', the most instructive tool is the Kaya identity, which establishes a connection between emissions and economic growth[53].

The Identity was named after the Japanese energy economist Yoichi Kaya and it relates population growth, per capita value added, energy per value added and carbon emissions per energy, with total carbon dioxide emissions, through the formula:

$$\Delta CO_2 = \Delta\frac{CO_2}{TPES} + \Delta\frac{TPES}{GDP} + \Delta\frac{GDP}{POP} + \Delta POP$$

Which means that:

$$\Delta CO_2 = Carbon\ intensity + Energy\ intensity + GDP\ per\ capita + Population$$

The Kaya identity decomposes the linkage between economic growth and carbon emission in two ratios: energy intensity ($\Delta\frac{TPES}{GDP}$), which is the amount of energy needed

[51] Obama, B. (2017). The irreversible momentum of clean energy. Science 355, 126–129

[52] Obama refers to data presented in the 2017 Economic Report of the President, ERP, Chapter 7, Addressing Climate Change, p. 424; available at: https://obamawhitehouse. archives.gov/administration/eop/cea/ economic-report-of-the-President/2017.

[53] Deutch J., *Decoupling economic growth,* "Joule", Elsevier Inc.,2017

to produce a unit of GDP and carbon intensity $\left(\Delta\frac{CO_2}{TPES}\right)$, which is the amount of CO_2 emitted to produce a unit of energy.

Energy intensity declines, for example, when higher energy prices cause firms to make energy efficiency investments that reduce the amount of energy needed to produce products, whereas carbon intensity decreases, for instance, when utilities shift from coal to natural-gas-fired generation, because coal emits almost twice as much CO_2 per kWe-hr as natural gas.

To understand how this Identity can be used in countries' reality, we observe Table 1 and Figure 1, which present data both for the time period 2008-2015 and the future period 2015-2040 in the U.S. and in China, the largest global economies.

As we can deduce, from the first to the second period, the United States improved energy (from -2.2% to -2.0% annually) and carbon intensity (from -0.7% to 0.2 % annually) sufficiently to enjoy modest economic growth (from +1.4% to + 1.7% annually) and reduced emissions (from -1.4% to -0.2 % annually).

Contrarily, China and the world only slowed down the percentage of growth of carbon emissions that, however, continuous to be positive (by 3.3 % for China and 0.5% for the world).

Indeed, while both carbon and energy intensity improved in China and globally, this improvement was insufficient to reduce carbon emissions over the period[54], also due to a decrease of economic growth (from 11.1 to 4.6 % per year for China and from 5.3 to 2.4 % per year for the globe).

According to the Identity, emissions derive by the addition of energy intensity, carbon intensity and GDP.

Therefore, by using the Kaya Identity with data in Table 1, we can highlight a decrease of CO_2 emissions, although the value continuous to be positive.

54 *Decoupling Economic Growth and Carbon Emissions,* John Deutch, Joule 1, 3–9, September 6, 2017

$$\Delta CO_2 = Carbon\ intensity + Energy\ intensity + GDP\ per\ capita + Population$$

$$\underline{\text{PAST}}: \Delta CO_2(\%\ of\ the\ whole\ period) = -11.2 - 21.6 + 77.7 = 45.34$$

$$\Delta CO_2(\%\ of\ the\ annual\ period) = -1.6 - 4.6 + 11.1 = 4.9$$

$$\underline{\text{FUTURE}}: \Delta CO_2(\%\ of\ the\ whole\ period) = -20 - 70 + 115 = 25$$

$$\Delta CO_2(\%\ of\ the\ annual\ period) = -0.8 - 2.8 + 4.6 = 1$$

Fractional changes	**Recent Past: 2008 – 2015**			**Future: 2015 – 2040**		
	US	*China*	*World*	*US*	*China*	*World*
GDP per capita %	9.8	77.7	37.1	42.5	115	60
GDP annual %	(1.4)	(11.1)	(5.3)	(1.7)	(4.6)	(2.4)
$\frac{\text{Energy use}}{\text{GDP}}$ %	-15.4	-21.16	-23.1	-50	-70	-47.5
$\frac{\text{Energy use}}{\text{GDP}}$ annual %	(-2.2)	(-4.6)	(-3.3)	(-2.0)	(-2.8)	(-1.9)
$\frac{\text{Carbon emission}}{\text{Energy use}}$ %	-4.9	-11.2	-2.1	-5	-20	-10
$\frac{\text{Carbon emission}}{\text{Energy use}}$ annual %	(-0.7)	(-1.6)	(-0.3)	(0.2)	(-0.8)	(-0.4)
Carbon emissions %	-9.8	30.1	10.5	-5	25	25
Carbon emissions annual %	(-1.4)	(4.3)	(1.5)	(-0.2)	(1.0)	(1.0)

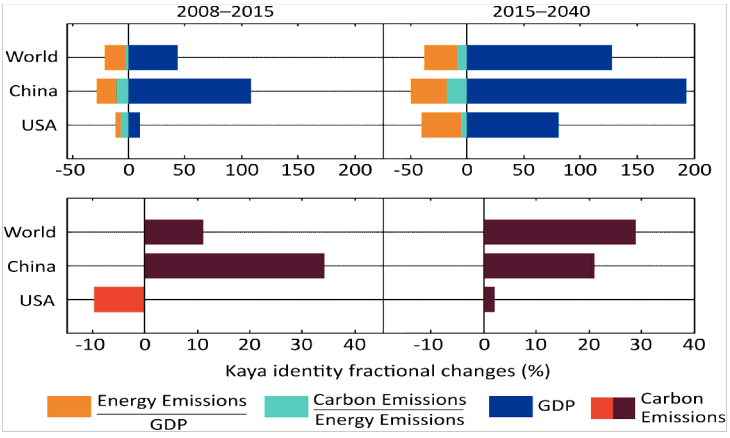


Table 2: Kaya identity Relations in Two time periods

Data sourced from Ref [55]. All quantities in parentheses represent the annual average % change over that time period.

[55] Sources for Table 2: All data are drawn from the EIA International Energy Outlook for 2011 and 2016, with the exception that data for the United States in the time period 2008– 2015. Kaya factor projections are found in Annex H and J of the 2011 and 2016 IEO. Data for the United States in the time period 2008–2015 comes from the IEA Annual Energy Outlook of 2011 and 2016; the IEA Annual Energy Outlook was sourced by The Council of Economic Advisors report: The Economic Record of the Obama Administration: Addressing Climate Change, September 2014, makes a similar point in its analysis. See, especially Figure 27, p. 49.

Figure 11: Kaya identity relations in two periods of time

For the United States, the Kaya identity allows only an annual 1.2 % decline in CO_2 emissions from more ambitious decarbonization assumptions of a 0.5 % decrease in carbon intensity, a 2.6% decrease in energy intensity, and 2% annual economic growth. If a trend as favorable as the annual 1.4% decline in CO_2 emissions experienced during 2008–2015 (a period of tepid economic growth) continues until 2050, CO_2 emissions in 2050 would be 56% below 2005, far below 80% mid-century Obama administration target.[56]

However, for emerging economies like China, now the globe's largest greenhouse gas emitter, the Kaya identity presents a different stark reality. China in its submission to the Paris Accord pledged to reduce CO_2 emissions per unit GDP by 60%–65% from 2005 levels by 2030 (an annual rate of 4.1%–4.7%). At the pace indicated in Table 1, China may well meet this target but at the expense of a lower economic growth average of 6% per year, which does not align with the economic goals of the Chinese government.[57]

The Kaya decomposition shows that the extent of "decoupling" economic growth and emissions depends entirely on reduction in energy and carbon intensity[58].

Indeed, as we can deduce, and see in Table 2, all the other socio-economic parameters of the Identity are set either directly or indirectly, or as exogenous inputs[59].

[56] United States Mid-Century Strategy for Deep De-carbonization, The White House, November 2016. https://search.archives.gov/search?query=Deep+ Decarbonization&op=Search& affiliate=obamawhitehouse.

[57] Fergus Green & Nicholas Stern, China's Changing Economy: Implications for its Carbon Dioxide Emissions, Climate Policy, http://dx.doi.org/10.1080/14693062.2016. 1156515 forecasts Kaya parameters for China's energy future See Table 1, page 13.

[58] Deutch J., *Decoupling economic growth,* "Joule", Elsevier Inc.,2017

[59] Grubb M., Sha F., Spencer T., Hughes N., Zhang Z., & Agnolucci P., *A review of Chinese CO_2 emission projections to 2030: the role of economic structure and policy,* Climate Policy, 15:1, S7-S39, 2015, Available at http://www.tandfonline.com/doi/full/10.1080/14693062.2015.1101307

Kaya element	Partial equilibrium approach	General equilibrium approach
CO_2 emissions	Constrained directly	Constrained directly, or indirectly via environmental parameters
Population	Defined exogenously	Defined exogenously
Energy demand	Defined exogenously, though can vary with own price elasticities	Generally linked to economic activity and price elasticities in the model
GDP	Defined exogenously	Usually a baseline exogenous assumption that is then impacted by mitigation policies as a key output[a]
Carbon intensity of energy	Varies endogenously	Varies endogenously

Table 3 : isolated study of the Identity's variables

Thus, with the purpose of cutting emissions, carbon intensity is the variable that should be given more emphasis.

China, for instance, had a rapid emissions growth in the 2000's at around 8% per year and this has gradually declined to zero growth in 2015.

In Figure 12, the recent slowdown in Chinese emissions growth (black line) is due to lower economic growth (green) and improvements in both energy intensity (purple) and carbon intensity (orange), with the latter largely due to an increase in non-fossil energy sources, like wind, solar and hydropower.

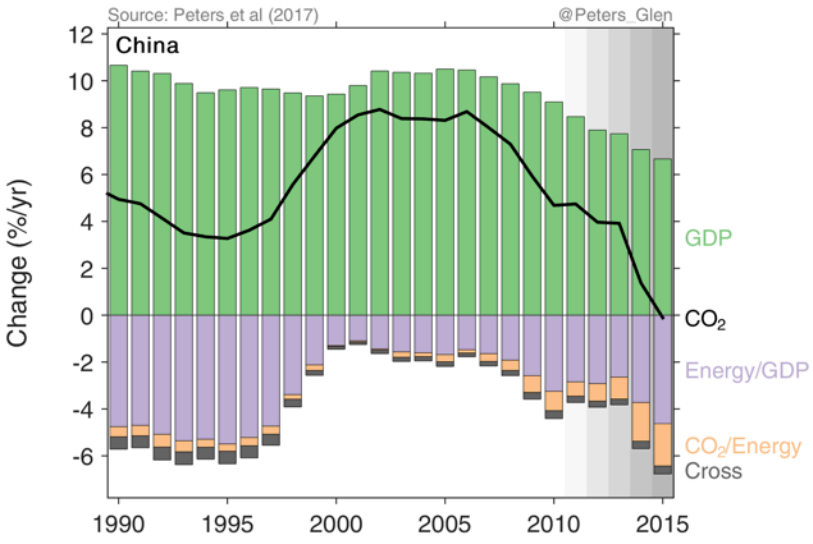


Figure 12: The growth in economic activity (green), energy intensity (purple), and carbon intensity (orange) sums to the growth in carbon dioxide emissions from fossil fuels (black line). To show longer term trends, the data is smoothed using an 11-year window, which reduces in length towards 2015 (grey shaded vertical bars).

The Chinese emissions growth slowed because of the simple fact that growth in coal consumption has stopped. In fact, coal consumption declined at around 1% per year on average since 2013, which is in strong contrast with the rapid growth of around 10% per

year in the 2000's.

Oil and gas have continued to grow strongly, as well as non-fossil energy sources, dominated by hydropower, with nuclear, solar and wind that have grown considerably, albeit from a low level.

The Chinese emissions story is really a coal story. The country has pledged to peak its carbon dioxide emissions before 2030 and to improve its emission intensity by 60-65% in 2030 relative to 2005 levels, which corresponds to about 3-4% per year improvements.

China's emissions will peak when economic growth balances with improvements in emission intensity. Since economic growth is lower than expected and emission intensity (energy intensity + carbon intensity) exceeds the required 3-4% per year declines, it is quite possible that it will meet its emissions pledge much earlier than expected.

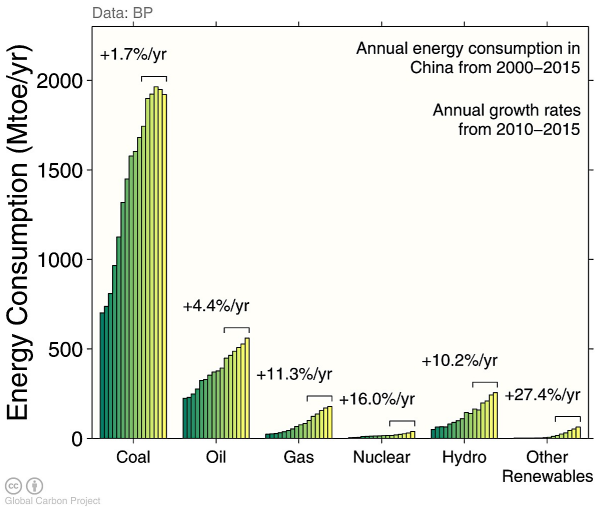


Figure 13: A simplified Kaya Identity decomposition of energy consumption in China, with smoothed data to remove annual fluctuations. Growth in energy consumption (black line) is the balance of growth in economic activity (GDP, green) and declines in energy intensity (purple). It is primarily lower GDP growth that explains the lower energy consumption growth.

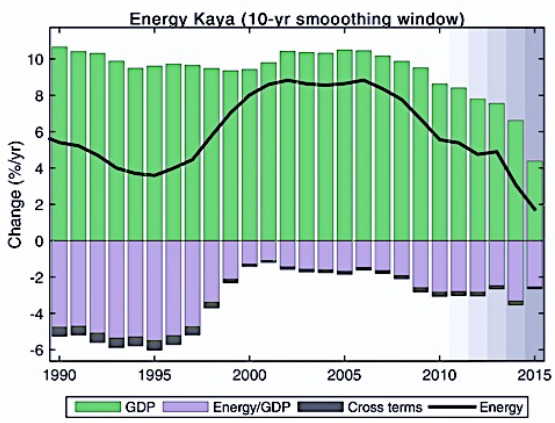


Figure 14: Primary energy consumption is dominated by coal in China,
and coal is behind the 2000's growth and the 2010's slowdown.
All other energy sources are growing fast, but from lower levels.

Given the size of complexity of China and global energy infrastructure, a stable policy is to guide public and private investments for the innovation necessary to develop, demonstrate, and deploy low carbon technologies in priority areas such as energy efficiency; smart electricity distribution systems; CO_2 capture utilization and disposal; energy storage, especially batteries; and increase in the uptake of CO_2 by the terrestrial biosphere.

3.2 From carbonization to decarbonization? Past trends and future scenarios for China[60]

Along the lines of the Kaya identity, a decomposition analysis of historical and projected emissions data for China is performed and confronted with the results of the reduction requirements implied by globally cost-effective mitigation scenarios.

By applying an enhanced Kaya decomposition method, it is also shown how the persistent increase in the use of coal has caused carbon intensity to rise throughout the last decades and how the future energy system developments will be influenced.

The result will be the reaffirmation of China's indispensable role in global efforts to implement one of three exemplary stabilization targets (400, 450 or 500 ppm) and underscore the increasing importance of carbon intensity for the more ambitious targets.

Decreasing energy intensity has primarily contributed to decelerating emission growth in the last decades of the 20th century, while a reversed trend of energy intensity and a continuous carbonization and fast growing economy were responsible for China's accelerated emissions growth in the first decade of the 21st century. Indeed, exploiting coal had a significant impact on the country's emission growth as compared to other transitional countries, industrialized countries and the global average, but it constituted the main driver behind Chinese increasing emissions.

Under business-as-usual assumptions, China's emissions could increase about threefold by 2050, underlining its status as a crucial actor in global mitigation efforts. In fact, in a

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[60] Steckel, J., M. Jakob, R. Marschinski, G. Luderer (in press): *From Carbonization to Decarbonization? – Past trends and future scenarios for China's CO2 emissions*, "Energy Policy", Available at 10.1016/j.enpol.2011.03.042

globally cost-optimal scenario aiming at stabilization of atmospheric CO_2-concentrations at 450 ppm, China's emissions would be 43% lower than in the baseline. In addition, reversing the trend in carbon intensity is essential for transforming the energy system, with renewable energies identified as the most important option for decreasing carbon intensity, followed by the smaller roles of biomass, nuclear energy and CCS expansion.

3.2.1 China's carbon emissions in retrospective

Considering the time-series of the standard Kaya factors (population, GDP per capita, energy intensity per GDP and carbon intensity of energy) the evolution of China's energy-related emissions between 1990 and 2015 can be investigated.

In order to determine the characteristics of historical emission dynamics, data are confronted with world and OECD countries' averages and an aggregate of six newly industrialized countries (NIC), including Brazil, India, Indonesia, Mexico, South Africa and South Korea. At the starting point of the analysis, the NIC aggregate had a total population nearly on par with China's and GDP and emissions per capita were also of similar magnitude.

China and NIC have followed a similar general trend of per-capita CO_2 emissions until the early 2000s, when emission growth in China accelerated substantially. Moreover, for both China and NIC the evolution of carbon intensity of energy has been characterized by an upward trend, albeit with a much faster overall rise and higher base level in China. Indeed, the countries' carbon intensity were initially below the world average, a persistent rise in China and the negative trend in the world average has driven Chinese carbon intensity above the global and OECD average by the early 1980s, while NIC's carbon intensity converged towards global and OECD levels. Today, China's carbon intensity is about 40% higher than global and OECD averages.

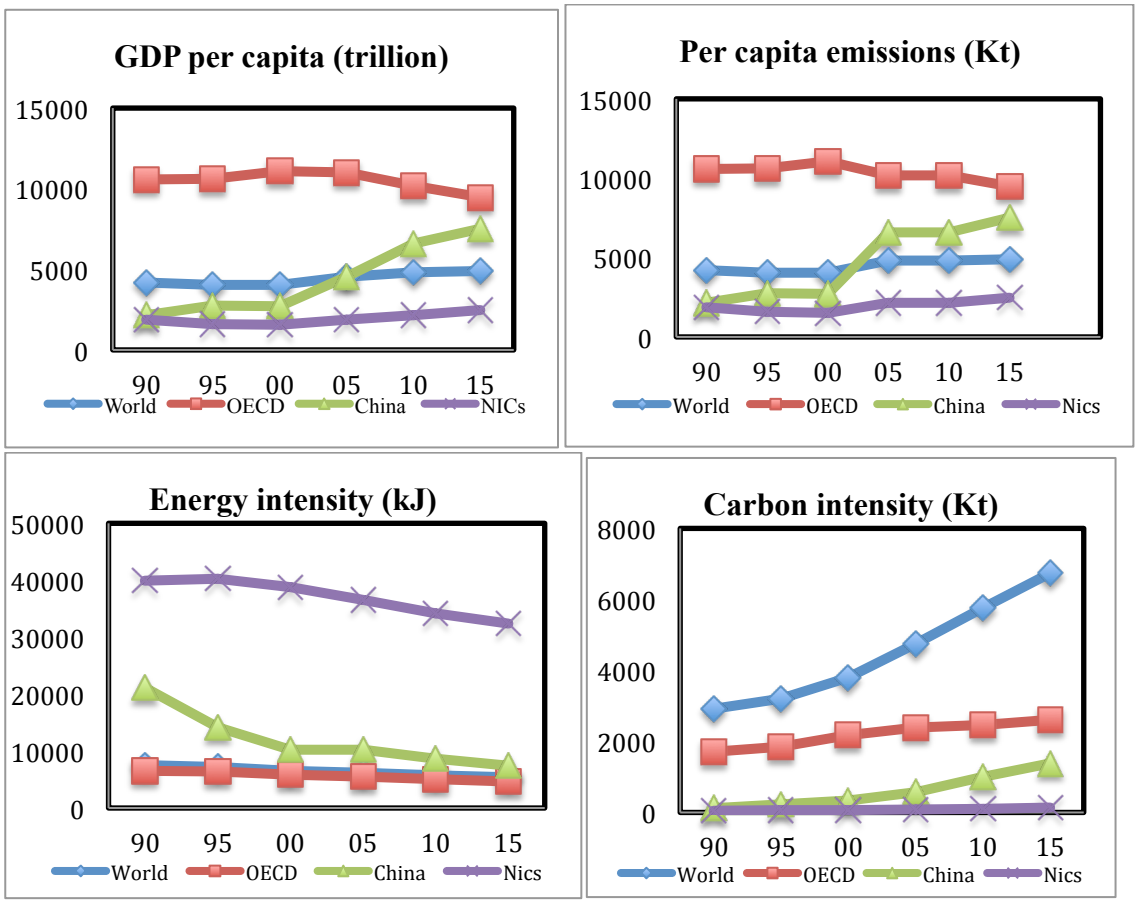

Figure 15: Key indicators of the Chinese economy compared to values for OECD, NIC and the world average. NIC represents an aggregate of Brazil, India, Indonesia, Mexico, South Africa and South Korea

Source for data: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD

China, as compared to NIC, was actually quite an average country also in the past, except for the persistently high growth of GDP until today, and its dramatically high initial energy intensity that fell dramatically until 2000. With regard to CO_2 emissions, energy intensity boosted resulting in the well-known Chinese per-capita increase and absolute emissions.

The last 25 years have been characterized by the general trend of steadily increasing carbon intensity in China and, due to its greater absolute economic size, the same percentage increase in carbon intensity now leads to much higher absolute emission increases in comparison with 30 years ago. This "scaling effect" is also manifest in the graph for global carbon intensity, where the influence of Chinese coal becomes visibly more pronounced, as opposite to the OECD countries, where the expansion of nuclear power has played a "decarbonizing" role.

The graphs suggest four main conclusions concerning the evolution of emissions: first, the overall very high annual percentage growth in emissions is a special characteristic of both China and NICs. Second, among the Kaya factors, growth of GDP per capita has for both regions been the largest single driver of emissions growth. Third, the main difference between China and NICs consists in the former's relatively stronger economic growth and its resulting larger contribution to emission growth and not primarily in different dynamics of carbon intensity or coal. Fourth, the most characteristic feature of China is the exceptionally high contribution of energy intensity, which partially counterbalanced the high growth in per-capita GDP.

3.2.2 Future Options for Decarbonization

In order to assess the role of China in the global efficient mitigation efforts, a set of scenarios have been generated by the multi-region integrated assessment model ReMIND-R[61].

ReMIND-R is a hybrid model that combines a Ramsey-type optimal growth model the macro-economy with a technology-rich energy system model. It assumes perfect foresight by all economic agents, since it is characterized by joint inter-temporal optimization of both model components. It includes a detailed description of energy carriers and conversion technologies and allows for unrestricted inter-temporal trade relation and capital movements between the eleven macro-regions represented.

The baseline scenario describes plausible future developments in a world without climate mitigation policy[62].

China's population is assumed to keep growing at a relatively low rate until 2030 and to stabilize at about 1.4 billion people afterwards. GDP per capita is projected to grow at an average of slightly above 4%, with an increase in average income per capita from US$ 1,800 in 2005 to US$ 14,000 in 2050. As improvements in energy efficiency are outpaced by growing economic activity, total primary energy consumption grows steadily at around 2% per year, boosting almost threefold throughout the first half of the century.

Thus, without additional measures to limit carbon emissions, China's energy system

[61] Leimbach et al.2009
[62] Jakob et al. 2009

TABLE 4: Role of China in global reduction efforts	BAU	500ppm	450ppm	400ppm
Global cumulative emissions 2005-50 [Gt CO_2]	2604	1655	1350	642
Global reduction below BAU [%]	-	36%	48%	75%
China's cumulative emissions 2005-50 [Gt CO_2]	381	278	218	110
China's share in global emissions [%]	15%	17%	16%	17%
China reduction below BAU [%]	-	27%	43%	71%
Share of global reduction [%]	-	11%	13%	14%

will likely remain dominated by fossil fuels (especially coal) and continue the past trend of carbon intensive growth and rising carbon emission for more than threefold to 11.4 Gt CO_2 in 2050.

3.2.3 The Role of China in Global Mitigation[63]

Table 4 lists global as well as Chinese carbon emissions for several scenarios: the baseline (BAU) scenario as well as several climate policy scenarios aiming at stabilization of atmospheric concentrations at 400, 450, and 500 ppm CO_2-only with minimized global costs.

The results illustrate the efforts that need to be undertaken to stabilize emissions at various climate policy targets. It gets obvious that China needs to take more responsibility in global mitigation once the more ambitious climate policy targets are set, both in absolute terms and compared to other regions. The share of global emission reductions that is undertaken in China increases with more ambitious climate targets, ranging from 11% in the 500 ppm to 14% in the 400 ppm scenario.

The fact that such sizable reductions in China are needed is intuitively clear: stabilizing

[63] Steckel, J., M. Jakob, R. Marschinski, G. Luderer (in press): *From Carbonization to Decarbonization? – Past trends and future scenarios for China's CO2 emissions*, "Energy Policy", Available at 10.1016/j.enpol.2011.03.042

atmospheric CO_2 concentrations requires limiting cumulative carbon emission in the period 2005-50 to 1350 Gt CO_2 globally (in the 450 ppm scenario). This corresponds to about 4.5 t of CO_2 per person per year, i.e. very close to China's current level and well below the baseline, which projects an almost threefold increase of Chinese annual per-capita emissions by 2050.

Table 5, instead, shows enhanced Kaya results for absolute emission changes between 2005 and 2050 for different scenarios, for population and GDP per capita and we find a decreasing contribution to emission changes with more ambitious climate policy target, which can be explained by the lower total emission levels in the policy scenarios. For instance, in a relatively carbon-neutral economy, a unit of GDP per capita or population growth will contribute less to emissions growth than in a carbon-intense economy.

Most important, Table 4 illustrates the interaction between energy and carbon intensity for different stabilization targets. With increasingly ambitious climate policy targets, the importance of energy intensity decreases while carbon intensity reductions get more and more important.

In the BAU scenario, energy intensity contributes most, which can be explained with higher absolute emission levels. Thus, significant emission reductions that can be derived from energy intensity improvements are already undertaken in the BAU scenario, but only limited additional reduction potential from decreasing energy intensity can be realized when climate targets become more ambitious.

Therefore, a focus on carbon intensity becomes increasingly important.

TABLE 5		**BAU**	**500ppm**	**450ppm**	**400ppm**
Population		20.0	14.3	12.2	10.1
GDP per Capita		481.5	373.2	331.2	291.3
Energy Intensity		-333.0	-288.0	-252.9	-182.1
Carbon Intensity		39.8	-55.0	-95.5	-167.6
....	***Coal w/o CCS***	58.7	13.4	-3.3	-20.7

	Gas	-0.3	0.2	0.1	0.6
	Oil	-1.3	-1.0	-0.7	-0.9
	Nuclear	0.3	-6.9	-6.9	-2.9
	Biomass w/o CCS	-13.6	-21.9	-23.9	-13.7
	Renewables (incl. Hydro)	-4.0	-31.8	-50.1	-52.1
	CCS	0.0	-7.0	-10.8	-78.1
Absolute emission change in 2050 compared to 2005 [%]		208.4	44.5	-5.0	-48.3

Table 5: Decomposition of China's absolute emissions change from 2005 to 2050 in different scenarios in per-cent.

Crucial assumptions for the policy scenarios are:

- An immediate action on climate change mitigation
- The presence of an international carbon market

The sizable physical emission reductions in China projected point to the presence of ample low-cost mitigation options, but not as an indicator of the reduction target in terms of emission rights.

3.2.4 Macroeconomic Effects of Climate Policy[64]

To keep the analysis tractable, the macroeconomic effects of climate policy, mitigation options and investment needs are shown in the following graph, with the example of the 450 ppm target.

[64] Ibid.

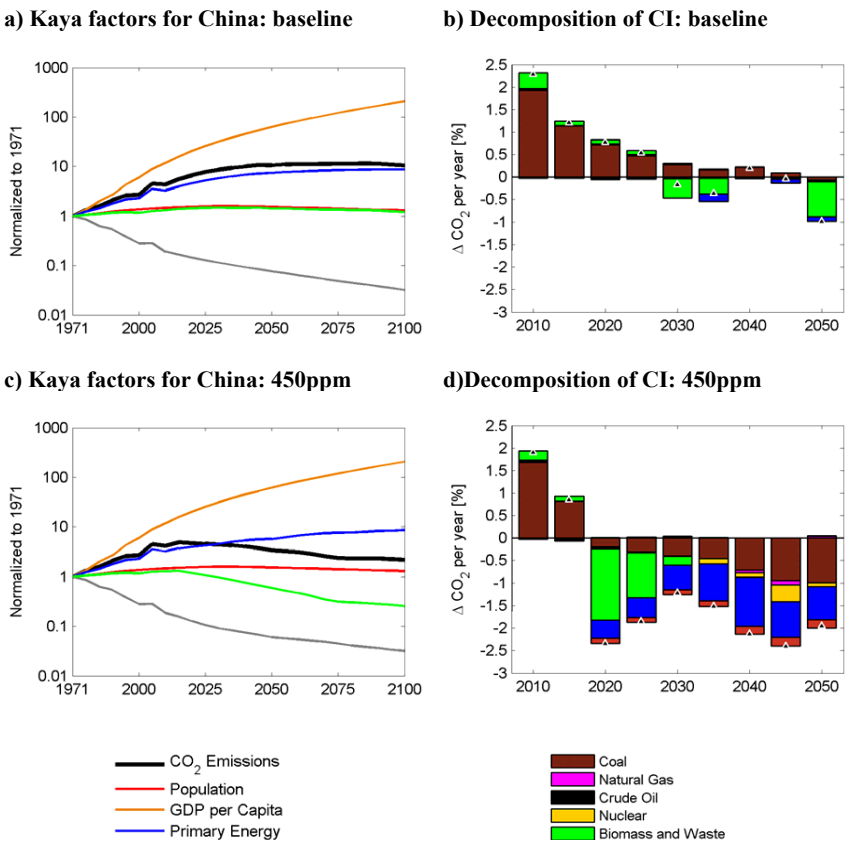

Figure 16: Kaya decomposition factors for historic data and model results for the baseline and the 450 ppm scenario (a, c), results are shown normalized to 1971 and decomposition of carbon intensity for model results (b, d)

Figure 16 illustrates the driving forces of carbon emissions as observed in the past and projected for the future under business-as-usual as well as for the 450 ppm stabilization scenario.

As can be seen from the Kaya decomposition in panel (a), robust economic growth in China has put, and is supposed to continue to do so in the future, considerable pressure on emissions, while population growth (which is expected to turn negative from 2030 on) has only minor impacts. Even in the baseline scenario, declining energy intensity acts as a counterweight to economic expansion, limiting the increase of energy consumption to rates well below the rate of economic growth.

No policy intervention would mean a move towards higher shares of coal in the energy mix a subsequent increase in carbon intensity of energy production. Nevertheless, this effect is by an order of magnitude smaller than the effects of changes in GDP and energy intensity.

In the 450 ppm scenario, Chinese emissions peak in 2002 and decline after that date. Then, climate measures can be targeted at decreasing the energy intensity of GDP (e.g. through energy efficiency improvements or industrial policies to shift the production structure towards less energy intensive sectors) lowering the carbon intensity of energy production (e.g. by encouraging the use of low-carbon energy technologies) or making structural changes in China's energy system (shown in panel (c)).

While improvements in energy efficiency only partially compensate economic growth, lowering carbon intensity is pivotal to reduce carbon emissions without compromising development.

The differences in per capita CO_2 emissions between the baseline (where they grow by about 2.2% per year on average) and the policy scenario (where they slightly decline) can, to a large part, be explained by the different trends in carbon intensities. In the baseline, carbon intensity grows by a little less than 1% per year on average, this trend is reversed in the policy scenario, in which it declines by roughly 2% per year. The decomposition of carbon intensity shown in panel (d) reveals that decreasing the consumption of coal and increasing use of renewables and biomass can make the largest contribution to reverse the current trend and achieve lower carbon intensity, with additional but smaller roles for nuclear power and CCS.

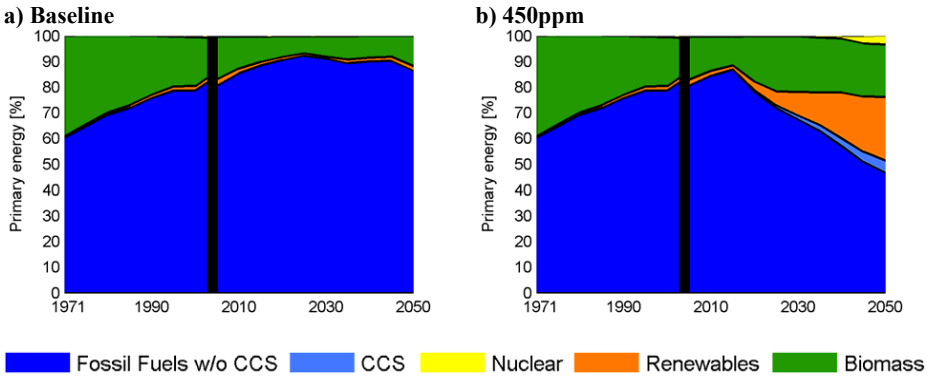

Figure 17: Composition of energy supply in the Chinese energy system from 1971 to 2050 for (a) the baseline and (b) the 450 ppm CO_2 only policy scenario. The vertical black indicates the change from historic data (IEA) to model results (ReMIND-R)

According to the baseline scenario, China's energy system will remain carbon-intensive, with the largest share of primary energy demand met by fossil fuels.

However, as argued above, as in the short- and mid- term the capital stock in the energy system is relatively inflexible, decarbonization of electricity generation is key to mitigating carbon emissions in China. In the stabilization scenario, by 2050 roughly 40% of electricity will be generated by renewable sources and 20% by biomass.

CHAPTER 4

Is the Green Choice the future of China? – pros and cons

During the last decades, the renewable energy sector is drawing increasing levels of new investments.

Commitments to slow the growth of carbon dioxide and other fossil fuel pollutants have played an important role in expanding investments. In addition, the tremendous growth in energy demand from developing economies, the increased instability of fossil-fuel prices and the concerns about energy security all contribute to growing the green sector.

Chinese efforts to develop renewable energy technologies have accelerated in recent years as the government has recognized energy as a strategic sector, as also seen through the decomposition of the Kaya equation.

China has, thus, adopted a host of new policies and regulations aimed at improving its energy supply and energy security and enhancing the quality and competitiveness of its economy, in addition to reducing pressure on the environment and mitigating the effects of climate change.

Indeed, although technological advancements are evident along the entire coal supply chain, the sheer scale of China's coal usage has led to significant environmental consequences for the country and beyond.

The only question to answer is: what are the real benefits of using renewable energy? While there are certainly advantages and disadvantages to switching to green economy, it is quite arguable that the benefits of using such sources outweigh the shortcomings of it, especially in the future.

4.1 China's pros to become Green

There are strong arguments in favor of the fact that China has much to gain and little to lose by playing a more active role in global climate mitigation.

A switch towards low-carbon development would be less costly for China than for most industrialized countries and it would provide opportunities to gain competitiveness, at

the same time as low-carbon technology exports could offer comparative advantages for Chinese production[65].

Yet, these are just some of the benefits that China takes by turning to a green development. A more extensive analysis even includes:

a. Fossil-fuel volatility[66]

Fossil-fuel prices have faced unprecedented volatility in the last decade. A rapid increase in oil prices in 2007 and 2008 was followed by an even faster collapse in 2009 that brought prices back to mid-2004 levels. This volatility has contributed to pushing oil out of the power-generation sector globally, though some fast-growing Asian countries such as Indonesia still use oil in power generation[67]. Coal and natural gas, while still not traded as widely as oil, have also seen an increase in international trade and price volatility.

China alone is such a large coal market that any domestic imbalance has the potential to destabilize the international coal trade[68].

Import dependency exposes an economy to several risks, including balance of payments risk, amplified economic impacts when prices rise, tremendous pressure on public budgets to blunt the impact of price increases on consumers, and the potential to lose access to fuel altogether, either by being priced out of the market by other bidders or by supply lines being physically cut[69]. Diversification of sources is one strategy to manage this risk, and countries are looking to both fossil and renewable domestic sources.

b. Renewable potentials

Renewable potentials refers to the fact that these sources do not deplete over a lifetime and there is zero possibility that they will run out. On the contrary,

[65] Handling K., Han G, Olsson M., *A balancing act: China's role in climate change*, The Commission on Sustainable Development 2009

[66] Tawney L., *Taking Renewable energy to scale in Asia,* Pacific Energy Summit, 2012 Summit Papers

[67] IEA et al., "Extending the G20 Work on Oil Price Volatility to Coal and Gas", October 2011; Müller et al., "Renewable Energy".

[68] IEA et al., "Extending the G20 Work", pp. 25.

[69] Ibid.; and Kojima, "the Government Response to Oil Price Volatility"

fossil fuel sources (oil, gas, and coal) are considered limited and there is strong possibility that they will run out in the future.

Renewable energy can help developing countries to decrease their over-reliance on fossil fuels. Powerful winds, heat emanating from beneath the Earth, sunshine and moving water can guarantee a huge and steady energy supply to a nation for many years.

China has the potential for developing significant renewable energy sources, most of which are still not utilized. Instead, despite the technical potentials of onshore wind and solar capacity, current installed capacities are minimal.

The northern parts of China have the best wind resources while the southeastern and central parts have high solar irradiation.

The country has also abundant biomass resources, little of which are effectively used today. Biomass is mostly related to agricultural and forest logging residues, animal waste and industrial and municipal bio-degradable wastes. The straw of this resource is concentrated in the northeast and lower Yangtse River and there are significant wood resources in the northeast and southeast[70].

c. Falling Technology Costs

Policymakers and academics have both assumed that the less-mature renewable-power technologies, such as solar photovoltaic, will continue a steady price decline as deployment provides opportunities to learn and find economies of scale. However, the actual decline in prices is a much less steady process. Sometimes supply constraints, rising commodity prices or the cost of capital drive project costs up; other times, oversupply or innovation push costs down.

Successful innovations and market changes are converging, and it is now widely expected that solar PV projects and onshore wind projects will be competitive with fossil-fuel power in several regions. Prices for solar panels have fallen dramatically, driven in part by China's expanding manufacturing sector. Indeed, while the first installations in a market always involve learning and thus can be more expensive, several renewable power technologies will likely be competitive with coal and natural gas within the next five years, dramatically

[70] IRENA, *Renewable Energy Prospects: China.* Remap 2030, pp. 47, a Renewable Energy Roadmap, 2014

changing the options energy regulators can consider while affordably meeting energy demand[71].

d. Climate Mitigation Pledges

Renewable energy resources are clean sources of energy, meaning, they have low or zero carbon and greenhouse emissions.

The use of renewable energy dramatically reduces dependence on fossil fuel as a source of energy, hence, cutting back on air pollution.

The Chinese government places a priority on investing in renewable energy, first because it enables the country to tackle problems of air and water pollution, and mitigate risks of socio-economic instability.

The 2005 National People's Congress (NPC) Environmental Committee observed that fossil fuel energy production and consumption is the cause of 90% of the country's sulfur dioxide emissions.

In 2013, Tsinghua University and the Asian Development Bank reported that 7 out of 10 most polluted cities in the world are in China[72].

Concerning the economic and health consequences of air pollution, RAND Corporation estimated that in 2012 air pollution costs China $535 billion, or 6.5% of its gross domestic product, due to losses in labor productivity[73]. A UC Berkeley study concluded that air pollution led to an estimated 1.6 million deaths a year, roughly 17% of all deaths in the country.

Another disquieting picture emerges from the *National Assessment Report* of how China will be affected by a changing climate[74]. Already by 2020, China's

[71] Project costs do not currently include the cost to the larger system of absorbing variable renewable energy sources, the "system costs". Investments in increased transmission or interconnections between regions, dispatchable backup generation, and energy storage are not typically paid by the individual solar or wind project that is selling power to the grid. As discussed above, each grid will have its own strenghts and weaknesses in absorbing these resources and so system costs will differ. However, as the proportion of variable resources increases, the issue of who pays system costs will become more pressing.

[72] Tracy Staedter, "7 of 10 Most Air-Polluted Cities Are in China," *Seeker*, January 16, 2013, https://www.seeker.com/7-of-10-most-air-polluted-cities-are-in-china-1766374196.html.

[73] Javier C. Hernández, "Climate Change May Be Intensifying China's Smog Crisis," *New York Times*, March 24, 2017, https://www.nytimes.com/2017/03/24/world/asia/china- air-pollution-smog-climate-change.html?_r=0.

[74] Handling K., Han G, Olsson M., *A balancing act: China's role in climate change,* page 42, The Commission on Sustainable Development 2009

average temperature is expected to increase by 1.3°C to 2.1°C, which means that many parts of the country will experience drastic temperature increases. Temperatures are expected to rise by a total of 3.3 degrees Celsius by 2050 and precipitation is expected to increase by 2% by 2020, and 7% by 2050.[75] This will worsen the already precarious situation of chronic water shortages in the north, and rather intensify flooding problems in the south. Increased precipitation will also increase flooding and drought disasters in general, with significant impact on the country's development potential.

Given China's precarious water situation, the pronounced temperature increase in the Himalayas is particularly worrying. Rising glacial runoff increases risks for large-scale flooding until the melt-off peaks between 2030 and 2050, at which point the head-flows of China's largest rivers will diminish, with huge consequences for all human activity along the big rivers. [76]

Additional climate change consequences include agricultural impacts that will dramatically undermine domestic food security, a rise in sea level that would threaten the lives of millions of Chinese coastal inhabitants and also devastate the country's economic production and GDP.

To the central government, the climate challenge is yet another destabilizing factor that not only constitutes an overall menace to national food supply, but is also a peril that will potentially worsen the situation for China's poorest and most susceptible citizens.

It is hardly a surprise, therefore, to see air pollution ranked as a top concern for people in the country.

Chen Jiping, a former leading member of the Communist Party's Committee of Political and Legislative Affairs, affirmed in 2013 that environmental issues are a major reason for mass protests.[77] Indeed, the Chinese population considers air

[75] Handling K., Han G, Olsson M., *A balancing act: China's role in climate change,* page 42, The Commission on Sustainable Development 2009

[76] Economist (2008a)

[77] https://www.bloomberg.com/news/articles/2013-03-06/pollution-passes- land-grievances-as-main-spark-of-china-protests.

pollution as the second largest problem affecting the country, second only to the issue of government corruption.

As maintaining domestic stability is the Communist Party's top priority, the need to combat air pollution by developing cleaner sources of energy is pivotal.

e. Development Opportunity

A November 2011 report by a Chinese government advisory agency estimated that China could net 9.5 million jobs in five years by transitioning from polluting industries to "green" business, including the renewable-energy sector. A recent report by the Brookings Institution found that the USA already had 2.7 million green jobs as of mid-2011, more than the number of jobs in the fossil-fuel industry or biosciences[78]. While these jobs span several sectors from energy-efficient construction to waste management, the report also found that clean technology in particular included high-value manufacturing-based and export-intensive jobs.

An assessment of independent reports and studies on trends in the clean-energy industry has found that the renewable energy sector also generates more jobs per unit of energy delivered than the fossil fuel-based energy sector.

However, it is China's explosion into the wind-power sector that gets the most notice by both potential emulators and competitors.

The perceived story of China's advance in this sector has led to an informal and often problematic formula for building a domestic industry in the low-carbon power sector that emphasizes the promotion of domestic jobs at the potential expense of the lowest costs or the best performing technology. This roughly dictates that policymakers should:

- Create domestic demand for renewable power, using a policy tool like mandates, targets or feed-in-tariffs
- Add to local-content requirement or some similar regulation to the requirements for project developers
- Provide the domestic industry with a protective tariff regime or another form of infant industry protection

[78] Tawney L., *Taking Renewable energy to scale in Asia,* Pacific Energy Summit, 2012 Summit Papers

This formula has some roots in fact. Globally, large and reasonably stable wind markets have drawn parts of the value chains to domestic shores. China has seen an explosion in wind companies, and a rapid appearance among the global top ten; growth that is often attributed both to the large domestic market and the local-content requirement[79].

f. The Waning Bargaining position

China's position in negotiations is a balancing act between "playing hardball" and making "strategic choices". With rapid increased emissions, China's negotiation position was weakened as its role shifted from being a victim of other countries' historical emissions to a dominant contributor to global emissions[80].

Indeed, climate security is increasingly seen as a geopolitical issue, where China's role as a responsible world actor is central to its range of options within global climate talks, especially because there are growing divergences within the G77 bloc. Some Least Developed Countries, such as Bangladesh, argue for differentiated treatment of large developing countries, notably China. China could therefore move to a position where it negotiates to maximize national interest rather than aligning with the developing world.

g. Increased competitiveness

A growing global focus on low-carbon economic development provides opportunities for China to gain competitiveness, international reputation and environmental benefits, at the same time as it lays the foundation for more balanced economic and social development[81]. International cooperation within a new climate regime could give China access to important technologies and investment capital and allow exports of low-carbon, high technology products.

[79] Ibid.

[80] Handling K., Han G, Olsson M., *A balancing act: China's role in climate change,* page 42, The Commission on Sustainable Development 2009

[81] ibid. pp. 22

4.2 China's cons to become Green

Despite all the advantages to turn green, the Chinese leadership is faced with difficult domestic challenges and tradeoffs between long and short-term development and security concerns. With half of the population living under two dollars (PPP) per day, development needs are immense and it is necessary to maintain stable growth. Moreover, the energy intensive stage of development makes it difficult to break out of coal dependence. Emissions are expected to grow over the coming decades and the only way to slow down this process is by achieving real carbon emission reductions. There is no precedent for China's situation, because no other country has been faced with the necessity to deal with the challenge of climate change during the same stage of development.

a. The climate and energy security dilemma [82]

The challenge for the global community as well as for individual countries, and perhaps for China in particular, is therefore to develop energy security strategies within the limitation of climate security. In its search for energy security strategies China runs into several underlying dilemmas.

To begin with, the Country is at a development stage of rapid industrialization and urbanization at a time when climate security has been put at the top of the global agenda, and the sheer size of the Chinese economy means that its development related emissions have large impacts on global climate change.

To decouple its carbon emissions from growth, China faces a challenge that no other country has previously mastered at a similar stage of development.[83]

Second, mounting domestic development challenges make it imperative for China to maintain high economic growth to finance a wide variety of much needed social reforms.[84] It is particularly urgent to reduce growing social disparities and provide development opportunities for the near half of the population that live under two dollars (PPP) a day. Equally important is to halt

[82] Ibid. pp. 35
[83] Pomfret (2008)
[84] Zheng and Tok (2007).

the rampant environmental degradation that limits growth potential and adds to social instability.

Third, with coal forming the foundation of its energy system, it is highly challenging for China to transform its energy structure to such extent that the global 2°C is within reach. Committing to a climate deal implies massive structural transformation for China, not only by the energy mix point of view, but also for the energy intensive transport and building sectors.

Finally, China's tradition of aligning with the G77 view that climate change is predominantly an OECD-world problem is becoming more and more contradictory as it has recently become the world's largest carbon emitter. With escalating emissions it will also prove increasingly difficult for China to keep up its foreign policy ambition to act as a "responsible great power" , and convince the world that its development is not a threat to global security[85].

b. Renewable energy can be unreliable

Renewable energy technologies totally depend on the weather (for e.g.: sun and wind) to be able to harness. In the case atmospheric conditions are not good enough, renewable energy technologies would lack the ability to generate any electricity. This might instigate campaigns by the authorities to reduce energy usage in order to serve the population for a longer period.

However, we find investments in renewable options like concentrating solar power, which with molten-salt technology can generate power 24/7, and for which the CSP power stations are envisaged as spanning continents that constitute the electric power generating systems of the future. These practical initiatives are the real answers to the endless debating points that renewables could not be "trusted" because of their fluctuating nature, their lack of reliability, their dependence on gas-fired backup generators, their excessive usage of land, their impact on traditional business models, etc.

None of these charges are true: the costs are coming down to approach grid parity and the storage capacities are growing.

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[85] Handling K., Han G, Olsson M., *A balancing act: China's role in climate change,* page 38, The Commission on Sustainable Development 2009

As one of the most carbon intensive economies in the world, China's low-cost mitigation potentials are extensive, but fully realizing those potentials requires transformative changes. A giant leap is required to move from the so-called reference or baseline scenarios to the level of emission reduction that is in line with reaching a global 2°C target. Yet to reach the reference or baseline scenarios already assumes a "grand achievement" of China's national ambition, which is far from certain and requires further sharpening of policies and effectiveness in their implementation.

The most ambitious vision comes from the Chinese economist Hu Angang, who argues that the peak of emissions should occur by 2020 and no later than 2030, and that by 2050 China should be able to cut its emissions by 50 % compared to 1990 levels.

The potential, however, dwindles rapidly if mitigation actions are delayed. Any meaningful outcome of the current climate negotiations must focus on how joint action can be leveraged to help China move on to a low-carbon development path and provide opportunities for China to help bringing down the global cost of mitigating climate change.

c. Time is of essence [86]

While China is convinced of the need for a low-carbon future, there is no proven international experience for China to "plug-in" right away. As its economy risks further slowing, or even a hard landing due to the global economic crisis, the mounting pressures to maintain growth, employment, and social stability are much more urgent priorities for the Chinese leadership. China's climate change strategy and actions will depend upon how it attempts to address its current domestic economic crisis and its economic development challenges. Success or failure in combating climate change globally however, is determined by how well China and the rest of the world can find common ground for productive low-carbon co-operation for economic development.

[86] ibid. pp. 17

d. Costs and externalities[87]

Wind and solar PV cannot compete with the low cost of coal power generation. They do become cost-competitive, however, when accounting for coal's significant externalities, such as air pollution and its impact on human health. China would need a nationwide price of about USD 50 per ton of carbon dioxide (CO_2) to raise the cost of coal power generation sufficiently to make distributed solar PV cost-competitive. Prices closer to USD 25-30 per ton CO_2 would ensure that wind and solar PV could compete with coal at utility scale.

In order to satisfy China's growing energy demand, sizable energy system investments in power sector will be needed in the next couple of decades.

e. Building a domestic market[88]

Establishing the national power market, creating economic incentives for flexible operation and bringing in new investors would be pivotal in order to develop the renewable sector.

The cost of energy is a very difficult political topic in most countries. There are often concerns that high power costs will hurt international competitiveness and constrain economic growth. High energy prices can also impact poor households and efforts to extend energy access. Policymakers can keep the consumer costs of renewable-energy subsidies to a minimum by encouraging renewable technologies to be more cost-competitive with fossil-fuel options.

While renewable-energy technologies still require price support in many markets, it is important to avoid creating an investment bubble and speculation through overly generous subsidies. The emerging best practice is implementing steadily and predictably declining production-based subsidies that allow for sharper or slower declines in response to evolving economics, to avoid creating investment bubbles and artificial supply-chain constraints. This should be done via methodical and transparent public processes.

It is critical to encourage renewable-power technologies to continue to mature, reduce their costs and improve their performance, both for the sake of domestic

[87] IRENA, *Renewable Energy Prospects: China.* Remap 2030, pp. 2, a Renewable Energy Roadmap, 2014

[88] Tawney L., *Taking Renewable energy to scale in Asia,* Pacific Energy Summit, 2012 Summit Papers

energy costs and for success in the international competitive landscape. This is an area where the principles of good governance, including transparency and allowing space for regulators to operate independently of politicians, are particularly powerful tools to prevent incumbents from capturing subsidies or inflating them at the expense of the consumer.

A fossil-fuel subsidy reform does not have to hurt poor consumers. One option is targeting subsidies more efficiently, rather than removing them. In addition to encouraging an efficient use of power, and thus slowing the growth of demand and taking pressure off public budgets, removing or more carefully targeting subsidies for fossil fuels means renewable-power technologies require a lower level of subsidy to compete with the existing technologies. As an example of this, Thailand subsidizes electricity for the very poorest households as opposed to all consumers, limiting the total subsidy needed substantially and encouraging efficiency among higher-income consumers. Since it is a consumer-focused subsidy rather than, for instance, a subsidy on the cost of coal for electricity generators, it does not make cost-competitiveness harder for renewable energy to reach.

f. Grid and transmission[89]

Power generation from both utility scale solar PV and wind in China has been curtailed by a lack of sufficient grid infrastructure, and because coal power plants are given priority dispatching. This is improving as preferential policies for renewables are introduced. China's power transmission system remains, in fact, under-developed.

Regional power shortages occur frequently when generation drops in one province or region and the lack of long- distance power transmission capacity means that power cannot be moved from regions where there is a surplus capacity.

There is no unified national grid. Instead, six major regional grids divide the territory: five managed by the giant State Grid Corporation and one managed by

89 IRENA, *Renewable Energy Prospects: China.* Remap 2030, pp. 2, a Renewable Energy Roadmap, 2014

the South China State Grid Corporation, covering the light manufacturing around Guangzhou-Shenzhen and the inland areas of Guandong, Guangxi and Guizhou. Northern areas are often subjected to shortages during winter due to increased heating demand and problems with coal deliveries. Eastern and southern areas are prone to shortages in late spring and early summer as temperatures and air-conditioning demand rise, while reservoir levels and hydro output fall until the arrival of the summer rains in July and August.

The lack of a unified national grid system also hampers the efficiency of power generation nationwide and heightens the risk of localized shortages, especially because inter-connections between the grids are weak and long distance transmission capacity is small.

Moreover the institutional framework in terms of energy market integration and infrastructure such as connectivity in power grid and natural gas pipeline networks are not in place.

Grid and transmission capacity issues will gain more importance in the future as an important share of China's wind and solar PV will need to be built far from population centers. Better regional coordination is needed to create power exchange and new interconnectors between provinces and power trading with neighboring countries.

More than 80% of the potential energy resources, such as coal, oil, natural gas, hydroelectricity, wind power and solar energy are distributed in the northern and western parts of China.

Around 80% of onshore wind energy capacity is distributed in the "3-North" regions (North, Northeast and Northwest), two-thirds of hydroelectricity is located in the southeast.

The spatial distribution of supply and demand creates challenges. Significant transmission capacity is planned, but not yet in place. Moreover, renewable power competes with coal power for the same transmission capacity. The distance between the best resources for renewable energy generation and the main areas of demand is a major obstacle because of the large investment needs for new transmission and distribution capacity.

The current electricity grid is not designed to handle high shares of variable renewable power. In order to accommodate it, accelerated power market reform will be needed, including establishing an electricity retail market segment, which would not only encourage competition on electricity retail prices, but also innovation in creating business models for applications of distributed generation renewable electricity.

China should expand the study on its future grid, particularly incorporating smart technologies to cope with large-scale variable renewables located in Northern and Western China, far away from the centers of the demand.

This has already constrained the rapid expansion of renewables. There is a considerable lag between additions in wind power capacity and the proportion that has been connected to the grid. In 2012, 22% of installed wind power was running idle, mainly due to the fact that coal-fired power plants have, in practice, priority grid access and grid capacity is limited. As of the same year, 20% of China's wind farms were not connected to a power grid. This was caused by a combination of factors that include: rapid capacity expansion, limited coordination between project developers and grid planner, lack of transmission capacity and technical concerns of regional utilities that the intermittency of wind power could be disruptive to normal operations.

So far, high curtailment rates related to problems with grid connections, the lack of priority dispatch and missing power grid capacity have led to uncertainty and financial losses.

The analysis of pros and cons for China of investing in the renewable sector highlights some important aspects to overcome in order to take a decision. However, from a rational point of view, China has much to win and little to lose by playing a more active role in global efforts to mitigate climate change. A growing global focus on low-carbon economic development provides opportunities for China to gain competitiveness, international reputation and environmental benefits, at the same time as it lays the foundation for more balanced economic and social development. International cooperation within a new climate regime could give China access to important

technologies and investment capital and allow exports of low-carbon, high technology products.

The consequences of China standing outside the global process would be dire. It would signal that China does not take the climate threat seriously and would thwart the world's chances to solve the climate crisis.

Without China as an active partner in a global climate compact the potential for global low-carbon economic development would also be reduced, particularly if the threats of carbon related border tax adjustments were to become a reality, or if China were hindered in its export of affordable low-carbon products to OECD markets.

China's ability and willingness to slow the growth of its carbon emissions, reaching a point within the coming couple of decades where total emissions start declining, is crucial for the success of a global effort to come to grips with the climate crisis. It is imperative, therefore, that the international community reaches a deeper understanding of the role that climate and energy security plays in China's development and emergence as a global economic, political and cultural power.

Part II – Towards a Green Policy and Economy

CHAPTER 5

China's transition to Green

Since the beginning of the 21st century, the conflict between human and nature has become increasingly apparent in China. Resources and energy, ecology and environment, carbon emissions and climate change have turned to be some of the biggest roadblocks and limiting factors for the development of China's economy and society.

In the face of these challenges, the Country has responded positively by constructing a green development concept and a modern framework while setting in motion an unprecedented revolution of green energy, manufacture, consumption and innovation. After the first four Five-Year plans, China has become a pioneer in green development and the biggest green energy country in the world.

Green development is a "no regrets" strategy; it offers a range of tangible benefits apart from its saving in terms of carbon emissions. Indeed, even though dangers of global warming turn out to be overstated, China would in any case accrue enormous advantages by adopting green strategies, simply in terms of their offering of greater security, resilience and development potential.

Therefore, China and the world have everything to gain by governing with a renewable energy and circular economy goals and little, if anything, to lose. What they "lose" is the prospect of endless war over fossil fuel resources, endless pollution and waste generation and dwindling of energy resources as supplies peak and prices spiral out of control.

What instead China could "win" is: first the fact that, as a latecomer, it has spent less in developing a green economy, and it can take advantage of the technology leapfrog effect to accelerate such development. Second, in the promotion of green economic development, the fact that there may be inadequate investments through market forces alone[90]. As a consequence, it may be necessary for the Chinese government agencies to

[90] Angang H., *China: innovative green development*, page 102

lend direction by generating appropriate policies and supplying suitable incentives as well as operating in a regulatory capacity with respect to development.

China will promote industrial agglomeration, enhance international competitiveness and accelerate the development of seven strategic emerging industries (Solar, Wind, Hydroelectric, Biomass, Hydrogen, Geothermal and Ocean energy industries). These will constitute the pillar sectors on which the national economy is based: energy saving and environmental protection, new generation IT, biological science and high-end equipment manufacturing, in addition to three leading industries: new energy, materials and energy vehicles.

Adopting these strategic emerging industries as its core, China will make efforts to shape its industrial structure in line with the needs of sustainable economic development such that it is able to implement a knowledge-intensive, resource-intensive and eco-friendly system.

China will lead the world's green energy efforts, through the optimization of energy structures in three ways: by increasing the proportion of non-fossil energy sources (especially solar, wind and other renewable forms) within the framework of total energy consumption; by reducing the proportion of coal within the consumption of fossil fuels and by using coal in a much cleaner fashion thanks to technical transformation.

It will become the world leader in developing a low-carbon economy and its huge domestic market and investment demand will stimulate the rapid development of low-carbon technologies.

The funding reason

While the international community has been busy debating global warming, and scholars and activists have been putting forward proposals for strengthened international treaties as a way of dealing with the problem of resource-intensive capitalism, China appears to be motivated by quite different considerations.

The incredible economic growth that had already characterized China since the 1980s increased at most after that the Country became a member of the World Trade Organization in 2001. The Communist Party saw a surge in investment in manufacturing activities for export, which called for huge expansion in energy industry

and took the tough decision of expanding coal-fired power generation and oil and gas industries, which led China to become dependent on overseas source for oil security.
However, when the USA was hit by the 9/11 terrorist attack[91], the Chinese leaders started to associate further expansion of their oil and fossil fuel interests with endless risk of war and terror, involving conflict not just with host nations in the Middle East but also with the United States and its seemingly unlimited appetite for Middle Eastern "energy"[92].
This circumstance was further emphasized by the endemic energy shortages and blackouts in 2003, after which, the development of an alternative energy pathway involving rapid buildup of renewable energy sources started to seem the best solution to adopt.
When China's top policy-makers met for the Central Economic Work Conference in late 2004 they decided that energy and saving of resources should become important targets in economic restructuring.
Indeed, one year later, investments in renewables, initially wind power and solar thermal, increased dramatically and at unprecedented rates in economic history.
While state-owned corporations remained the bedrock of the energy system in coal, oil, gas and in electric power generation, it was new and privately founded corporations that implemented their entrepreneurial head in the renewables sector generally.
Of course, China's backing of fossil fuel expansion continues apace, at a rate of roughly one thermal (coal-fired) power station of 1 billion watts per week; however, these investments go hand in hand with expenditures on renewables, so that the character of the energy sector is changing, driven by national security as well as economic concerns.

The war on pollution

In addition to the energy saving priority, the Chinese government puts a lot of emphasis on pollution control in the development of renewable resources. During the last years[93], with the increasing public concern on the country's environmental degradation and the media coverage of hundreds of incidents, pollution has already become a top worry for

[91] Mathews J.A., *Greening of Capitalism. How Asia is driving the next great transformation*, Chapter 2 Stanford University press, 2015

[92] ibid pp. 44-45

[93] Wike & Parker, 2015

the Chinese public. In 2012, the Communist Party revised its constitution by adding in the overall plan "the establishment of an ecological civilization"[94], identifying resources conservation and environmental protection as basic policies. Ecological civilization is a concept that reflects an important change in the Party's understanding of development. Rather than emphasizing economic construction as the core of development as it did in the past, the leadership have come to realize that development, if sustainable, must entail a list of elements including the right relationship between man and nature.

This concept was proposed at a time when 62% of the country's major rivers have been seriously polluted, 90% of waterways flowing through urban areas are contaminated, more than 300 million residents are yet to have clean water to drink and quite a number of localities fail to fulfill the required quotas for pollutant emission reduction and energy saving.

Facing such a reality, the construction of ecological civilization needed to be transformed into tangible measures that aim at changing the Chinese economic development[95].

Furthermore, from 2011 to 2014, China's legislative body amended its Environmental Protection Law (EPL). This, taking effect since 2015, set forth a stringent legal framework for China's sustainable development with critical revisions in several aspects including penalties for environmental offenses, establishing a public environmental litigation system and building unified pollution control and coordination mechanism for some key areas across administrative units.

Over the last years, the State Council has released three specific action plans of prevention and control for air (2013), water (2015) and soil pollution (2016).

On air pollution control, by 2017 China aims at reducing the consumption of coal to below 65% in terms of total energy consumption and it aim at cutting the level of fine particulate in Beijing-Tianjin-Hebei Province, the Yangtze River Delta and the Pearl River Delta by 25%, 20% and 15% respectively.

In the prospect on water, the targets by 2020 are to lift the share of good quality water in seven major river basins to more than 70% and to ensure at least 93% of urban drinking water supply to be at least "level three", that is drinkable standard[96].

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[94] Sun Y., *The changing role of China in Global Environmental Governance*, "Graduate Institute of International and Development studies", pp. 45, 2016

[95] China daily, *Ecological civilization*, 2007. Available at [http://www.chinadaily.com.cn/opinion/2007-10/24/content_6201964.htm] (Accessed January 2018)

Finally, with respect to soil, the relevant plan aims to decontaminate 90% of the nation's polluted farmland and industrial sites by 2020.

5.1 National plan to promote green development

In the emissions reduction efforts, the Five-Year Plans have provided guidance and motivation.

It has promoted cooperation between the government and the market, the state and society, the central and the local authorities and local and foreign entities.

It is one of the most significant national policy tools in China and provides a clear national strategy and intention.

The Plan aims to provide knowledge for the whole society and it regulates the functions of government in economic, physical, social and other fields.

The Five-Year Plan has three main features[97]:

- First, promoting management according to objectives.

  A long-term goal of five years is set by the central government and distributed to the local authorities. This clarifies obligatory indices to allow local agencies to define and reach their goals.
- Second, it connects the target accomplishment with local achievement evaluation.

  The achievement of goals is ensured through supervision, assessment, reward and punishment while implementing goals at the provincial government level.
- Third, the scenarios of government management and market are considered.

  The market plays a decisive role in resource allocation and allows the goverment to operate more effectively.

[96] Sun Y., *The changing role of China in Global Environmental Governance*, "Graduate Institute of International and Development studies", pp. 47, 2016

[97] Angang H., *The Five-Year Plan: A new tool for energy saving and emissions reduction in China,* Science direct, Ke Ai, Advances in Climate Change Research 7 (2016) 222e228. Available at www.sciencedirect.com

China has developed its Five-Year Plans since the 1950s, initially having been modeled on those of the Soviet Union and after reforms and opening-up having gradually transformed into strategic plans.
Their purpose is that of clarifying national strategic intent and government priorities as well as to guide the behavior of market players.
The path to green development, as marked out by successive Five-Year Plans, has been long and tortuous. These have undergone a transformation from economic to strategic plans and finally to comprehensive development plans; in this process, they have developed from a promotion of the black economy to that of the green economy.

In the analysis that follows, the development of the Five-Year Plans is described over the years and a particular focus is given to the latest three, pioneers of the "Green" transition[98].

The Black Development period- 1st to 5th Five-Year plans (1953 – 1980)

During this period, the main task to achieve an independent and relatively comprehensive industrial and economic system by the end of the 5th Five-Year Plan. Hence, industrialization was promoted through the development of industry and agriculture.

The early Plans were characterized by emphasis on heavy industry: the First plan established heavy industry as a priority; the Second one placed its focus on the development of the steel industry, while the Third and the Fourth underlined the importance of heavy industry as the basis of military preparedness. Finally, the Fifth plan aimed to promote a significant advance in the industrial sector, which set China on the road to black industrialization, characterized by high input, consumption and emissions.

These years were marked by significant wastage of energy and resources and outstanding performance was achieved at the cost of rising energy consumption and carbon emissions per unit of GDP.

98 Angang H., *China: innovative green development*, Chapter 5

Initial transition – 6th to 8th Five-Year Plans (1981 – 1995)

With the transformation of China's economic system since the reform and opening- up, the Five-Year plans have also undergone considerable modifications. They have gradually changed from mandatory to guiding plans, from solely economic plans to economic and social development plans. In addition, they have progressively abandoned the path of the black economy, having undergone their preliminary transformation from the Sixth to the Eighth.

Differently from the old approach, which took economic construction as its central element, the Sixth plan aimed at improving the national economy through healthy and steady development.

The Seventh Plan implemented adjustments, reforms, rectifications and improvements and it required a "total social product and national income growth rate based on improving economic efficiency", whereas the Eight placed an emphasis on development and conservation.

Further transition – 9th to 10th Five-year Plans (1996 – 2005)

The process of change, which had started a decade earlier, continued with the Ninth Five-Year Plan, which introduced two developments: the economic system changed from being a traditional planned economy to a socialist market economy and the economic growth changed from being extensive to intensive.

This indicates the time when China begun to enter the transition from a black to a green development path. During this period, indeed, the proportion of green development indicators increased to 11.8%, playing a large role in promoting an initial change in the economic development mode, in dropping energy consumption per unit of GDP and in decreasing emissions of major pollutants.

During the Tenth Plan an additional indicators increase to 16.7% was reached.

However, despite the progress made with the Ninth Plan, the following years were also characterized by a development mode reverted to one of high consumption, investment and pollution. There were sharp increases in national and energy consumption and the average of economic growth rate rose to 10.2%, which was only 1.6% higher than in the 9th Plan.

In addition the industrial value added, as a percentage of GDP, increased indicating that there was further industrialization during this period, mainly of the heavy sectors.

With the weakening regulatory functions of the Tenth Five-Year Plan, China was unable to cut emissions of major pollutants and there were increases, rather than decreases, in carbon dioxide intake in the air.

Turning to green development - 11th Five-Year Plan (2006 – 2010)

After the 9th and the 10th Five-Year Plans had failed badly on both energy and pollution reduction targets, Hu-Wen administration (in power since 2002) showed its political commitment to reverse these trends by setting ambitious compulsory targets to reduce energy and pollution intensities from their 2005 levels.

The Eleventh Five-Year Plan was the first plan to be drawn up after the central government proposed in 2003 that scientific outlooks be included into such plans.

From this moment, combating climate change has become the most prominent component of China's new environmental policy.

The proportion of economic development indicators dropped to its lowest-ever levels, while the proportion accounted for by energy saving, emissions reduction and environmental protection rose to its highest levels. This fully constitutes the change to green development.

Since 2007, the state shut down thousands of inefficient power and industrial facilities so that its energy consumption per unit of GDP continued to decrease (19.1% from 2005 to 2010 and 18.2% from 2010 to 2015 and a target of further 15% decrease by 2020 has been set)[99].

Although green development of zero growth of total irrigation water and the optimization of industrial structure were not achieved, other nine indicators were accomplished. These include forest coverage rate of 20.36 % - a net increase of forest reserves of 1.123 billion m^3, the reduction of industrial value added of water consumption by 30 %, the solid-waste comprehensive utilization rate at 65 %, which exceeded the planned aim of 60 %, and the increase of treatment rate of urban sewage from 48.4 % in 2005 to 72.3 % in 2009.

In addition, cumulative sulfur dioxide emissions were reduced by 14 %, and chemical oxygen demand was reduced by 12 %, which exceeded the planned objective of 10 %.

China also initiated domestic carbon trading to combat climate change: it started seven

[99] Sun Y., "The changing role of China in global environmental governance", *Graduate institute of International and Development studies,* 2016

pilot markets at the city or provincial level in 2014 with the purpose of making a national cap-and-trade system[100] full in operation between 2017 and 2020.

The important innovation brought by this Plan was the definition of government responsibility targets as binding and legally effective.
Indeed, the achievement of improved resources and energy efficiency and the reduction of pollution emissions clearly shows that binding indicators obliged the government to implement its goals and adjust its behavior. Therefore, this made a significant contribution to the transformation of the government and it pushed the national economy and society onto the path of green development. As a result, all local governments have introduced policies, measures, laws and regulations to promote market development as well as various enterprises have increased the intensity of their investments in energy saving.
Finally, China's great improvement in energy and environmental policies during this period indicated the great potential and bright future for China in green and low-carbon industrial development.

To address the stipulation of the 11th Five-Year Plan, the government has broken down the Plan's energy-conservation and emissions-reduction targets and delegated responsibility for meeting them to various regions and sectors, as well as thousands of energy-intensive businesses nationwide[101].
The specific energy efficiency initiatives that were implemented during these years included:

- Ten Key Energy-Saving Projects to encourage energy conservation, among which we can find initiatives in the areas of public transport and alternative fuels, combined heat-and-power (CHP), surplus heat utilization, green lighting, high-performance appliances, and energy-saving buildings[102]. Altogether, these efforts represented potential energy savings of 240 million Tec between 2005

[100] When the government limits the total level of specific chemical byproducts resulting from private business activity
[101] *Workable Measures Adopted to Conserve Energy and Reduce Emission*, People's Daily, 1 December 2007

[102] State Council Information Office, China's Energy Conditions and Policies, White Paper (Beijing: 26 December 2007), at www.china.org.cn/english/environment/ 236955.htm

and 2010[103].

- Energy Efficiency Benchmarking in Key Energy-Consuming Sectors that, as suggested by the name, has been used to oversee efficiency achievements in specific sectors of the economy[104].

  For example, in the construction sector, the task of saving energy, including connecting thermostats to 150 million square meters of building space, has been allocated to regional governments, while the transportation sector has issued energy conservation plans for railways, highways, waterways, and civil aviation projects[105].

- A Top-1000 Enterprises Energy Conservation Program to encourage the nation's largest energy-consuming businesses to develop energy auditing, report on their energy usage, and prepare conservation plans.

Green development as the Theme - Twelfth Five-Year Plan (2011- 2015)

The period covered by the 12th Five-Year Plan (2011–2015) was an extraordinary time for China's development. In the face of a complex international environment and challenging domestic tasks related to carrying out reform, pursuing development, and ensuring stability, the CPC Central Committee and the State Council united with and led the people of China in exerting themselves and pushing forward with a pioneering spirit[106].

As a result, significant economic and social achievements were made, and the main tasks and targets set out in the 12th Five-Year Plan were fulfilled.

Major progress was achieved in economic structural adjustment. Agriculture grew steadily. The value-added of the tertiary industry accounted for a larger share of GDP than that of the secondary industry.

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[103] National Development and Reform Commission (NDRC), *Medium and Long-term Energy Conservation Plan* (Beijing: 25 November 2004).

[104] NDRC, "Energy Efficiency Benchmarking Implementation Plan for High Energy Consumption Industry" (in Chinese), www.365jn.cn/HTML/17/200903/5.htm.

[105] Ministry of Housing and Urban-Rural Development, "Notice on Accomplishing Energy Saving Goals Set for the 11th Five-Year period" (Beijing: 17 May 2010)

[106] Central Committee of the Communist Party of China Beijing, China*, the 13th five-year plan for economic and social development of the people's republic of China 2016–2020,* Translated by Compilation and Translation Bureau

Even consumer spending continued to rise and disparity between rural and urban areas and between regions has been narrowing. By 2015 permanent urban residents accounted for 56.1% of the total population[107].

Infrastructure improved markedly in all respects and the development of high-tech industries and strategic emerging industries picked up speed.

In addition, the public service system has been basically established and coverage has continued to expand; education levels rose remarkably; public health saw a noticeable improvement and job creation was sustained.

Indeed, the number of people affected by poverty was reduced by a significant margin and the standards of living and quality of life continued to improve.

Finally, further progress has been made in ecological improvement.

The Twelfth Five-Year Plan was China's first green development plan and its historical starting point for green modernization.

The Plan proposed to establish a resource-saving, environment-friendly society and to improve the level of ecological civilization as one of its focuses of development in addition to aim significant reductions in the levels of energy consumption and carbon dioxide emissions as binding indicators.

It introduced four essential energy saving projects, namely: Energy Saving Reconstruction, Beneficial Products that Save Energy, Demonstration of the Industrialization of Energy Saving Techniques and Further Implementation of Energy Management Contracts.

The Plan also proposed seven essential initiatives to recycle economy (ranging from comprehensive utilization of resources to the demonstration of the recycling system of worn-out merchandise) and launched four environmental projects, including city wastewater treatment and construction of garbage disposal facilities, desulfurization and denitrification, heavy metal pollution prevention and control and improvement of the water environment in critical river basins.

Furthermore, it emphasized comprehensive, fair and harmonious sustainable development of the economic system, natural systems and the social system by means of green growth through the promotion of green benefits and wealth, these included average life expectancy, increase in the number of new urban jobs, affordable housing

[107] Ibid.

construction, disposable income of urban residents and pollution reduction.

The Plan aimed to stimulate the transformation of business enterprises and encourage such enterprises to become major players in the area of green development.

Enforcing green planning at the national level and advancing the green transformation of the market were possible through the improvement of price formation mechanism of resource products, the promotion of environmental reform and the establishment of trading mechanism resources along with other policies and measures.

Table 7	**Fulfillment of the Main Target of the 12th Five-Year Plan**			
Indicator	**Target**		**Fulfillment**	
	2015	**5-year average [cumulative total]**	**2015**	**5-year average [cumulative total]**
Economic development				
1. GDP (trillion of yuan)	n/a	7%	67.7	7.8%
2. Value-added of the service sector (% of GDP)	47	n/a	50.5	n/a
3. Permanent urban residents (%)	51.5	n/a	56.1	n/a
Science, technology and education				
4. Nine-year compulsory education completion rate (%)	93	n/a	93	n/a
5. Senior secondary education gross enrollment rate (%)	87	n/a	87	n/a
6. Research and	2.2	n/a	2.1	n/a

development expenditure (% of GDP)				
7. Patents per 10.000 people	3.3	n/a	6.3	n/a
Resources and the environment				
8. Arable land (millions of hectares)	121.2	n/a	124.3	n/a
9. Water use reduction per unit of industrial value-added (%)	n/a	[30]	n/a	[35]
10. Agricultural irrigation efficiency	0.53	n/a	0.532	n/a
11. Non-fossil energy (% of primary energy consumption)	11.4	n/a	12	n/a
12. Energy consumption reduction per unit of GDP (%)	n/a	[16]	n/a	[18.2]
13. CO2 emissions reduction per unit of GDP (%)	n/a	[17]	n/a	[20]
14. Aggregate major pollutant emissions reduction (%) Chemical oxygen demand Sulfur dioxide Ammonia nitrogen Nitrogen oxide	n/a	[8] [8] [10] [10]	n/a	[12.9] [18.0] [13.0] [18.6]

15. Forest growth Forest coverage (%) Forest growing stock (billions of m^3)	21.66 14.3	n/a	21.66 15.1	n/a
Living standards				
16. Urban disposable income per capita (yuan)	n/a	>7%	n/a	7.7%
17. Rural net income per capita (yuan)	n/a	>7%	n/a	9.6%
18. Registered urban unemployment rate (%)	<5	n/a	4.05	n/a
19. New urban employment (millions of people)	n/a	[45]	n/a	[64.31]
20. Urban participants in the basic pension plan (millions of people)	357	n/a	377	n/a
21. Basic state health insurance coverage (%)	n/a	[3]	n/a	[>3]
22. Government-subsidized urban housing (millions of units)	n/a	[36]	n/a	[40.13]
23. Total population (billions of people)	<1.390	n/a	1.375	n/a
24. Average life	74.5	n/a	76.34	n/a

expectancy (years)				

Notes:

1. GDP and personal income growth are computed using comparable prices, while absolute figures are computed using current prices.
2. The 2015 figure for arable land has been updated according to data from the second national land survey.
3. Figures in square brackets are five-year cumulative totals.

Sources: THE 13TH FIVE-YEAR PLAN FOR ECONOMIC AND SOCIAL DEVELOPMENT OF THE PEOPLE'S REPUBLIC OF CHINA (2016–2020), Central Committee of the Communist Party of China Beijing, China

Energy saving and emissions reduction – the 13th Five- Year Plan (2016 -2020)

Efforts made toward ecological and environmental protection proceeded smoothly, and deterioration in the ecological environment was initially contained.

Conservation areas were effectively protected and forest coverage increased to 20.36%; ecological degradation has gradually been brought under control and restored; the natural wetland protection rate of 45% in 2005 has increased to 49.6% and the phenomena of soil erosion, grassland degradation and desertification decreased.

During this period particular importance has been given to the Central Committee headed by General Secretary Xi Jinping that, since the 18th National Party Congress, has remained firmly committed to upholding and developing socialism with Chinese characteristics. It has been bold in putting ideas into practice and adept at making innovations, and has developed a deeper understanding of the laws related to Communist Party governance and the development of socialism and human society. In doing so, new concepts and strategies for the governance of China have been promoted. They will serve as theoretical guidance and a guide to action as the country deepens reform and opening up and accelerates socialist modernization under the new historical conditions.

The Fifth Plenum of the 18th Central Committee of the Chinese Communist Party applied a comprehensive strategic arrangement and disposition in the 13th Five-Year Plan, which features green development as one of the key concepts.

Hence, this plan is another brand-new milestone in China's green development history, promoting first and foremost, that China should "maintain a medium-high economic

growth" and second, that the proportion of the service industry in the GDP is expected to rise, whereas that of traditional industries will fall.

It presents the improvement of the overall ecological environment quality as a core objective for the first time.

The relevant activities it has implemented include boosting the efficiency of energy resource usage; effectively controlling water consumption, construction space usage and carbon emissions; significantly decreasing pollution discharge and forming development priority zones and ecological security barriers.

In terms of the proportion of green development quotas to the total of the recent Five-Year Plans, the 13th increased the number of green development quotas to 10 (33 in practice), compared with the 11th Plan that had 7 (8 in practice) and the 12th, which had 8 (12 in practice)[108].

Moreover, it lists 11 priority green development quotas as an important addition, which will become key quotas to meet for special national programs and help guide various departments in their work, especially for comprehensive management departments (National Development and Reform Commission, the Ministry of Finance, etc.) and ecological environmental departments (the Ministry of Land and Resources, the Ministry of Environmental Protection, the Ministry of Water Resources, etc.).

Another area where China showed its willingness to take leadership role is the green finance, which constitutes a key element of the country's 13th Plan with the aim at building a green financial system, developing green credits, green bonds and establishing green development funds.

Given its enormous potential in further development and four Five-Year Plans, to cover a total of 20 years (2006-2025), China has a long way to go before successfully accomplish the transition from black to green development.

Nevertheless, it is not impossible for the Country to go from relative to complete emissions reduction, to disconnect economic growth from carbon emissions and make a decisive contribution to the process of disconnecting economic growth from carbon emissions on a global scale.

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[108] Angang H., *The Five-Year Plan: A new tool for energy saving and emissions reduction in China,* pp. 226, Science direct, Ke Ai, Advances in Climate Change Research 7 (2016) 222e228. Available at www.sciencedirect.com

Table 8		**Main Economic and Social Development Indicators for the 13th Five-Year Plan Period**			
Indicator		**2015**	**2020**	**5-year average [cumulative total]**	**Type of indicator**
Economic development					
1. GDP (trillion of yuan)		67.7	>92.7%	>6.5 %	Anticipatory
2. Overall labor productivity (10,000 yuan per employed person)		8.7	>12	>6.6%	
3. Urbanization	Permanent urban residence (%)	56.1	60	[3.9]	
	Registered urban residents (%)	39.9	45	[5.1]	
4. Value-added of the service sector (% of GDP)		50.5	56	[5.5]	
Innovation-driven development					
5. Research and development expenditure (% of GDP)		2.1	2.5	[0.4]	
6. Patents per 10.000 people		6.3	12	[5.7]	
7. Contribution of		55.3	60	[4.7]	

scientific and technological advances to economic growth (%)					Anticipatory
8. Internet Access	Households wit h fixed broadband (%)	40	70	[30]	
	Mobile broadband users (%)	57	85	[28]	
Wellbeing of people					
9. Growth in disposable income per capita (%)		n/a	n/a	>6.5	Anticipatory
10. Average length of education received by the working-age population (years) reduction per unit of industrial value- added (%)		10.23	10.8	[0.57]	Obligatory
11. New urban employment (millions of people)		n/a	n/a	>50	Anticipatory
12. Rural population lifted out of poverty (millions of people)		n/a	n/a	[55.75]	Obligatory
13. Basic old-age insurance coverage (%)		82	90	[8]	Anticipatory
14. Rebuilt housing in rundown urban areas (millions of units)		n/a	n/a	[20]	Obligatory
15. Average life expectancy (years)		n/a	n/a	[1]	Anticipatory
Resources and the environment					

16. Arable land (millions of hectares)		123.4	123.4	[0]	Obligatory
17. Increase in land newly designated for construction (millions of hectares)		n/a	n/a	[<2.17]	
18. Water use reduction per 10,000 yuan of GDP (%)		n/a	n/a	[23]	
19. Energy consumption reduction per unit GDP (%)		n/a	n/a	[15]	
20. Non-fossil energy (% of primary energy consumption)		12	15	[3]	
21. CO2 emission reduction per unit GDP (%)		n/a	n/a	18	
22. Forest growth	Forest coverage (%)	21.66	23.04	[1.38]	
	Forest growing stock (billion m^3)	15.1	16.5	[1.4]	
23. Air quality	Days of good or excellent air quality in cities at and above the prefectural level (% of the year)	76.7	>80	n/a	
	Reduction	n/a	n/a	[18]	

	in PM 2.5 intensity in cities and at above the prefectural level missing the target (%)				
24. Surface water quality	Grade III or better (%)	66	>70	n/a	
	Worse than Grade V (%)	9.7	<5	n/a	
25. Aggregate major pollutant emissions reduction (%)	Chemical oxygen demand; Ammonia nitrogen; Sulfur dioxide; Nitrogen oxide	n/a	n/a	[10];[10];[15];[15]	

Notes:

1. GDP and overall labor productivity are computed using comparable prices, while absolute figures are computed using 2015 constant prices.
1. Figures in square brackets are five-year cumulative totals.
2. Missing the target for PM2.5 means the annual average figure exceeds 35μg per cubic meter.

Source: THE 13TH FIVE-YEAR PLAN FOR ECONOMIC AND SOCIAL DEVELOPMENT OF THE PEOPLE'S REPUBLIC OF CHINA (2016–2020), Central Committee of the Communist Party of China Beijing, China

China's energy saving and emissions reduction approach has its own advantage because of the Five-Year Plan. Economic growth rate, industrial structure and energy structure are the three elements that significantly influence the reduction of energy consumption and carbon emissions intensity per unit. The central government use Five-Year Plan to regulate and control the three elements effectively through national goal governance, obligatory index policy and key projects.

The development philosophy[109]

China needs to firmly establish and put into practice a new development philosophy if it wants to achieve the objectives of the 13th Five-Year Plan period, resolve difficulties encountered during development, and cultivate strengths for further development. the development philosophy needs to be based on innovation, coordination, greening, opening-up, and sharing:

- *Innovation: the primary driving force for development*

  Innovation must be placed at the heart of China's development and advanced in every field, from theory to institutions, science, technology, and culture. Innovation should permeate the work of the Party and the country and become an inherent part of society.

- *Coordination: an integral quality of sustained and healthy development*

  While keeping firmly in mind the overall strategy for developing socialism with Chinese characteristics, we need to properly handle relationships between major areas of development, focusing on advancing coordinated development between rural and urban areas, between different regions, and between economic and social development, and advancing the synchronized development of a new style of industrialization, information technology adoption, urbanization, and agricultural modernization. While increasing China's hard power, also its soft power must be improved, striving constantly to make development more comprehensive.

- *Green: both a necessary condition for ensuring lasting development and an important way in which people can work to pursue a better life*

  The Country needs to uphold the fundamental state policy of conserving resources and protecting the environment for pursuing sustainable development, and keeping to a civilized development path that ensures increased levels of production, better living standards, and sound ecosystems. China will move

[109] Central Committee of the Communist Party of China Beijing, China*, the 13th five-year plan for economic and social development of the people's republic of China 2016–2020,* Translated by Compilation and Translation Bureau

faster to build a resource conserving, environmental -friendly society and bring about a new model of modernization whereby humankind develops in harmony with nature.

- *Opening up: vital for China's prosperity and development*
  In adapting to China's ever-deepening integration into the world economy, it will pursue a mutually beneficial strategy of opening up, coordinate the role of domestic and foreign demand in stimulating growth, balance imports and exports, stress the importance of both bringing in and going global, and work simultaneously to attract foreign investment, technology, and talent. A higher level of openness within the economy will be achieved, through the active participation in global economic governance and the global supply of public goods, in addition to seeking a greater say in the institutions for global economic governance, and looking to build more international communities of interests.

- *Sharing: the essence of Chinese-style socialism*
  China must ensure that development is for the people, that it is reliant on the people, and that its fruits are shared by the people. Institutions will be improved to enable the people to have a greater sense of benefit as they contribute to development and share in its fruits, thus increasing unity among the people, and helping them move steadily toward common prosperity.

The pursuit of innovative, coordinated, green, opened, and shared development represents a profound change in China's development effort. This new development philosophy constitutes a joint body of parts internally linked together and an embodiment of the country's thinking, direction, and the focus of its efforts related to development during the 13th Five-Year Plan period and beyond; it must permeate all areas of economic and social development over the coming years.

5.2 China's further key policies

The Five-Year Plans furnish the framework and motivation at the basis of the Chinese political, Social and Economic decisions. Furthermore, their evolution represents the

Country's increasing attention to energy conservation, efficiency and struggle against pollution.
However, further key policies, which have followed the Five-Y Plans guidelines, worth to be mentioned in the context of the "Green Transition".

China unveiled its plan to ramp up renewable energy production in 2004, at the International Renewable Energy Conference in Bonn, Germany. The following year, China enacted its milestone *Renewable Energy Law*, which took effect in early 2006.
This, along with its supporting amendments for implementation, comprises the legal framework for China's renewable energy policies. It covers all relevant regulations, sectorial targets, development plans, fiscal and subsidy policies and national standards[110].
In October 2007, the former President Hu Jintao reported that a Chinese strategic goal is that the country "must adopt an enlightened approach to development that results in expanded production, a better life and sound ecological and environmental conditions and build a resource-conserving and environment-friendly society that coordinates growth rate with the economic structure, quality, and efficiency.[111]"
To achieve this, China has embarked on a comprehensive energy conservation program that covers all major economic and social sectors and has few equals in other countries, developed or developing.
Some of the policies that have been successful in protecting the environment and promoting clean energy are:

The Top-1000 Enterprises Energy Conservation Program

In April 2006, the Chinese government launched the Top-1000 Enterprises Energy Conservation Program, which aims to boost conservation in the country's largest energy-consuming businesses. The program follows relevant provisions under China's Energy Conservation Law and Key Energy Users Energy Conservation Management Measures.

[110] Worldwatch Institute, report 182, *Renewable Energy and Energy Efficiency in China: Current Status and Prospects for 2020,* page 24, Mastny L., 2010
[111] Hu Jintao, *Report to the Seventeenth National Congress of the Communist Party of China*, 15 October 2007, at http://japanese.china.org.cn/english/congress/229611.htm

The "top-1000 enterprises" refers to large businesses with independent accounting in nine energy-intensive industries: iron and steel, nonferrous metals, coal, electricity, petrochemicals, chemicals, building materials, textiles, and paper production. In 2004, China was home to some 1,008 such businesses with individual total energy consumption of 180,000 tce or more. Their combined energy use was 670 million tce, representing 47% of China's industrial energy use and 33% of total energy use.

The main objectives of the Top-1000 Program are: significantly improving energy efficiency, elevating the energy consumption per unit of major industrial product to an advanced international level for that industry, increasing the energy usage of some businesses to the international advanced level or leading domestic industry level, and saving roughly 100 million tce during the 11th Five-Year Plan period (2006–10).

In 2006, China's National Development and Reform Commission signed letters of responsibility for energy conservation goals with roughly 1,000 businesses, setting clear objectives and responsibilities for conservation and holding a series of trainings in energy measurement, energy auditing, conservation planning, and advanced and applicable energy-saving technologies. As a result of these measures, the businesses saved a combined 20 million tce in 2006 and 38 million tce in 2007.

Establishing a high-level leadership was one of the steps at the basis of the country's change.

The Energy Conservation Law

In 2007, the State Council - China's cabinet - set up a leading working group on energy conservation and emissions reduction, headed by Premier Wen Jiabao[112]. At the same time, several Chinese provinces set up similar high-level working groups, headed by senior provincial officials with leadership in energy conservation management[113].

Through this initiative, the State Council called on all provinces to evaluate and assess the progress of these businesses toward meeting the energy conservation targets.

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[112] Worldwatch Institute, report 182, *Renewable Energy and Energy Efficiency in China: Current Status and Prospects for 2020,* page 11, Mastny L., 2010

[113] Ma Kai, *The 11th Five-Year Plan: Targets, Paths and Policy Orientation*, 19 March 2006, at www.gov.cn/english/ 2006-03/23/content_234832.htm, Accessed on July 2017

Then, in October 2007, the Standing Committee of the National People's Congress passed a revised Energy Conservation Law, and in 2008 the government promulgated two new regulations, on Energy Savings in Civil Buildings and Energy Conservation by Public Institutions. It also released mandatory national standards that place an energy consumption limit on 22 energy-intensive products, including crude steel and cement, as well as mandatory national energy efficiency standards for 19 major energy consuming end-use products, including refrigerators.

In addition to regulating industries directly, the government put increased pressure on local and regional officials to better enforce China's energy and climate policies. The revised Energy Conservation Law holds local governments and their officials responsible for implementing the national energy-intensity reduction target (decoupled to the local level), by making completion of the target one of the standards for performance evaluation. Certain regions have conducted similar breakdowns of their conservation objectives and established performance evaluation and assessment systems, including a mechanism for publicly reporting on entities that do not meet the targets.

As an accountability measure, the Energy Conservation and Emission Reduction Statistical Monitoring and Implementation Assessment Plan and Methods, is designed to assess the performance of various regions and businesses in achieving the nation's energy conservation and emissions reduction goals.

The regulations include three main components: (1) a system for evaluating energy consumption per unit of GDP, which aims at strengthening government and corporate responsibility by implementing quantitative assessment and enforcement measures on provincial governments and energy-intensive companies; (2) a statistical index and system for monitoring energy consumption per unit of GDP, which enables the creation of a comprehensive survey of energy consumption and energy efficiency; and (3) a system for statistical analysis, which includes monitoring and evaluating total emissions of major pollutants, such as sulfur dioxide and carbon dioxide; and methods for assessing compliance with emissions-reduction targets[114].

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114 Worldwatch Institute, report 182, *Renewable Energy and Energy Efficiency in China: Current Status and Prospects for 2020,* page 13, Mastny L., 2010

These new regulations are having an effect on the behavior of local governments and officials. Zhejiang province, for instance, now requires municipal and county-level mayors to include the energy-reduction goal as a standard for performance assessment. Shandong and Guangdong provinces also plan to incorporate environmental responsibility into the performance assessments of government officials[115]. In Beijing, the city government has designated the first workday of each month as "Energy Conservation Day," during which all air conditioners and elevators in city governmental offices are powered down and government officials are encouraged to take mass transportation, ride bicycles, or walk to work[116].

The Medium and Long-Term Energy Conservation Plan

Another important policy component of China's energy strategy is the Medium and Long-Term Energy Conservation Plan, adopted in 2004 by the National Development and Reform Commission (NRDC).

It is the second most important strategy to support renewable energy development, after the Renewable Energy Law and it lays out the guiding principles to "speed up the development of renewable energy, promote energy conservation and reduce pollutants, mitigate climate change and better meet the requirements of sustainable social and economic development by 2020"[117].

The plan serves as the guidance for China's future energy conservation work and is the basis for developing energy-saving projects. Its goals are to encourage energy conservation, improve energy efficiency, accelerate the creation of an energy-saving society, ease resource constraints and environmental pressures and meet the overall goal of building "a moderately prosperous society".

The Medium and Long- Term Energy Conservation Plan has focused on energy conservation targets and development priorities along the 2010s and has proposed goals for 2020. When fully implemented, the measure has the potential to save an estimated

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115 *Local Officials' Performance on Energy Consumption and Emission Reduction under Supervision* (in Chinese), http://news.xinhuanet.com/fortune/2006-06/ 19/content_4716056.htm (Accessed on August 2017).

116 Ibid.

117 National Development and Reform Commission (NDRC), *Medium and Long-Term Development Plan for Renewable Energy in China* (Beijing: September 2007)

1.4 billion tce of energy, enough to cover the projected 1.26 billion tce of additional energy production capacity needed during the period 2003- 20.

The Plan's four priority goals are to[118]:

- *Improve national energy efficiency*

  According to the Plan, energy consumption per 10,000 Yuan of GDP (1990 fixed price) should decrease from 2.68 tce in 2002 to 2.25 tce by 2010, registering an annual energy efficiency average rate of 2.2% from 2003 to 2010, with the capacity to save 400 million tce. By 2020, energy consumption per 10,000 Yuan GDP should be 1.54 tce, with an annual energy efficiency average rate of 3% from 2003 to 2020.27

- *Improve the energy efficiency of major industrial products*

  Energy consumption per unit of major industrial products, such as ammonia, steel, cement, and aluminum, should reach or be close to the international advanced standard of the early 1990s by 2010 and reach or be close to the international up-to-date level by 2020.

  By 2010, large and medium-sized businesses should reach the international advanced level for energy consumption of the early 2000s.

- *Improve the energy efficiency of major energy-consuming equipment*

  By 2010, the energy efficiency of new major energy- consuming equipment should reach or approach the international advanced level. For some vehicles, electric motors, and household appliances, efficiency should reach the highest international level.

- *Improve energy conservation management*

  By 2010, China should establish a fairly complete system of energy-saving regulations and standards, policy support, supervision and management, and technical service that is adapted to the country's economic system.

[118] Worldwatch Institute, Report 182, *Renewable Energy and energy efficiency in China: current status and prospects for 2020*

Concerning key stipulations for renewable energy in both the Renewable Energy Law and the Medium and Long-Term Development Plan for Renewable Energy include[119]:

- *National targets*

  According to both plans, renewable energy should account for 10 % of China's total energy supply by 2010 and 15% by 2020. By writing these targets into national law, China has indicated its long- term commitment to the development of renewable energy.

- *Mandatory grid access*

  The Renewable Energy Law stipulates that grid companies have to purchase all of the power generated from renewable energy sources within their coverage areas.

- *Feed-in-tariffs/ Power pricing*

  In July 2009, the NDRC divided China into four regions according to their wind energy resources and set fixed benchmark power prices at 0.51, 0.54, 0.58, and 0.61 RMB (7.4 cents, 7.9 cents, 8.5 cents, and 8.9 cents) per kilowatt-hour, effectively establishing a feed-in tariff for wind power. China is moving gradually toward a system of fixed tariffs for solar PV as well. For ground-mounted PV projects, the government now pays a set price of 1.09 RMB (15.9 cents) per kWh for a 10 MW solar PV power plant, which is nearly three times the rate paid to coal-fired generators but still not high enough to spur a sizable domestic market[120].

5.3 Renewable sources of energy

The Renewable energy sector is the basic mean through which many of the above mentioned policies could be achieved.

[119] ibid. pp. 24.

[120] China Research and Intelligence, *Research Report of Chinese Wind Power Industry, 2009* (Beijing: 18 May 2009).

Its development is strictly linked with both the increase of energy efficiency and the reduction of carbon dioxide and pollution. Hence, setting specific and ambitious targets to this sector is extremely important for China's transition to Green.

Renewable energy sources are growing faster than fossil fuels and nuclear capacity in China.

Although the Country has currently the world's largest installed capacity of hydro, solar and wind power, its energy needs are so large that in 2015 renewable sources provided just a little over 24% its electricity generation, with most of the remainder provided by coal power plants.

Nevertheless, the share of renewable sources in the energy mix had gradually risen in recent years and this phenomenon is not going to stop.

Rather, in addition to the reduction of carbon emissions, a rise in energy intake from renewable sources is considered for energy security.

China's Action Plan for the Prevention and Control of Air Pollution, issued by China's State Council in September 2013, illustrated the government's desire to increase the share of renewables in the energy mix. Unlike oil, coal and gas, subjects to geopolitical tensions, renewable energy systems can be built and used wherever there is sufficient water, wind and sun.

- Hydropower:

  Hydropower is the most widely used form of renewable energy, accounting for 16% of global electricity generation – and is expected to increase about 3.1% each year for the next 25 years.

  The Asia Pacific region specifically generated 32% of the global hydropower in 2010, and China's total capacity is 22% higher than any other countries' install base.

  The chief advantage of hydropower is its considerable cost-effectiveness in comparison with other renewable energy forms. Electricity produced by hydroelectric power is the most cost-effective and stable form of renewable energy, allowing developers to install hydroelectric power without the need for considerable feed in tariffs. This energy source also benefits from flexibility,

with plants being able to adjust their output quickly to adapt to changing energy demands over certain periods.

With the 13th Five-Year Plan policy frameworks, the aim is focusing on increasing pumped storage capacity, with its total volume representing just 1.5 per cent of China's installed electricity capacity at the beginning of 2016. In order to address this shortage, the country aims to reach 40 GW total pumped storage capacity by 2020.

The new Five-Year plan also sets out commitments to emphasize ecological and environmental protection in the development of hydropower, to strengthen international cooperation, and to advance the alleviation of poverty.

In December 2016, China's ministry of water resources adopted 'guidelines on promoting the development of small hydropower plants. The document outlines plans to develop and grow the small hydropower industry in China by 2030 with a respect to environmental protection, focusing on technology improvements and best practices for plant construction, operation and management.

- Wind power:

  As a clean, relatively cheap and reliable alternative to burning fossil fuels, wind power plays an important role in China's energy mix.

  China is the world leader in wind power generation, having the largest installed capacity of any nation and continues its rapid growth in new wind facilities.

  With its large land mass and long coastline, China has exceptional wind power resources: it is estimated to have about 2,380 gigawatts (GW) of exploitable capacity on land and 200 GW on the sea.

  This energy source has identified as a key growth component of the country's economy. Indeed, in 2016, China added 19.3 GW of wind power generation capacity to reach a total capacity of 149 GW and generated 241 TWh of electricity, representing 4% of total national electricity consumption.

  The Country forecasts to have 250 GW of wind capacity by 2020 as part of the government's pledge to produce 15% of all electricity from renewable resources by that year and it has set out a road map for wind power up to 2050 (with power capacity goals of 400 GW by 2030 and 1,000 GW by 2050).

Yet, China fails to take full advantage of its extensive wind power resources. According to the central government, 33.9 GW of wind-generated electricity went unused in 2015 alone — representing nearly 15% of total wind energy generated, valued at $2.77 billion. This wasted energy reflects not only sunk investment and foregone economic benefit, but also a missed opportunity to fight climate change. Wind power in China has the potential to offset billions of kilowatt-hours of electricity generated by fossil fuels, such as coal, that produce substantial greenhouse gas emissions.

- Solar power:

  China is the world's largest market for both photovoltaic and solar thermal energy. Since 2013, the Country has been the world's leading installer of solar PV, in which more than 400 companies now work.

  In 2015, China added more than 15 gigawatts and reaching 43.2 GW of solar capacity, surpassing Germany, fixed at 38.4 GW.

  According to the new projections, it seems that this trend is going to continue and, under the 13th Five-Year Plan projections, China will nearly triple solar capacity by 2020 (adding 15 to 20 GW of solar capacity each year).

- Biomass power:

  Today, biomass is becoming a very significant energy source in China, especially in rural areas, because it is a readily available source of fuel. The country's main biomass resources are agricultural wastes, scraps from the forestry and forest product industries, and municipal waste. Additionally, organic materials like poultry manure, fallen leaves and industrial waste, can be added to the supply mix and converted to biomass energy.

  Modern biomass technologies can increase living standards in rural areas and promote industrialization and the generation of employment. Moreover, they can provide clean, low-cost fuels for heat and power and reduce carbon dioxide emissions.

  The primary focus of China's biomass energy development is on power generation, biogas, biomass pellets and liquid biofuels.

Researchers from the Chinese Academy of Engineering have estimated that if all the available biomass feedstock in China were utilized, it would create the energy equivalent of 1.2 billion tons of coal, more than the entire country's total annual energy consumption.

However, only about 5 % of the total potential is currently being collected on a systematic basis.

Since the Renewables Law has been introduced , more than 260 new biomass projects have been completed providing a considerable 4,870 megawatts (MW) of additional grid-connected power. In 2012, China introduced a law that limits the harmful emissions of nitric oxide and nitrogen dioxide and which forces both old and new power plants to adhere to this policy. Existing biomass power plants, especially those low-tech facilities have, thus, quickly upgraded or been forced to shut down.

By 2020, China aims to have 30 GW of installed biomass generation capacity[121].

Previously, the Clean Development Mechanism (CDM) – which was a key part of the UN's global climate treaty and allows emissions reduction credits related to projects in developing countries to be traded- supported over half of China's biomass generation projects. With the end of the CDM, and a drop in Certified Emission Reduction prices, there has been a decline in the growth of biomass generation projects in the last few years. Yet, although corporations no longer receive the same level of added benefits offered by emission reduction credits, biomass power generation can still be a viable, low-cost, on-site renewable energy option[122].

This energy source's development has been introduced in the 13th 5Y Plan and it is expected that, by 2020, the installed capacity of biomass power will be around 30 GW, with 50 million tons of biomass pellets, 44 billion cubic meters of biogas, 10 million tons of bio-ethanol, and 2 millions of biodiesel used annually.

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[121] Zhao, X., Tan, Z., Liu, P. Development goal of 30 GW for China's biomass power generation: Will it be achieved? 2013. http://www.sciencedirect.com/ science/article/pii/S1364032113002591

[122] The Climate Group (w/t CDP, CREIA, IRENA, We mean business), *RE 100: China's fast track to a renewable future,* 2015

Continued strong expansions of non-fossil energy supply are rendered more likely by: reducing air pollution; improving energy security; and promoting growth in strategic clean-technology industries.

Beyond the electricity sector, there is great scope for improvements industrial efficiency and continued substitution away from coal-intensive production processes in the steel and cement industries, which will likely continue to put downward pressure on coal's share in the overall energy mix.

Oil and gas consumption in China are likely to grow significantly over at least the next decade although there is considerable uncertainty as to the pace of growth and the expected peak year for their consumption.

Oil consumption growth will be driven by rising demand from private and commercial transportation, associated with rising household incomes and economic growth.

Hence, while there are many variables at play, it appears likely that the transformation of China's energy sector will continue and indeed strengthen, to the disadvantage of coal.

However, there are two significant risks that could slow the transformation of China's energy mix over the next decade. In the 'new normal' context, continued strong expansions in non-fossil energy will reduce the market share of existing coal-fired generation. China's energy supply challenge thus shifts from ensuring that all incremental capital stock in the electricity sector is zero or low-carbon to also reducing or retiring existing, high-carbon stock.

This challenging dynamic took place during the slower electricity demand growth and high non-coal capacity expansions of 2014-2015. As coal-fired generation output fell while coal-fired power capacity expanded, the utilization of the coal-fired power fleet has dropped to less than 50%[123]. The falling utilization of coal plants has inflamed disputes among generators and grid operators about which sources should be given priority to dispatch electricity and, therefore receive payments for electricity supplied.

Coal- fired power generators were often given priority over wind and solar generators, leading to high rates of wind and solar cut and more coal being consumed than needed to be.

[123] National Energy Administration, 2015

These disputes will likely intensify in future, due not only to lower energy demand and increased non-fossil supply, but also to the expansion of China's coal- fired generation capacity, which has continued — in fact, it has accelerated — in 2014–15 despite already enormous amounts of excess capacity. The main causal factor behind the most recent expansions appears to be the devolution of authority over environmental approvals from the center to provincial governments, many of which have welcomed the opportunity for short-term economic growth from the construction of new plants with little regard for the long-term productivity of the investment[124].

A second risk is the expansion of coal conversion industries, which produce, for example, synthetic natural gas or chemicals from coal using highly energy, and emissions-intensive processes.

It is unlike the central government approves a large development of coal conversion industries in light of : China's climate change commitments, the dubious economic case for their expansion and the extremely high impacts on local water consumption and air pollution [125], but there is a risk that enterprises and local governments might expand them contrary to central government policy.

These risks suggest the need for various policy responses[126].

First, a series of measures would help to limit the expansion of new coal infrastructure in electricity and industry, including a ban or at least restrictions on new coal-fired power stations and coal conversion projects, recentralized control over approvals and financing, and stringent restrictions on overall coal consumption.

Such moves would also free up capital in the energy sector that could be reallocated to expanding non- fossil energy deployment.

A second priority is to reform the electricity sector operation to ensure that the lowest-carbon and most efficient electricity generation sources are given priority to dispatch electricity into the grid, implementing the so-called 'green dispatch'. This would help to ensure non-fossil generation sources to be prioritized over fossil generation, and that gas and more efficient coal- fired generators are prioritized over less efficient coal generators.

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[124] Myllyvirta, Shen & Lammi, 2015

[125] Ding et al. 2013; Ottery, 2014; Sheehan et al., 2014; Yang & Jackson, 2013

[126] Green F., Stern N, *China's changing economy: implications for its carbon dioxide emissions,* pp. 19, "LSE Research Online", 2016, Available at 10.1080/14693062.2016.1156515

A third useful policy would be the increase of effective carbon prices on fossil fuel energy sources, especially coal.

Even tough generators cannot pass through carbon price costs onto consumers, effective carbon pricing would alter the economics on the supply-side in ways that would disadvantage high-carbon generators and support green dispatch[127].

[127] ibid.

CHAPTER 6

Obstacles to the Green transition achievement

As the world's largest developing country, China has significant domestic market potential for renewable energy and energy efficiency. The development if these two sectors, already crucial for the country's green transition, will get further importance in the near future, when population and income levels will grow, leading domestic energy consumption to surge.

So far, the Chinese various plans and measures have highlighted the leadership's willingness to improve the environmental conditions and contribute to global sustainability.

However, the ultimate impact of such measures depends on their effective implementation and, despite the efforts made, the current governance model is imposing considerable obstacles to its realization.

If China really aims at achieving greater energy efficiency and developing renewable sources, there are some priorities it should refine:

a. **Give equal weight to both the scale and quality of renewable energy development**[128]

   The early development of renewable energy in China has benefited greatly from preferential policies. As the pace of development has accelerated, however, many industries in both the energy efficiency and renewable energy sectors have experienced blind expansion. Rather than focusing its actions on merely attracting investment and expanding scale, the government should pay equal attention to the quality of development. One important step is to formulate effective product quality standards and to establish a national testing and certification system for renewable energy and energy-saving products. Although

[128] Worldwatch Institute, report 182, *Renewable Energy and Energy Efficiency in China: Current Status and Prospects for 2020,* page 11, Mastny L., 2010

China is pursuing some pilot projects, there is a need to establish nationwide standards and to improve the current certification system.

b. Enact long-term, stable fiscal policies[129]

To finance renewable energy development, the government should establish additional energy efficiency and renewables funds, raising support through such sources as a special earmarked fund, an energy efficiency levy, renewable power surplus fees, and a "special tax" on fossil fuel consumption (essentially a carbon tax levied on fossil energy consumption).

It should also reform the pricing and taxation structure for both energy resources generally and the renewable energy sector specifically, to reflect their full environmental costs. This will help create a "win-win-win" situation for manufacturers, sellers, and users of energy efficient and renewable energy equipment.

c. Allow for sufficient market competition[130]

China should establish a sound market mechanism for energy efficiency and renewable energy to encourage industry concentration and consolidation and to improve economies of scale. This would help prevent large manufacturers from dominating the market and nurture small firms that can serve less profitable market segments, allowing for a more diverse and healthy market. China should also increase transparency in the national bidding process, creating a fair environment for competition to enable the introduction of high-quality products and to encourage renewable energy development. The government should continue to encourage contract energy management, such as through energy service companies, to accelerate development of the energy-saving service sector.

d. Direct more effort to the basic work of resource assessment and statistics[131]

China currently lacks reliable data on both its renewable energy resources and its overall energy consumption—information that is indispensable for further developing renewables and improving energy efficiency. In particular, the

[129] ibid.
[130] ibid.
[131] ibid. pp. 41

country should carry out a thorough assessment of its solar and wind resources to provide a basis or national planning and to improve on past assessments. It should also enhance statistical work on energy consumption and energy efficiency in buildings, transportation, and key industrial sectors to provide a basis for conservation planning. In addition, special focus should be given to the tracking and analysis of energy efficiency in power-consuming equipment.

e. Support the creation of a large talent pool for development of the renewable energy and energy efficiency sectors[132]

At present, China's talents do not meet the demand from its industries. A sound, need-based mechanism is needed to nurture talent in a variety of professions, including energy auditors and energy- saving managers in companies, financial analysts for energy saving and renewable energy, bank staff for energy saving and renewable energy loans, skilled technical workers, R&D and innovation personnel, and strategic decision makers. A sound system is also needed to nurture and introduce talent through training, exchanges, and university education to ease the current constraints on the renewable energy and energy efficiency sectors.

As global climate change attracts increasing attention, the twin solutions of improving energy efficiency and developing renewable energy sources are receiving unprecedented attention worldwide.

Tackling climate change is a global undertaking that cannot be solved by a few countries alone. As effective solutions, renewable energy and energy efficiency require concerted efforts from all players, working both alone and in partnership. As countries strengthen the exchange of information and technology and break technical and trade barriers, this will help bring more capital and advanced technology to China. By embracing its huge potential for technology transfer and diffusion, the country can more rapidly realize its energy conservation and emission reduction targets and effectively address the climate threat.

Already, China's active improvement of energy efficiency and development of

[132] ibid.

renewable energy are having a significant and far-reaching impact on global sustainable development. Through its efforts to conserve energy and reduce emissions, China is improving the living environment of its own people. It is also creating the world's biggest market for energy efficiency and renewable energy industries, contributing to the recovery of the global economy after a severe financial crisis.

Over the long term, China's development path will have a significant impact on global economic trends. The country is now actively exploring a low-carbon development path that hinges on energy efficiency and renewable energy. If a low-carbon economy can be developed and extended in China, it will set a model for other countries to follow.

There are key areas that the Asian leaders should reform if they really want to build an ecological civilization for the wellbeing of the country and the globe.

f. Changing the relative power dynamic between the state and society[133]

To begin with, private actors have to be truly empowered and engaged in governance. Similar to its path of economic takeoff, China's achievement in environmental policy can be attributed to the state's strong presence, namely top-down approach through command-and-control mechanisms led by Beijing. However, this approach has shown its limits as private actors- business, NGOs, and the public- have few opportunities for formal participation in the political process[134].

As local government often prioritize economic growth over environmental protection, the frequency and scale of environmental protests are quickly increasing across all China, in both urban and rural areas[135].

Hence, for having a sustainable future, China can no longer rely on its previous mode of governance led by the state, with little support from business and civil society. Instead, the government needs to private capital and finance its pollution control and energy transition of civil society for further transparency. While

[133] Sun Y., *The changing role of China in Global Environmental Governance*, "Graduate Institute of International and Development studies", pp. 48, 2016
[134] Economy, 2014
[135] Albert & XU, 2016

most plans implemented so far include an element of enhancing public participation, reforms in this respect seem insufficient.

For instance, civil society is tightly controlled by the government so that environmentalism as a mass movement is still in its infancy. Although the Chinese government is increasingly responsive to public pressure on environmental issues, it remains concerned that activism could lead to a broader push for political reform[136].

Another example is the fact that on green finance, China has not established a credible third-party verification system to evaluate whether or not projects are eligible as "green". Such a system is necessary for a successful green financial system and the engagement of private actors including auditors, standard-setting institutions and rating agencies.

Furthermore, awareness of climate change in China has been growing over the past few years both among leaders at different levels but equally importantly among the public. However, the top-down approach is still very prevalent in China. Any incentive for increased response to the climate issue must therefore be initiated from the central government, and the opportunity for bottom-up initiatives is still very limited[137].

g. Reforming fragmented governance structure[138]

Moreover, the Chinese government must structure both horizontally and vertically its fragmented governance system to carry out unified policy management.

On the one hand, the poor track record of China's environmental performance is often caused by overlapping authority across different government agencies. Taking the example of water pollution, the relevant regulatory responsibility is shared by various ministries, including Ministry of Environmental Protection responsible for pollution prevention and control, Ministry of Water Resources in charge of protection of land-based water resources, State Oceanic

136 Economy, 2013

137 Handling K., Han G, Olsson M., *A balancing act: China's role in climate change,* page 45, The Commission on Sustainable Development 2009

138 Sun Y., *The changing role of China in Global Environmental Governance*, "Graduate Institute of International and Development studies", pp. 49, 2016

Administration if the pollution concerns seawater, Ministry of Housing and Urban-Rural Development taking care sewage treatment plants, and Ministry of Agriculture overseeing water pollution from farmland.

It is therefore of paramount importance to formally set a unified governance system led by one leading agency to coordinate the actions and prevent slackness.

On the other hand, unified management across substantial units is also critical to the effectiveness of governance. In this respect, China's decentralized authoritarian system, which lacks enforcement by the central government, seems "highly damaging" to the environment. Indeed, pollution often affects different administrative units at the same time, so the government needs a unified approach to ensure the adoption of control measures in the whole polluting area while preventing free riding.

h. Raising public awareness on the broader issue of sustainable development[139]

Finally, an efficient governance system should be based on public awareness about environmental protection and more broadly sustainable development. While the Chinese leadership has put sustainable development high on the government's agenda, many Chinese citizens still lack a through understanding on environmental impacts of their behavior. Indeed, most participants in environmental protests only care about their local situation, instead of the overall environment.

A growing public environmental awareness has the potential to accelerate China's green reforms by leading consumers to choose environmental-friendly or energy-efficient products over conventional ones. Such changes in people's daily life can provide further impetus through supply chains to the transformation of China's development model. More broadly, market pressure as well as environmental awareness of business leaders can push companies to be more socially responsible.

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139 Sun Y., *The changing role of China in Global Environmental Governance*, "Graduate Institute of International and Development studies", pp. 49-50, 2016

Another critical issue lacking attention in China is the impact of China's development on natural resources beyond its borders. The continuous expansion of its domestic market has made China the world's largest importer and consumer of many commodities and thereby negatively affects the environment in other developing countries. For instance, by accounting for half of all trade in illegal wood-based products, China's growth indirectly exacerbate deforestation in Africa and South Asia. Similarly, China's growing meat consumption is causing increasing land clearing for soybean plantation in Brazil.

Nonetheless, most Chinese know little about such consequences of their rising standard of living, and consequently lack incentives to push the government taking responsibility or change their own consumption behavior. Therefore, raising public awareness about China's environmental impact on other countries is a necessary part of the solution for the depletion of global natural resources.

i. Improve enforcement

Even though the laws to protect the environment appear well conceived in general, and the government has set up an administrative structure for environmental protection, the central government has failed to achieve its environmental policy objectives. One reason for this failure is that local governments interested in economic development of their region often allow pollution to occur illegally in order to promote a higher rate of economic growth and the central government cannot control them.

Local government officials benefit from higher levels of output in their region because they receive credits for economic development and sometimes bribes from polluting producers.

In April 2007, Premier Wen Jiabao gave the following example of failure to meet targets to protect the environment: " the challenge of reducing energy consumption and greenhouse gas emissions has proved arduous as China's economy grew 11.1% in the first quarter [of 2007] but power consumption surged 14.9%. Energy consumption as a fraction of GDP fell only 1.23% in

2006, well short of the annual goal of 4% [as stated in the 11th Five-Year Plan of 2006–2010].”[140]

The central government has recognized this problem and has updated its policy for evaluating the performance of local government officials to include their record on environmental protection.

On 28 October 2007, the National People’s Congress enacted the Law on Conserving Energy, which states that work on energy conservation carried out by local government officials should be integrated into the assessment of their political performance along with output growth.[141]

6.1 Fostering the deployment of renewable sources

Reaching higher shares of renewable energy use also has an important role to play in meeting China’s policy objectives in respect to job creation, new economic activity and a better trade balance.

At the beginning of the 2000s, China decided to boost the development of renewable energy through energy policies and industry policy measures.

This brought the country to be a global leader in renewable energy although, before realizing its full potential, it must overcome a number of further challenges and barriers.

There are a number of policy recommendations that might help accelerating the deployment of modern renewables in China and to account for some of the requirements during the transition period[142]:

A. Renewable energy policy

- Develop a comprehensive national energy plan that accounts for the needed infrastructure for transmission and distribution of electricity, heat and gas
- Introduce taxation, caps and/or CO_2 trading systems to account for the damage of CO_2emission and other air pollution from coal combustion
- Assess the socio-economic, energy security, health, land and water use impact of various technologies

[140] People’s Daily 2007
[141] National People’s Congress 2007
[142] IRENA, *Renewable Energy Prospects: China.* Remap 2030, a Renewable Energy Roadmap, 2014

- Set targets for renewables in manufacturing, buildings and transport

B. Power market design

- Establish national power market, creating incentives for flexible operation and bringing in new investors
- Develop the grid to better integrate renewable energy, enhance trade and deal with variability

C. Technology focused policies

- Enhance government support for innovation, research and development to reduce renewable energy costs
- Support development of next-generation renewable energy technologies
- Improve knowledge and data collection on biomass and develop a working biomass feedstock market

In addition to these high-level policy recommendations, other detailed advices to the IRENA[143]'s country analysis of policy action were grouped. These are:

I. Planning transition pathways

- Diversify technology deployment to include options which are being deployed slowly today, including offshore wind, CSP, large biogas and waste to energy
- Largest cost reductions and power system market re-design for the short term, and integration of large shares of renewables into the system for the long term
- Ensure grid development as part of the development strategy for renewables
- Cooperate with neighboring countries in grid integration to allow renewable electricity trade (e.g., wind and solar with Mongolia, hydro with Siberia and South East Asia)

[143] International Renewable Energy Agency, 2014

- Continue to focus on renewable energy use for end-use sectors and expand target setting

II. Creating an enabling business environment

- Allow prices to reflect the marginal cost realistically (i.e. spot markets, day/hour ahead markets)
- Continue using subsidy schemes until technologies reach a mature level, in a way that supports cost reduction and efficient use of renewable energy
- Revise renewable power subsidies to enhance effectiveness by rewarding both construction and operation, reach power generators in a timely manner and avoid delays in reimbursement

III. Ensuring smooth integration of renewables into the system

- Ensure economic incentives for flexible operation of thermal power plants and grids
- Develop solutions for pumped hydro business as part of the power sector market reform
- Strengthen decentralized solutions, notably for rooftop solar PV, including leasing models and policies such as net metering and smart grids
- Improve planning and organization to stabilize biomass feedstock supply and improve feedstock logistics
- Improve planning for effective utilization od straw residues as an energy source

IV. Creating and managing knowledge

- Support the building of qualified human and institutional capacity for deployment of renewables and related infrastructure
- Improve data collection as well as the quality of biomass statistics

V. Unleashing innovation

- Assess best practice technology and policies abroad and evaluate their applicability to China conditions
- Consider biomass co-firing and waste use in coal-fired power plants
- Explore options for advanced biofuels and develop innovative solutions for energy-intensive industries that account for large industrial energy use share
- Strengthen renewable energy use in newly constructed building in cities

Environmental governance is critical to China's future because better environment and cleaner energy are helpful to restoring the government's legitimacy, moving towards a sustainable model of economic growth and building an image of responsible rising power.

While these changes seem encouraging, the actual impact of China's actions remains highly uncertain because of many challenges in the policy implementation.

CHAPTER 7

New Systems for Development

In traditional "black" development, rapid development of the human economic system depends on uncontrolled use of resources obtained from the natural system that leads to the emission of large quantities of pollutants and ecological deficit. In the green development, instead, the growth of the human economic system is completely decoupled from resource consumption and pollution emissions. At the same time, humanity invests in natural capital by ecological planning, pollution control, forestry and water conservation, among others, to establish an ecological surplus.

In the previous Chapter, those policies and market adjustments that, whether implemented, would help China in the transition to a green multisectoral transition have been highlighted.

Giving play to the leading role of economic, natural and social reforms, this chapter aims at emphasizing the main changes which have characterized these sectors since China decided to turn Green.

7.1 Green Development Systems: Social, Natural and Economic

The green development is a system that does its best when the elements of which it is composed (social, natural and economic) work in synergy and harmony.

Going from "black" to green development entails the comprehensive transformation of the system by the social (from unfairness to fairness), natural (from ecological deficit to surplus) and economic (from black to green growth) points of view.

These are accomplished though the achievement of specific goals, which are different according to the systems.

The goal for the social system[144], for instance, is to move to a system of human development based on fairness rather than unfairness, in which humanity is both the driving force and the purpose of development.

[144] Hu A., *China: Innovative Green Development,* pp. 42, Springer, second edition, 2017

Indeed, while the traditional path was at the expenses of future generations, the green system focuses on the care of vulnerable groups and on equity between contemporary and future global populations.

The main objective for the economic system, instead, is to change the aim of development from maximizing growth to maximizing net welfare. In the early stages of economic development, too much emphasis is put on the expansion of the scale of the economy, but this ignores the quality of growth and its development costs. The later stages, contrarily, do not simply focus on the scale of growth, but consider its quality and its development costs. The objective becomes maximizing the net welfare of the economic system, i.e., by maximizing growth in terms of green GDP, which includes both the quality and quantity of growth, with deduction of various development costs (resource, ecological and social costs).

The ultimate goal of green development is the overall greening of the natural, economic and social systems.

From a linear to a circular economy

Industrialization has everywhere meant an enormous increase in the scale of usage of raw materials and the components fashioned from them.

The traditional "Western" linear model of the economy, in which raw materials come in at one end and wastes go out at the other reflects a long-standing assumption that nature has limitless supplies of resources and limitless capacity to absorb wastes. For instance, the usual classification of water was divided between fresh or salt water but now it has also to include "sweet water", as more and more industrial sweeteners used in food penetrate the environment and permanently modify its composition[145].

This, basing its profits on the use of fossil fuels (and oil in particular), has encountered several problems over the last decades.

Finding a way to curb the relentlessly increasing throughput resources, with their damaging extraction at one end and the problems created by their disposal at the other, is now the subject of the second major revolution that is transforming our system of industrial capitalism. It is changing the economy from a linear to a circular construct, which means that wastes from one process can be transformed into inputs to another.

[145] Mathews J.A. (2015), "Greening of Capitalism. How Asia is driving the next great tranformation", Chapter 5, *Stanford University press*

In contrast with this linear economy, the concept of *circular economy*[146] has developed, mainly in Germany, Japan, and China.

This type of economy can be considered as a circular material flow, in which the output of one process becomes the input for another process, within the same organization or through inter-organizational linkages. It can also be called *regenerative economy*, because resources are regenerated within each iteration of a cycle or a *close-cycle economy*, because it operates with closed-loop cycles of materials.

Germany has been one of the pioneers of the closed-loop economy, enacting legislation as early as 1996 in the Closed Substance Cycle and Waste Management Act, which introduced the concept of product responsibility to German manufacturing industry.

In Japan, the government has coordinated the activities of leading corporations through the Ministry for Economy, Trade and Industry so that regulatory requirements reducing resource throughput, reusing materials and recycling components have been extended from one industry to another.

China, as the latecomer, has learnt from these practices and gone beyond them, with its pressing need to solve the problems of poor resources and toxic wastes, it promotes the concept assiduously through its national planning system overseen by the National Development and Reform Commission.

China adopted a law for the promotion of the circular economy in 2008, modeled on the Japanese legislation, but it has taken the concept further, adopting it as a national development goal.

The country is setting itself ambitious targets in terms of energy and materials efficiency and, in order to achieve them, it is specifying a range of means, including the implementation of circular economy, through interconnecting the chains of resource and energy utilization so that wastes from one process can be captured and used as raw materials for another, with energy generation being shared along the value chain.

This makes the idea of the circular economy far more ambitious and effective than mere recycling, which simply calls for the redirection of expended articles from waste to industrial input. The circular economy, instead, envisages the interconnection of all industrial processes, particularly those that lead up to the final product.

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[146] Neumayer (2003) captures this argument neatly in the idea that the neoclassical production function, with its absorption in notions of substitutability, can provide only a weak concept of sustainability and that real sustainability calls for a different and deeper approach

In the mid-2008, the Chinese People's Congress passed a national circular economy law, the Law for the Promotion of the Circular Economy. While inspired by legislation in other countries, such as Japan and Germany, the law in China seems to be the first in the world putting circular economy as a national strategy of economic and social development. It provides a framework within which incentives and disincentives may be developed, at multiple levels, to encourage firms and municipalities to take eco-industrial initiatives and for the creation of networks of by-product exchange. This framework was incorporated into the country's Twelfth Five-Year Plan.

China creates a new model of How the Economy works

The 20th century witnessed the first fundamental changes in industrial production systems, from craft production to mass production systems. Then, in the postwar period a second fundamental transformation was driven through the lean production system. Now, in the 21st century, the third industrial transformation is occurring and it might dub the circular production system[147]. If the USA was the pioneer of the first (MPS) and Japan of the second (LPS), China is the uncontested leader of the third (CPS).

China, indeed, may be defined as the most pragmatic exponent of circular and eco-responsible thinking, even though it struggles with the worst forms of industrial pollution.

This is the "green and black" paradox of China and its national leadership seems to have understood the unsustainability of the past path, promoting resource recirculation, after the pattern of the 3Rs (reduce, reuse, recycle).

The eco-initiatives carried out have been seen as a key part of the solution for China's battle in addressing its environmental problems while maintaining its economic growth. The goal of the eco-initiatives is to eventually establish a circular economy at three levels: at single enterprise or group of enterprises level, enhancing energy and resource efficiency (cleaner production); at cluster or supply-chain level, where a group of collocated firms share certain streams of resources and energy and so enhance their collective energy and resource efficiency and at the whole city or whole municipal area level, in which recycling and interconnected processes are promoted through economic and administrative incentives.

[147] Pearce D., *Blueprint for a Green Economy,* 1989

The transition to a green economy

If it is true that there is under way a vast transformation of the global economy, toward a new set of rules and institutions favoring renewables over fossil fuels, and resource recirculation over the linear economy, as well as eco-finance over generic finance, then it will have to involve an equally vast disruption to political and economic institutions that are already in place. The green economy will bring new economic and entrepreneurial forces into play, creatively destroying the established industrial order.

The green economy refers to a new market-oriented economic form aiming at economic and environmental harmony as part of overall green development. It constitutes a form of development in which industrial economy is adapted to human environmental and health needs.

The term "green economy" contains two meanings: first, the greening of the entire economic system, i.e., the reduction of energy and resource consumption, pollution emissions and carbon emissions; second, the increasing proportion of green economy in the overall economy, i.e., the relative amounts of green technology, green energy and capital-driven low-power industry increase to adapt to human health and environmental protection throughout the entire economic system.

The fundamental aspect of the transition to new green sectors is that reduce costs drive rapid diffusion, and so cost reduction must be the highest policy priority.

Diffusion of renewables, low-carbon and low-waste technologies is held back while their costs exceed fossil-fueled technologies and carbon-intensive products and processes. However, the technologies needed for the shift to renewables have all been invented and many are already out of patent protection. The process of diffusion depends on the speed with which new industries producing the new technologies can be built and new markets for utilizing them can be created.

Nevertheless, as grid parity is approached, fundamental policies are needed to drive diffusion faster. This is where market mandates and direct support policies, such as feed-in tariffs as well government procurement, play a significant role.

Governments can make the difference in promoting a new sector simply by stating a target for substitution, as in the case of China's targets for electric power to be generated from renewable resources, where this technique is widely practiced.

By simply making such a statement and backing it with policies to make it credible, governments can reduce the risk and uncertainty associated with investing in the new sector.

The expansion of the economic green sector and the weakening of political opposition from traditional energy and commodities firms can be seen as a political advantage. This is what was achieved in the case of the *Renewable energy sources Act* in Germany, as the system of feed-in-tariffs created new entrepreneurial opportunities for promoters of renewable energy projects. Likewise in China, the *Renewable Energy Law* and *Circular Economy Promotion Law* are achieving a similar result, opening up economic space for entrepreneurial opportunities.

The experience in Germany and elsewhere reveals how effective feed-in tariffs can be in promoting the uptake of renewable energies. These work by encouraging independent power producers to invest in REs and connect up to the grid, knowing that they have a guaranteed right to so connect at a guaranteed tariff or price. Feed-in tariffs are actually very efficient policies in driving conversion to renewables when computed according to wattage generated per dollar expanded, because they promote improvements in productivity by rewarding the improver, who continues to receive the mandated tariff. Yet, this highlights at the same time an intrinsic weakness, that is they do not build in cost improvements in graduated reductions of the tariff to be paid, resulting in the possibility to result in overpayments and declining political support for such policies. The answer is to build a down-escalator clause (tariff digression) into the contracts, requiring the tariffs to decline by a certain amount each year.

Conclusion

Modern world is the product of industrialization and it is industrialization that all countries now seek to achieve as their highest priority.

Since ancient times in China there has been a unity between nature and humanity. Having respect for nature, protecting nature, and conforming to the laws of nature have long been mainstream elements of traditional Chinese culture.

However, since the New China developed, it became the fastest-growing economy and the most populous country in the world, starting to place enormous pressure on its fragile environment.

Today, China is the global largest emitter of greenhouse gases and pollution, burning half of the coal consumed in the world and it finds itself at a turning point. On the one hand, it faces an unprecedented ecological crisis as well as the tremendous challenge of climate change; on the other hand, it is also on the verge of the fourth industrial revolution- that of an innovative green economy and ecological civilization.

Throughout the historical development of the Chinese policy and economy, the Thesis underlined the starting point of environmental degradation in the Country.

While the Western predecessors took centuries to modernize and build up industries, China has undergone an equivalent process in just a few decades. The incredible economic growth that had characterized the Country since the 1980s, increased at most after it became a member of the World Trade Organization in 2001. The Communist Party saw a surge in investment in manufacturing activities for export, which called for huge expansion in coal-fired power generation and oil and gas industries.

During this period, however, China added further complexity to the already challenging task of managing domestic energy intensive development and global climate change mitigation and it soon realized that this development model was becoming unsustainable both by the political and economic point of view. The Chinese population started to complain about the dangerous conditions of air, water and land, especially since they have provoked premature deaths and birth defections. In addition, the old model became unfavorable in a conventional economic sense. As demand in many parts of China's construction and heavy industrial sectors passes saturation points, continued

political-economic incentives to invest in these areas have resulted in widespread excess capacity and diminishing returns on capital, undermining their competitiveness and resulting in weak productivity growth.

These are only two of the numerous reasons at the basis of the Communist Party's decision to implement the green transition.

Resources and energy, ecology and environment, carbon emissions and climate change have turned to be some of the biggest roadblocks and limiting factors for the development of China's economy and society.

In the face of these challenges, the Country has responded positively by constructing a green development concept and a modern framework while setting in motion an unprecedented revolution of green energy, manufacture, consumption and innovation. After the first four Five-Year plans, China has become a pioneer in green development and the biggest green energy country in the world.

Green development is a "no regrets" strategy; it offers a range of tangible benefits apart from its saving in terms of carbon emissions. Indeed, even though dangers of global warming turn out to be overstated, China would in any case accrue enormous advantages by adopting green strategies, simply in terms of their offering of greater security, resilience and development potential.

Therefore, China and the world have everything to gain by governing with a renewable energy and circular economy goals and little, if anything, to lose. What they "lose" is the prospect of endless war over fossil fuel resources, endless pollution and waste generation and dwindling of energy resources as supplies peak and prices spiral out of control.

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Summary

Modern world is the product of industrialization and it is industrialization that all countries have sought to achieve as their highest priority.

Since the 19th century, distinct types of industrial revolutions have taken place, as a result of different combinations of strategic production functions.

The first industrial revolution created the "steam age" (1760-1840) and marked the transition from agricultural to industrial civilization, from the muscle power to the use of coal as the prime energy source. Thereafter, in the "electric age" of the second industrial revolution (1840-1950), heavy industries - such as electricity, steel, railways, chemicals and automotive - arose and oil started to be used as the new energy source. This revolution promoted the rapid development of transportation, both within and between countries, and a globalized international political and economic system gradually emerged. After two World Wars, the third industrial revolution gave rise to the "information age" (1950-2000).

These marked unprecedented phases of human development and led to the occurrence of the so-called "Great Divergence" between the West and the "rest", based on economic, social and political disparities.

Indeed, this period accounted for the current distribution of wealth and power that has seen the West in a favorable position during the last three hundred years.

This condition lasted until the second half of the 20th and the beginning of the 21st centuries when, thanks to incredible efforts made to industrialize underdeveloped areas, the first signs of the "Great Convergence" were starting to be seen, as China employed catch-up strategies to bridge the gap with the Western leaders.

With the funding of New China in the 1950s and the beginning of reforms and opening-up, Chinese economic development went into overdrive, continuously shrinking the huge gap with Western countries that developed during the first and second revolutions.

Industrialized countries' traditional development presented two distinct features whether in Europe, in the United States and in Japan, despite their different national and development conditions. One was that high-speed growth is sustained by high consumption of resources (especially non-renewable resources); the other was that the

high-speed growth is stimulated by high consumption of the means of subsistence (the traditional model). China, instead, had different conditions and could not realize modernization by following the traditional model, because of numerous reasons.

- First, when Europe, the United States and Japan launched industrialization, they took an active part in international trade and linked themselves with the world market, accumulating industrial capital and opening up the international market through war and colonization. On the contrary, China had endured a hundred years of suffering before opening its doors and its exports product mix, principally primary goods, playing an unfavorable role.
- Second, industrialization has come very late in China, with a subsequent large gap with industrialized countries to bridge in production technology, development and resource use.
- Third, China's per capita resources were less than a fraction respect in Europe and United States.
- Fourth, China has always been an extremely populous country.
- Lastly, it was impossible to realize past models of capital accumulation by waging wars and plundering resources from other countries, as the industrialized economies did. China must rely on internal reform and development.

Between 1949 and 1978, China basically achieved its initial goals of industrialization that were advanced in the 1950s and 1960s. The country started its development path by implementing a conventional resource-intensive and fossil-fueled model.

It established an independent and relatively complete industrial and economic system, laying the foundation for the development of industrialization and achieving the highest economic growth in history.

With the aim of transforming China into a modern, powerful, socialist nation in the long run, the Chinese Communist Party promoted massive investments on heavy industry, which set the country on the road to black industrialization, characterized by high input, consumption and emissions.

By the end of the Maoist era, China had become the world's third largest consumer energy, with industry accounting for 60 % of the Chinese energy demand, the transport sector for 7 % and residential and commercial sectors for 28 %.

On the eve of the 1978 reform and opening up, China was the fourth largest energy producer in the world, after the USA, Saudi Arabia and the Soviet Union. Its energy mix was more diversified than it had been in 1949, consisting of 75% coal, 17.5% oil, and 5.5% natural gas and 2% hydropower.

The development trend continued even with the transition to the 21st century, witnessed by China's increase in total energy consumption (from 1.470 million tons of coal equivalent (Mtce) in 2000 to 4.260 Mtce in 2014, which was covered by 70% coal until 2009.

To this day, China burns 50% of the world's total coal consumption, more than the amount of the U.S., Russia and India combined.

Nevertheless, in addition to fossil fuel production, the increase in demand for oil products, natural gas and electricity over the past two decades is striking. The Country has also become the largest oil consumer and importer, with a significant boost between 2000 and 2005, when demand for oil reached one-quarter of the total, and in 2016 when it increased of 11.5 million barrels, over a half million-barrel more than in the previous year.

Since the past century, China's economic miracle has been fuelled by cheap coal, like the Western world's industrialization during the 20th century was driven by oil. This was a key reason for China's exceedingly high-energy intensity and it is at the heart of the country's current carbon emissions' intake and health related pollution problems.

Indeed, despite the numerous benefits, the development process has also led huge and invisible costs.

According to the U.S. Department of Energy database's figures, from 1800 to 1900 northern countries were responsible for over 90% of global carbon dioxide emissions; of that proportion, 70% was due to European countries, and the United States accounted for 23.6%, while from 1900 to 2000, northern countries were responsible for 50-90%.

Yet, also China's rapid economic growth, along with the greatest industrialization and urbanization in history, has produced considerable consumption of energy and resources, high emissions of industrial pollution and damage to the environment.

The Country's urge to develop was such that it implemented successful and cheap early reforms to become a great superpower, but it ignored the ecology and focused only on short-term profits.

This led to an expansion in the area of land under cultivation and increased the speed of deforestation, soil erosion and desertification and stimulated an economy's reliance on coal-fired power and heavy industrial production, which have all contributed to provoke the most widespread and severe ecological destruction in history.

Since the 1990s, China has been a major producer of greenhouse gas emissions, and its proportion of the world's carbon dioxide emissions has rapidly raised: 8.08 % in 1980, 11.3% in 1990, 19.16% in 2005, when it surpassed the U.S. as the largest emitting country.

As the new century began, the "business as usual" way of growth started to emerge as unsustainable in the long term. China could no longer follow the old model of heavy industrialization with its high-energy consumption, pollution emissions and low resource efficiency; also, it could not imitate the modern mode of high consumption, high expenditure of resources and pollution emissions.

The only viable way forward is to be inventive and to innovate the path of green development, even though there are worries about how to fuel China's future growth as well as international concerns about escalating carbon emissions.

The emerging of energy security concerns has driven China to promote ambitious carbon mitigation policies, not merely because of an economic necessity, but for a matter of political survival. Indeed, it was essential in order not to jeopardize the legitimacy of the Chinese Communist Party, which depends on its ability to deliver continued reform and development.

The Chinese leadership has put a new emphasis on the energy mix in China, with the aspiration of achieving a greener and more efficient energy system, through a focus on conservation, renewable power, and on the shift toward natural gas as the principle primary energy source, in the place of coal and oil. The contribution of natural gas to total energy consumption increased from 2.2% in 2000 to 6.2% in 2014 and the share of other energy sources increased from 6.4% to 10.7% over the same period.

Furthermore, the combined government policy requirements for improving air quality and lowering CO_2 emissions have driven a series of reforms that emphasized relaxing central planning, introducing gradual market mechanisms and encouraging limited foreign participation in the economy.

Commitments to slow the growth of carbon dioxide and other fossil fuel pollutants have played an important role in expanding investments. In addition, the tremendous growth in energy demand from developing economies, the increased instability of fossil-fuel prices and the concerns about energy security all contributed to stimulate green development.

Chinese efforts to develop renewable energy technologies have accelerated in recent years, since the government has recognized energy as a strategic sector.

Decoupling energy emissions from economic growth is the key to take a more sustainable development path.

This phenomenon is explained by the decomposition of the Kaya Identity, which relates population growth, per capita value added, energy per value added and carbon emissions per energy, with total carbon dioxide emissions, through the formula: $\Delta CO_2 = \Delta \frac{CO_2}{TPES} + \Delta \frac{TPES}{GDP} + \Delta \frac{GDP}{POP} + \Delta POP$, which can be decomposed as

$\Delta CO_2 = Carbon\ intensity + Energy\ intensity + GDP\ per\ capita$+ *Population.*

The Identity shows that the extent of "decoupling" economic growth and emissions depends entirely on reduction in energy and carbon intensity, since all the other socio-economic parameters are set either directly or indirectly, or as exogenous inputs.

However, the Chinese leadership is faced with difficult domestic challenges and tradeoffs between long and short-term development and security concerns. With half of the population living under two dollars (PPP) per day, development needs are immense and it is necessary to maintain stable growth.

Moreover, the energy intensive stage of development makes it difficult to break out of coal dependence, despite emissions are expected to grow over the coming decades.

There is no precedent for China's situation, because no other country has been faced with the necessity to deal with the challenge of climate change during the same stage of development.

The challenge the global community and China, in particular, have to face is to enhance energy security strategies within the limitation of climate security. In doing so, China has run into several underlying dilemmas.

To begin with, the Country is at a development stage of rapid industrialization and urbanization at a time when climate security has been put at the top of the global agenda, and the sheer size of the Chinese economy means that its development related emissions have large impacts on global climate change.

To decouple its carbon emissions from growth, China faces a challenge that no other country has previously mastered.

While China is convinced of the need for a low-carbon future, there is no proven international experience for China to "plug-in" right away. As its economy risks further slowing, or even a hard landing due to the global economic crisis, the mounting pressures to maintain growth, employment, and social stability are much more urgent priorities for the Chinese leadership.

China's climate change strategy and actions will depend upon how it attempts to address its current domestic economic crisis and its economic development challenges. Success or failure in combating climate change globally is determined by how well China and the rest of the world can find common ground for productive low-carbon co-operation for economic development.

The second dilemma refers to mounting domestic development challenges that make it imperative for China to maintain high economic growth to finance a wide variety of much needed social reforms. It is particularly urgent to reduce growing social disparities and provide development opportunities for the near half of the population that live under two dollars (PPP) a day. Equally important is to halt the rampant environmental degradation that limits growth potential and adds to social instability.

Third, with coal forming the foundation of its energy system, it is highly challenging for China to transform its energy structure to such extent that the global 2°C is within reach. Committing to a climate deal implies massive structural transformation for, not only by the energy mix point of view, but also for the energy intensive transport and building sectors.

Power generation from both utility scale solar PV and wind in China has been curtailed by a lack of sufficient grid infrastructure, and because coal power plants are given priority dispatching.

China's power transmission system remains, in fact, under-developed.

Regional power shortages occur frequently when generation drops in one province or region and the lack of long-distance power transmission capacity means that power cannot be moved from regions where there is a surplus capacity.

There is no unified national grid. Six major regional grids divide the territory: five managed by the giant State Grid Corporation and one managed by the South China State Grid Corporation, covering the light manufacturing around Guangzhou-Shenzhen and the inland areas of Guandong, Guangxi and Guizhou. Northern areas are often subjected to shortages during winter due to increased heating demand and problems with coal deliveries. Eastern and southern areas are prone to shortages in late spring and early summer as temperatures and air-conditioning demand rise, while reservoir levels and hydro output fall until the arrival of the summer rains in July and August.

The lack of a unified national grid system also hampers the efficiency of power generation nationwide and heightens the risk of localized shortages, especially because inter-connections between the grids are weak and long-distance transmission capacity is small.

Moreover, the institutional framework in terms of energy market integration and infrastructure such as connectivity in power grid and natural gas pipeline networks are not in place. More than 80% of the potential energy resources, such as coal, oil, natural gas, hydroelectricity, wind power and solar energy are distributed in the northern and western parts of China.

The spatial distribution of supply and demand creates challenges. Significant transmission capacity is planned, but not yet in place. Moreover, renewable power competes with coal power for the same transmission capacity.

Thus, the distance between the best resources for renewable energy generation and the main areas of demand is a major obstacle because of the large investment needs for new transmission and distribution capacity.

These problems are highly relevant for China and it is clear that their overcome will take a long time and they will need massive investments to be fulfilled. However, no policy intervention would mean a move towards higher shares of coal in the energy mix and would cause extreme effects of changes in GDP and energy intensity.
From a rational point of view, China has much to win and little to lose by playing a more active role in global efforts to mitigate climate change.
Green development is a "no regrets" strategy; it offers a range of tangible benefits apart from its saving in terms of carbon emissions. Indeed, even though dangers of global warming turn out to be overstated, China would in any case accrue enormous advantages by adopting green strategies, simply in terms of their offering of greater security, resilience and development potential.

By a domestic perspective, the Chinese government places a priority on investing in renewable energy, first because it enables the country to tackle problems of air and water pollution, and mitigate risks of socio-economic instability and second, because renewable sources do not deplete over a lifetime and there is zero possibility that they will run out.
Hence, China's huge potential for developing significant renewable power sources would help the country to ease its over-reliance on fossil fuels.
As a result, it would benefit from the pollution and emissions' cut and from the diversification of energy sources to manage the risk of fossil fuel volatility. Indeed, import dependency exposes an economy to several risks, including balance of payments risk, amplified economic impacts when prices rise, tremendous pressure on public budgets to blunt the impact of price increases on consumers, and the potential to lose access to fuel altogether, either by being priced out of the market by other bidders or by supply lines being physically cut.
In addition, as reported by a Chinese government advisory agency, the country could profit by transitioning from polluting industries to "green" business, including the renewable-energy sector, by net 9.5 million jobs in five years.
Domestic jobs would be promoted at the potential expense of the lowest costs or the best performing technology, whether policymakers create domestic demand for renewable power, using a policy tool like mandates, targets or feed-in-tariffs; add to

local-content requirement or some similar regulation to the requirements for project developers; and provide the domestic industry with a protective tariff regime or another form of infant industry protection.
This formula has some roots in fact. Globally, large and reasonably stable wind markets have drawn parts of the value chains to domestic shores. China has seen an explosion in wind companies, and a rapid appearance among the global top ten; growth that is often attributed both to the large domestic market and the local-content requirement.

By an international perspective, a growing global focus on low-carbon economic development provides opportunities for China to gain competitiveness, international reputation and environmental benefits, at the same time as it lays the foundation for more balanced economic and social development.
The tradition of aligning with the G77 view that climate change is predominantly an OECD-world problem is becoming more and more contradictory as China has recently become the world's largest carbon emitter.
Climate security is seen as a geopolitical issue, where China's role as a responsible world actor is central to its range of options within global climate talks, especially because there are growing divergences within the G77 bloc. Some Least Developed Countries, such as Bangladesh, argue for differentiated treatment of large developing countries, notably China. Hence China, after having weakened its position with its rapid increase in emissions' intake, could move to a position where it negotiates to maximize national interest rather than aligning with the developing world.
Furthermore, it will prove increasingly difficult to keep up its foreign policy ambition to act as a "responsible great power", and convince the world that its development is not a threat to global security.

At the same time, the consequences of China standing outside the global process would be dire. It would signal that China does not take the climate threat seriously and would thwart the world's chances to solve the climate crisis.
A switch towards low-carbon development would be pivotal to manage the problem of emissions and environmental degradation and it would be less costly for China than for most industrialized countries, providing opportunities to gain competitiveness; at the

same time as low-carbon technology exports could offer comparative advantages for Chinese production.

In light of this analysis, the Country has responded positively by constructing a green development concept and a modern framework while setting in motion an unprecedented revolution of green energy, manufacture, consumption and innovation. The first two decades following the founding of the People's Republic of China were marked by the alternation between substantial growth of per capita GDP and output, fuelled by heavy industrial development, and sharp reversals.

However, after the first four Five-Year plans, China has become a pioneer in green development and the biggest green energy country in the world.

Indeed, with the transformation of China's economic system since the reform and opening- up, the path of the black economy has progressively been abandoned.

During the Ninth Five-Year Plan, the proportion of green development indicators increased to 11.8%, playing a large role in promoting an initial change in the economic development mode, in dropping energy consumption per unit of GDP and in decreasing emissions of major pollutants.

Then, the Hu-Wen administration (in power since 2002) showed its political commitment to reverse past trends by setting ambitious compulsory targets to reduce energy and pollution intensities from their 2005 levels and, from this moment, combating climate change has become the most prominent component of China's new environmental policy.

The proportion of economic development indicators dropped to its lowest-ever levels, while the proportion accounted for by energy saving, emissions reduction and environmental protection rose to its highest levels.

The important innovation brought by this Plan was the definition of government responsibility targets as binding and legally effective.

The achievement of improved resources and energy efficiency and the reduction of pollution emissions clearly shows that binding indicators obliged the government to implement its goals and adjust its behavior. Therefore, this made a significant contribution to the transformation of the government and it pushed the national economy and society onto the path of green development.

As a result, all local governments have introduced policies, measures, laws and regulations to promote market development as well as various enterprises have increased the intensity of their investments in energy saving.
Finally, China's great improvement in energy and environmental policies during this period indicated the huge potential and bright future for the Country in green and low-carbon industrial transition.

The following period, covered by the 12th Five-Year Plan (2011–2015), was an extraordinary time for China's development. In the face of a complex international environment and challenging domestic tasks related to carrying out reform, pursuing development, and ensuring stability, the CPC Central Committee and the State Council united with and led the people of China in exerting themselves and pushing forward with an innovative spirit.
As a result, significant economic and social achievements were made, major progress was achieved in economic structural adjustment; agriculture grew steadily and the value-added of the tertiary industry accounted for a larger share of GDP than that of the secondary industry.
The Plan promoted seven essential initiatives to recycle economy (ranging from comprehensive utilization of resources to the demonstration of the recycling system of worn-out merchandise) and launched four environmental projects, including city wastewater treatment and construction of garbage disposal facilities, desulfurization and denitrification, heavy metal pollution prevention and control and improvement of the water environment in critical river basins.
Furthermore, it emphasized comprehensive, fair and harmonious sustainable development of the economic system, natural systems and the social system by means of green growth through the promotion of green benefits and wealth. These included average life expectancy, increase in the number of new urban jobs, affordable housing construction and disposable income of urban residents and pollution reduction.
The Plan also stimulated the transformation of business enterprises and encouraged such enterprises to become major players in the area of green development, thanks to price formation mechanism of resource products, the promotion of environmental reform and the establishment of trading mechanism resources along with other policies

and measures.

Yet, all these efforts were just the beginning and with the transition to the Thirteenth Five-Year Plan, the Fifth Plenum of the 18th Central Committee of the Chinese Communist Party applied a comprehensive strategic arrangement and disposition to feature green development as one of the key concepts.

This plan is another brand-new milestone in China's green development history, promoting first and foremost, that China should "maintain a medium-high economic growth" and second, that the proportion of the service industry in the GDP is expected to rise, whereas that of traditional industries will fall.

It presents the improvement of the overall ecological environment quality as a core objective for the first time and it aims to implement the efficiency of energy resource usage boost; the effectively water consumption control, carbon emissions cut and the development priority zones and ecological security barriers' creation.

China's energy saving and emissions reduction approach has its own advantage because of the Five-Year Plan. Economic growth rate, industrial structure and energy structure are the three elements that significantly influence the reduction of energy consumption and carbon emissions intensity per unit. The central government use Five-Year Plan to regulate and control the three elements effectively through national goal governance, obligatory index policy and key projects.

Given its enormous potential in further development and four Five-Year Plans, to cover a total of 20 years (2006-2025), China has a long way to go before successfully accomplish the transition from black to green development.

Although the Country has currently the world's largest installed capacity of hydro, solar and wind power, its energy needs are so large that in 2015 renewable sources provided just a little over 24% its electricity generation, with most of the remainder provided by coal power plants.

Renewable energy sources are growing faster than fossil fuels and nuclear capacity in China.

Nevertheless, it is not impossible for the Country to go from relative to complete emissions reduction, to disconnect economic growth from carbon emissions and make a decisive contribution to slow down the process of environmental degradation.