

Energy and Environmental Policy Laboratory

Overview of China's Energy Policy

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ABSTRACT

China is the world's 4th largest country by area and the largest energy producer and consumer worldwide since 2009, right above the United States. Taking into consideration the importance of the energy sector for the country's economic growth and sustainability, this research provides a detailed review of the energy sector and the energy system of China. The Chinese energy sector is dominated by coal, followed by oil, while there are efforts towards a cleaner energy mix, as well as cleaner and high-efficiency technologies. Nevertheless, the fact that the use of alternative resources remains inferior, combined with China's high dependency on certain sources, create concerns and pose harsh challenges regarding its energy security and independence. Thus, this study puts special focus on the Chinese energy path, the rise of renewable energy sources in its energy mix, as well as the estimated energy demand in the upcoming years, which all equally serve as a stimulus for diversification of energy routes, sources and suppliers.

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ACRONYMS AND ABBREVIATIONS

CPC	Communist Party of China	
GDP	Gross Domestic Product	
GHG EMISSIONS	Greenhouse Gas Emissions	
IEA	International Energy Agency	
IMF	International Monetary Fund	
KTOE	Kilo tons of Oil Equivalent	
MTOE	Million tons of Oil Equivalent	
PRC	People's Republic of China	
RES	Renewable Energy Sources	
SCE	Standard Coal Equivalent	
SQ KM	Square Kilometers	
TWh Tera Watt Hours		
UN	United Nations	
WCMC	World Conservation Monitoring	
	Centre	

INTRODUCTION

Energy comprises the driving force of society, both at individual and at state level, by being at the core of all its activities. Thus, the energy sector is inevitably linked to a country's economy. The unhampered functioning of an economy, capable of achieving social development and prosperity, requires efficient energy systems and infrastructure. Lately, much focus has been directed, firstly, to the concepts of diversification of sources, routes and providers and, secondly, the environmental impact of energy production and use as parts of energy security. China, the world's worst polluter and greatest investor in green energy at the same time, faces severe challenges, among which high dependence on coal and insufficient share of renewable sources in its energy mix. For this reason, China, as numerous other countries, has undertaken measures to secure energy supply while reducing its environmental footprint and mitigating the adverse effects of climate change.

The purpose of this research is to broaden the understanding of the energy sector and the energy system of China. Reviewing the Chinese energy sector will provide a great insight of the country's energyrelated strengths and weaknesses, the dominant and upcoming energy sources as well as future projections. Additionally, a descriptive and retrospective presentation of China's policies and existing institutional framework supplement the research. Great attention is, lastly, directed towards the expansion of renewable energy use, especially wind and solar, and its role as a means for greater energy security, an issue that has progressively received significant governmental attention.

The above components of the Chinese energy sector are the subject of examination in four parts of this research. To begin with, the study will introduce the basic characteristics of the country's profile by presenting fundamental demographic and economic indexes.

The first unit encompasses an overview of the three phases of the Chinese energy policy, throughout which China shifted from a state that relied almost entirely on coal to a state that takes the environment into account and uses renewable energy in a greater extend.

The second part is an in-depth analysis of the Chinese energy system, with focus on legislation, energy strategies and plans, as well as an overview of the country's Total Primary Energy Supply, Total Energy Production, Import dependency ratio, Total Final Energy Consumption and Energy Sectors. As it will be presented, China faces great challenges due to increasing energy demand and high dependency ratio from energy imports, since the domestic production fails to fully meet the country's needs. Therefore, the questions that will be answered are the following: What is the level of imports compared to domestic production and exports? What is observed from the total energy consumption comparison between China and US? What are the fluctuations in the Chinese energy consumption by source throughout the years?

In the third chapter of this paper, we will explore separately and in depth three energy sectors included in China's energy mix, starting with its main energy sources, coal and oil, and concluding with renewable energy. More precisely, China's energy needs have dramatically expanded due to rapid economic growth, with it being, as a result, the world's largest consumer of energy, the largest producer and consumer of coal, and the largest emitter of carbon dioxide. As expected, coal's dominance is closely connected to the country's energy security. Nevertheless, despite the fact that fossil fuels have boosted hyper growth of the Chinese economy, they remain the chief source of air pollution and CO_2 emissions. Aware of the heavy toll that reliance on fossil fuels has exacted on the environment and public health, Chinese leaders have shifted to alternative sources of power. Indeed, according to BP, "strong growth of renewable power is the key driver of China's energy transition", as the share of renewables in electricity generation is of paramount importance.

Last but not least, the final part of this paper will conclude with some outcomes of the research.

COUNTRY OVERVIEW

China is located in Southeast Asia along the coastline of the Pacific Ocean. It shares its land borders with 14 countries: Afghanistan, Bhutan, Burma, India, Kazakhstan, Kyrgyzstan, Laos, Mongolia, Nepal, Pakistan, Tajikistan, Vietnam and Russia. Its maritime neighbors are North Korea, Korea, Japan, the Philippines, Brunei, Indonesia, Malaysia and Vietnam. China is the 4th largest country by area worldwide, after Russia, Canada and the United States, with its territory covering 9,596,960 sq km. ^[1] Its territory can be divided in approximately 9,326,000 sq km of land and 270,550 sq km of water (Figure 1.1). ^[2] China is also the world's most populous country, right above India and the United States of America, gathering 18.16% of the world's population and reaching 1,444,216,107 people, while having 56 officially recognized ethnic groups. ^[3]



Figure 1.1: Map of China^[4]

China's vast terrain and climate are diverse and thus provide rich biodiversity and suitable conditions for its agricultural and industrial development. The country covers a wide range of climatic zones, among which tropical, subtropical and temperate zones, and is dominated mostly by dry seasons and wet monsoons. China is also one of the top 17 mega-diverse countries, according to the World Conservation Monitoring Centre (WCMC) of the United Nations Environment Program.

¹ (Central Intelligence Agency, n.d.)

² (Central Intelligence Agency, n.d.)

³ (Country meters, 2021)

⁴ (Central Intelligence Agency, n.d.)

China's capital is Beijing, and its largest city is Shanghai. The official language is Standard Chinese, yet there are other recognized regional languages, such as Mongolian, Uyghur, Tibetan etc. China's national currency is the Yuan, also referred to as Renminbi, which means "the money of the people".

China represents one of the first civilizations worldwide with a long and rich history. From about 2070BC until 202BC and from 220AD until 1911AD^[5], the Chinese political system was based on dynasties. The dynasty era started with the Xia Dynasty and ended with the Qing Dynasty, which was replaced by the Republic of China. During the dynastic periods, the Chinese nation progressed in various fields, such as economy, science, agriculture, handicraft, arts, technology, commerce and overseas trade. The Great Wall, the Grand Canal, the inventions of gunpowder, block printing and the astronomical clock altogether prove the country's engineering capability, assorting it at the same time among the most advanced countries of the world. During that time, China forms friendly ties with neighboring and nonneighboring countries, such as Japan, Korea, West Asian countries, Europe and Africa. The Qing Dynasty (1644AD-1911AD), throughout which the country's territory was expanded and its production was boomed, marked the zenith of the Chinese nation's power. However, the isolationist tendencies of the Qing government inevitably restrained both capitalism and the country's political, economic, military and cultural modernization compared to the West.

The Opium War against China, launched by the British in 1840, turned China into a semi-colonial country, a political phase which ended with the revolution led by Dr. Sun Yat-sen, in 1911, and the founding of the Republic of China.

In October 1st, 1949, Chairman Mao Zedong proclaimed the foundation of the People's Republic of China, which was followed by several changes: consolidation of socialism, privatization of the means of production, transformation of capitalist into state-owned socialist enterprises, stabilization of commodity prices, educational, scientific and cultural transformations, social reforms etc. ^[6] In September 27th, 1949, the red five-star flag was accepted as the national flag of the People's Republic of China (PRC). The red color of the flag symbolizes revolution and the yellow color of the stars the golden brilliant rays radiating from the vast red land. The design of four smaller stars

⁵ (Government of China, 2004)

⁶ (Government of China, 2004)

surrounding a bigger one signifies the unity of the Chinese people under the leadership of the Communist Party of China (CPC). ^[7] By the end of 1952, China's industrial and agricultural production had reached record levels.

The Communist Party of China (CPC), founded in 1921, is the party still in power, functioning according to the principle of democratic centralism. Apart from the CPC, there are furthermore eight democratic parties. Multi-party cooperation and political consultation under the leadership of the CPC ^[8] frame China's political system, the People's Congress System.

From economic perspective, during the first 30 years of the PRC, the Chinese government applied a planned economy system, through which it controlled the industrial and agricultural production as well as the stocking and selling of goods. In other terms, China established a socialist market economy, the main principles of which were the dominance of the public sector, linking domestic and international markets, people's prosperity, a social security system for both urban and rural residents and by extension economic development and social stability.^[9] As a result, the Chinese economy became one of the world's fastest growing economies, making China a potential superpower mainly thanks to its massive population, economy, and military power.

Nowadays, as the national economic development has made very rapid progress, China represents the world's second largest economy, with its GDP rapidly increasing especially after 2005 and reaching 14.72 trillion U.S. dollars in 2020 with a GDP growth rate of 2.27%, the lowest level recorded in the past 2 decades. However, it is impressive how the current GDP growth is expected to rebound after the first phases of the COVID-19 pandemic, amounting to 8.44%. China's GDP is also estimated to reach 24.13 trillion U.S. dollars in 2026, with a growth rate of 4.86% (Figures 1.2, 1.3). Overall, China owned 18.34% of the world's GDP in 2020 (Figure 1.4), while estimations forecast a steady rise in all the Chinese indexes.

⁷ (Government of China, 2004)

⁸ (Government of China, 2004)

⁹ (The World Bank, 2019)



Figure 1.2: GDP of China 1985-2020, with forecasts until 2025^[10]



Figure 1.3: Growth rate of China's real GDP 2010-2020, with forecasts until 2026 $^{[11]}$

¹⁰ (Statista, 2021)

¹¹ (Statista, 2021)



Figure 1.4: China's share of global GDP based on PPP 2010-2020, with forecasts until 2026 ^[12]

According to China's 13th Five-Year Plan (2016-2020), the country pledges to efficiently deal with high inequalities, challenges in environmental sustainability and external imbalances, all caused by the rapid economic development.

Last but not least, the People's Republic of China is a member of many International Organizations; the IMF, the UN, the World Health Organization, the World Trade Organization, the Asia-Pacific Economic Cooperation, the Group of 77, the International Atomic Energy Agency, International Bank for Reconstruction and Development, the International Red Cross and Red Crescent Movement. The country is also a member of the BRICS.

¹² (Statista, 2021)

1. THE THREE PHASES OF THE CHINESE ENERGY POLICY

China's shift from a state that relies almost entirely on coal to a state that takes the environment into account and uses renewable energy in a greater extend has taken place after the better understanding of its energy problem. China has always been aiming to its economic recovery, meaning the growth of employment and production, rather than tackling with the social problems of the past decades and the problems concerning the environmental pollution. Thus, the conditions of production, the way of life of the Chinese population, its industrial needs, the wastefulness and reckless use of resources and the dependence on coal provoked a severe energy consumption problem and extensive environmental pollution and degradation. In other words, the rate of consumption exceeded the country's growth rates and the domestic resources were not sufficient enough to meet the increasing demand for energy. In order to understand China's shift from a state that fulfills its energy needs using almost exclusively coal to a state that considers the environment, it is highly important to a look back at the Chinese nation's recovery period and examine its first steps in the energy sector.

The People's Republic of China started a new era in 1949, retaining some of its traditional imperial elements, the most defining of which being self-sufficiency. The prominent figure of that time was Mao Zedong, who took over a devastated economy with a poorly developed industry, a limited food production, and an unstable financial system. Thus, he tried to find the ideal model of development and organization of the country, which would be based on a combination of Socialist and Marxist elements, while taking into account the real needs and particularities of China. As in the case of the Soviet Union and Yugoslavia, the Socialist model with its centrally planned economy rapidly bore some fruits to China, and even though it caused political and social upheaval, it eventually allowed the country's rebuilding, industrialization and general development.

After the first phase of the rebuilding process, the power is conferred on Deng Xiaoping, who focuses more on the capitalist model, rather than on the socialist, with the aim of opening up China's economy, boosting its productivity, accelerating its modernization, and developing ties with western countries. Among his objectives were also included the greater balance between social classes and the end of China's withdrawn attitude, responsible for its growth retardation and the development gap between China and the West. Therefore, after having kept its head above the water, the new goal of the Chinese government was to gain confidence and extroversion.

Phase I (1949-1993) - Energy Self-Sufficiency [13]

During its first years of forming, the Chinese state maintained close ties with the Communist Soviet Union, the country's role model as far as development is concerned, and from which China imported the necessary technological know-how, the experts and most importantly oil. In the early 1960s, however, relations between China and the Soviet Union were terminated, leading Mao Zedong in his quest to overcome difficulties to declare two key strategic state goals: "independence and self-sufficiency".

Over the next few years, China explored other oil wells and from 1973 and onwards began exporting oil to Japan, the Philippines, Thailand, Romania and other countries, with the aim of increasing its financial resources to import sufficient equipment and technology from abroad. These new steps accelerated economic growth and increased energy demand.

Phase II (1993-2003) - China's exit to international markets

During this second period, China moves towards overseas markets, making small and large-scale investments in order to adapt to the international competitive environment and ensure the adequacy of the domestic oil and gas reserves. 2000 is the milestone year of the large expansion of the Chinese oil companies to overseas markets, in the efforts to secure long-term partnerships with suppliers.

At the same time, China created a special relationship generating mutual profits with several countries of the African continent, which were underdeveloped, yet endowed with natural wealth. Unlike the former colonial states that exploited the resources of the African countries without investing in the latter's' development, China invested not only in infrastructure, but also in the improvement of the educational system by facilitating pupils and students to study in their own country or abroad. China used, in other terms soft power, in exchange for exploiting the continent's natural resources.

The benefits of this partnership were numerous for both partners:

¹³ (N. Petrovits, 2014)

- E China could support its construction industry, allowing the Chinese construction companies to carry out investment projects using materials exclusively from China.
- The aforementioned construction projects were conducted on credit so that the African countries would maintain long-term relations with China and repay their debt.
- China had the opportunity to exploit the countries' oil and mineral wealth without burdening the Chinese economy.
- E China thus shaped the image of a "friendly partner" rather that a 'malevolent exploiter' since its activity created mutual benefits and did not interfere in these countries' internal affairs.

At the same time:

- = The African countries were benefited from the more than necessary investments in their infrastructure.
- The educational opportunities for African pupils and students were broadened.
- The African–Chinese cooperation ensured a long-term relationship with a powerful global player.

Phase Three (2003 - today) - Scientific Development

In this final phase, the slow economic growth, the increased energy demand, and the deterioration of the environmental problems lead to the redesign of the Chinese energy policy and the assertive shift to renewable energy. The *new targets* of the government were set as follows: reduction of the energy consumption, diversified development, environmental protection, international cooperation, energy saving, self-sufficiency and innovation.

New priorities were also defined. The Chinese government strove for the substantial use of sustainable energy sources, the prudent use of fossil fuels, the reform of all state industrial structures, the saving of energy in transport. One of the first initiatives was the formation of 'test cities', which would put the policy of low carbon emissions with widespread use of renewable energy into practice. Indeed, at the Copenhagen Conference in 2010, China pledged to reduce by 2020 carbon dioxide emissions by 40-45% compared to 2005 levels, a task that, nevertheless, remains far from being accomplished ^[14].

Throughout China's history, there were and still are internal and external factors that influence the formulation of the energy policy. ^[15]

Internal factors:

- *Leadership*: The Prime Minister, the Ministry of Energy, the State Energy Bureau and the State Council can equally direct the State's energy policy in their own interests.
- Think Tanks: Those refer to research centers and institutes, as well as academic institutions, operating within national oil companies and providing valid information on energy issues. The largest Think Tanks are the Development Research Center of the State Council and the National Development and Reform Commission (NDRC), while the academic institutions include the Tsinghua University, the China University of Petroleum, the Chinese Academy of Sciences (CAS) as well as the Chinese Academy of Social Sciences (CASS).
- = Other Ministries and public administration: They tend to propose and implement specific measures, thereby affecting the national energy related decisions.
- = *Energy Resources*: Stocks, available technology, energy and transport infrastructure constitute certain key factors equally involved.
- = *Lobbies*: Chinese industries, public and private interests and the interests of foreign companies influence the policy-making process through lobbying.
- = *Consumers*: The consumption rate and the energy needs of industrial, commercial and residential consumers are taken into account during the development of the energy policy.
- Information and human resources: After the termination of the Soviet-Chinese relations in the 1960s, the lack of adequate human resources, as well as the lack of data and reliable information have been an impediment to the development of Chinese energy sector.

¹⁴ (East Asia Forum, 2010)

¹⁵ (N. Petrovits, 2014)

External / International Factors:

- = The policy-making process may be influenced by energy policies and strategies of other neighboring and non-neighboring countries.
- = International economic developments and the state of foreign economies affect China's exports and by extension its policies.
- E China, as a member of the UN, the WTO and the BRICS, commits itself to comply with the decisions of the international community and the international Agreements and Commitments.
- Regional and international security also plays a major role. Instability in the Middle East and North Africa region as well as potential terrorist attacks on oil and gas infrastructure perturb China, threatening its overall stability.

The result of the above phases and their subsequent reforms was the creation of the People's Republic of China with the form and the characteristics it has today; the 4th largest country in the world ^[16], the most populous one ^[17], the world's largest energy consumer of both conservative and alternative energy, and one of the most important industrial centers.

¹⁶ (Central Intelligence Agency, n.d.)

¹⁷ (Country meters, 2021)

2. ENERGY SYSTEM OVERVIEW

The fourth major and most complex national system, after the financial, fiscal and enterprise systems that support China's economic structure, is energy. China's energy use is closely linked with two issues: the nation's air pollution problem and climate change. When analyzing the Chinese energy sector, certain key-concepts that ought to be examined are: (i) Legislation, (ii) Energy strategies and Plans, (ii) The Chinese energy system.

China's Energy Policy was first published in October 2012, setting out the county's energy goals, focusing on the promotion of clean and renewable energy and citing the central strategic energy issues. ^[18] As mentioned in the preface of the State Council's text, "Energy is the material basis for the progress of human civilization and an indispensable basic condition for the development of modern society. It remains a major strategic issue for China, as the country moves towards its goals of modernization and common prosperity for its people". ^[19] Thus, the Chinese government recognized that issues, such as a sustainable economic and social development, the creation of a modern, secure and stable energy industry based on clean energy resources, the reduction of harmful emissions, energy efficiency and upgraded industries are of significant national importance.

2.1 LEGISLATION

The organization, development and functioning of the energy sector is based on several laws and regulations which have been amended over time, in order to adapt to the latest developments and the country's needs. Each of these laws is correlated to one of the following sectors: electric power, coal, renewable energy, energy conservation, oil and gas pipeline protection.

The main targets of China's energy laws are the following ^[20]:

¹⁸ (Government of China, 2012)

¹⁹ (Government of China, 2012)

²⁰ (International Energy Charter, 2018)

LAW	DATE OF ENACTMENT	<u>TARGET</u>
Law on Electric Power	(01/04/1996)	Protect and promote the development of the power industry, protect the legitimate rights and interests of investors, operators and customers, and ensure the safe operation of electric power.
Law on the Coal Industry	(01/12/1996)	Rationalize the use coal, standardize coal production and business activities, as well as promote and ensure the development of the coal industry itself.
Law on Energy Conservation	(01/01/1998)	Promote energy conservation in all sectors of society, increase energy efficiency, protect and improve the environment, promote comprehensive, balanced and sustainable economic and social development.
Law on Renewable Energy	(01/01/2006)	Promote the development and use of renewable energy resources, increase energy supply, improve energy structure, ensure energy security, protect the environment and achieve sustainable economic and social development.
Law on Oil and Gas Pipeline Protection	(01/10/2010)	Protect oil and natural gas pipelines, ensure the safety of petroleum and natural gas transportation, and maintain national energy security and customer safety.

2.2 ENERGY STRATEGIES AND PLANS

After the publication of the national Energy Policy, in 2012, China's President Xi Jinping presented the strategy of "Four Revolutions and One Cooperation", concerning energy security development. Around the same time, the Chinese government developed a series of highlevel energy policies, such as the Strategic Action Plan for Energy Development (2014-2020) and the Five-Year Plans for Energy Development, in order to direct the evolution and growth of the country's energy sector over the next years. The aforementioned energy strategies and plans frame the Chinese energy policy and are further analyzed below.

THE STRATEGY OF "FOUR REVOLUTIONS AND ONE COOPERATION"

During the 6th meeting of the Central Leading Group on Financial and Economic Affairs, on June 13th, 2014, President Xi Jinping announced China's strategy for energy security development, under the name of "Four Revolutions and One Cooperation". ^[21] This was the first time after the founding of the Republic of China that the Chinese government had held a special meeting on energy security issues. The "Four Revolutions and One Cooperation" strategy's content included the transformation of four energy sectors and the cooperation towards this direction. Namely, the strategy aimed to: ^[22]

- = Promote *energy consumption revolution* by removing unreasonable and irrational energy consumption.
- Promote energy supply revolution by establishing greater diversity in China's energy supply.
- = Promote *energy technological revolution* by driving industrial upgrading.
- = Promote *energy* system revolution.
- = *Strengthen international cooperation* to achieve energy security under open economy conditions.

STRATEGIC ACTION PLAN FOR ENERGY DEVELOPMENT (2014-2020)

The Strategic Action Plan for Energy Development was issued by the State Council of China in June 2014 and was valid until 2020. Its purpose was to clarify the strategic tasks of China's energy development and focus on various subjects, among which *energy*

²¹ (Xinhuanet, 2014)

²² (International Energy Charter, 2018)

efficiency, renewable energy, environment, energy supply and infrastructure, trade, investments, pricing, governance, technology and innovation. Each of the aforementioned sectors has its own priorities and targets. ^[23]

Its main general tasks were:

- = To enhance the ability of energy independence.
- = To promote the energy consumption revolution.
- = To optimize the energy structure.
- = To expand international cooperation in energy fields.
- = To promote energy R&D and technological innovation.

More precisely,

Energy Efficiency

<u>Priorities</u>	<u>Targets</u>	Public awareness & promotional programs
Promotion of energy conservation in key areas for rapid economic and social development.	Implementation of an energy-saving old coal unit upgrade project, serving 600,000 kilowatts.	Implementation of the National Energy Action Plan.
Development of pure electric, hybrid and natural gas vehicles and ships and expansion of alternative transportation fuels.	Attainment of coal- powered unit efficiency, with a decrease to approximately 300 grams of coal per kilowatt-hour within 5 years.	Increase of publicity and education, as well as popularization of energy-saving knowledge.
Implementation of energy consumption controls to high energy-consuming industries.	-	Promotion of new energy-saving technologies and products, in order to empower citizens to embrace a green lifestyle.

²³ (Asia Pacific Energy Portal, n.d.)

Optimization of the economic structure and energy consumption concept and strengthening of energy efficiency in the industrial,	_	_
and strengthening of energy efficiency in	-	-
building and		
transportation sector.		
-		

Renewable Energy

Priorities	Targets
A substantial increase in the wind, solar, geothermal and nuclear power consumption ratio.	Attainment of the following by 2020:
A significant reduction of energy consumption emissions and promotion of an ecological civilization.	 ≡ 15% non-fossil fuels in primary energy consumption. ≡ More than 10% of natural gas share. ≡ Less than 62% of coal
Promotion of R&D in advanced biomass technologies, for the development of a new generation of non-grain fuel ethanol and biodiesel.	 consumption. 350 million kilowatts of conventional hydropower installed capacity. 100 million kilowatts of PV installed capacity.
Development of renewable energy sources with equal emphasis on both centralized and distributed development.	= 50 million tons of coal equivalents of geothermal energy.

Environment

Energy Environmental Priorities	<u>Targets</u>
Reduction of energy consumption emissions, especially from coal.	Implementation of a Decarbonization strategy.
Implementation of environmental impact assessment of new projects.	Study and formulation of development incentives to promote green credit policy.
Promotion of an ecological civilization.	_

Energy supply and infrastructure

Priorities		
Steady increase of domestic oil production and promotion of clean and efficient development and utilization of coal.		
Apart from natural gas, hydropower and solar power, the equal development of geothermal, biomass and ocean energy is also important.		
Greater use of renewable energy within grids.		
Acceleration in the construction of natural gas pipelines and storage facilities.		
Improvement of the Eastern region's energy structure.		
Establishment of reliable and flexible electricity and gas transmission networks.		
Creation of a competitive electricity market.		
Expansion of international cooperation in energy.		

Trade

Energy Trade Priorities

Reinforcement of bilateral and multilateral international energy cooperation between major energy regions, such as Russia, Africa, Central Asia, the Middle East, the Americas and Asia-Pacific, to establish a regional energy market.

Increase natural gas imports.

Increase LNG and pipeline gas import intensity.

Investments

Energy	investment	priorities

Technological innovation in energy sector.

Improvement of energy investment and industrial policies.

Promotion of international cooperation on scientific and technological research.

Support of energy conservation policies and clean energy projects.

Encouragement of energy team-building and leading talent.

Pricing

Energy taxation Priorities	Energy pricing Priorities
Improvement of the energy conservation tax policies.	y Promotion of energy price reforms.

Improvement of the ecological compensation mechanism and acceleration of the environmental tax legislation. In other terms, creation of a green tax system.

Governance

Energy management principles	Means of implementation
Strengthening of the organization and leadership, as well as the leading role of the National Energy Commission, to tackle with major energy issues.	Greater supervision an inspection by the Office of th National Energy Commission.
Transferring of the Office of the National Energy Commission's responsibilities to the Energy Board.	
Strengthening of the emergency reserve capacity.	

Technology

The technological sector includes 7 subcategories which embody different priorities, as presented below:

Clean energy technology priorities

R&D to upgrade innovation and build an energy technology powerhouse.

Establishment of:

- = unconventional and deep-water oil and gas exploration,
- = clean and efficient use of coal,
- = distributed energy,
- = modern power grid,
- = advanced nuclear power,
- = energy saving and energy storage,
- = PV, solar, wind power, biofuels and geothermal energy,
- = ocean energy power generation,
- = large capacity storage.

Gas-to-power technology priorities

Moderate development of natural gas to generate electricity.

Air pollution prevention and control in Beijing, Tianjin and Shandong, the Yangtze River Delta, Pearl River Delta region.

Low-emission and cleaner coal technology priorities

Clean and efficient development and use of coal, with significant reduction of its direct combustion.

Low-emission and cleaner oil technology priorities

R&D in advanced biomass technologies, for the development of a new generation of non-grain fuel ethanol and biodiesel.

Advanced **fuel extraction** technology priorities

Greater storage potential and maintenance of output stability, as well as exploration of shale gas.

Natural gas transportation technology priorities

Construction of natural gas storage facilities, liquefied natural gas vehicles and compressed natural gas vehicles.

Industrialization support priorities

Energy equipment innovation, to adjust to the international competitive industry of energy equipment.

Encouragement of a diversified energy technology venture capital fund.

THE 13TH FIVE-YEAR PLAN FOR ENERGY DEVELOPMENT (2016-2020)

Planning is a key-characteristic of socialist economies. Thus, in its efforts to achieve transition from the Soviet-type command economy to a socialist market economy, China regularly issues a series of social and economic development guidelines, the so-called Five-Year Plans. During Mao Zedong's tenure, the Chinese five-year plans were strictly implemented, while in the early 1980s their enforcement became less strict, as they served more as detailed guidelines to steer the country. In other words, the Five-Year Plans do not require absolute obedience as they once did, however they still remain behind the majority of governmental policies. Their formation includes six phases (Figure 2.2 1). ^[24]

²⁴ (1421 Consulting Group, 2019)



Figure 2.2 1: The stages of a five-year plan's formation ^[25]

In the first stage, intensive research is conducted upon the national socioeconomic needs, in order to interpret and fully understand them. Then, the floor is open for possible ideas that will respond to the above needs. Following, the most viable ideas proposed during the previous stage are examined on the base of a cost-benefit analysis and then lead to specific plans. In the fifth stage, a preliminary five-year plan is tested among various industry professionals, in order to verify its effectiveness and feasibility. Finally, a revised proposed plan is submitted for official approval to the People's Congress. Even though the first five-year plans aimed merely at the country's social and economic development and industrial expansion, their agenda has expanded, since much attention is also given to environmental issues and technological update.

In further detail, the key tasks included in the very first Five-Year Plan (1953-1957) were the construction of 694 large and medium-sized industrial projects, along with another 156 with Soviet Union's aid, the beginning of China's socialist industrialization, the development of agricultural cooperatives, and the socialist transformation of private industry and commerce. ^[26] Nevertheless, these tasks were not carried out successfully at that time, due to the rise of fiscal expenditure in capital construction investments, as well as the inability of the agricultural production to keep pace with industrial production.

²⁵ (1421 Consulting Group, 2019)

²⁶ (Wikipedia, n.d.)

The environmental factor emerged in the Sixth Five-Year Plan (1981– 1985) which defined the strengthening of the environmental protection efforts. Following, the Tenth Five-Year Plan (2001-2005) aimed to increase forest coverage to 18.2% and the urban green rate to 35%, reduce the total amount of major urban and rural pollutants by 10% compared to 2000, as well as conserve natural resources. ^[27] Even more detailed was the Eleventh Five-Year Plan (2006-2011) which ordered the following: ^[28]

- = A 20% decrease of energy consumption per unit of GDP within five years.
- = A 30% decrease of water consumption per unit of industrial added value within five years.
- An increase of the coefficient of effective use of water for irrigation from 0.45% in 2005 to 0.5% in 2010.
- An increase of the rate of comprehensive use of solid industrial waste from 55.8% in 2005 to 60% in 2010.
- A decrease of the total acreage of cultivated land from 122 million hectares in 2005 to 120 million in 2010.
- = A 10% decrease of the total discharge of major pollutants within five years.
- = An increase of the forest coverage from 18.2% in 2005 to 20% in 2010.

China has just completed its <u>13th Five-Year Plan</u>. Namely, top officials met in Beijing in order to sign off a national development plan, which would run from 2016 until 2020, featuring targets concerning economic growth, environmental protection and innovation. All major actors of both public and private sector were obliged to comply with the Plan's specifications by altering their policies and strategies if necessary.

The main focus areas of this period were the optimization of the energy system and its overall efficiency, the promotion of efficient energy conservation and management, the promotion of clean and efficient development and use of fossil fuels, the improvement of the level of cleanliness of the energy consumption, the adoption of an ecological culture, as well as innovation and abandonment of the old heavy industry. At the same time, the government tried to rationalize the price system, eliminate institutional barriers, build a fair competition in the energy market system, strengthen international

²⁷ (Wikipedia, n.d.)

²⁸ (Wikipedia, n.d.)

cooperation and enhance the Belt and Road Initiative, and encourage people to share the fruits of the country's economic growth, so as to achieve a shared energy development and bridge the existing welfare gaps.

The 13th Five-Year Plan included sub-plans referring to *coal, electric power, petroleum, natural gas* and *renewable energy*, with their own detailed objectives (Tables 2.1, 2.2) and covered the industrial, transport and building sectors, as far as energy conservation is concerned.

The 13 th FYP's key energy sub-plans				
Sub-Plans	Main Objectives	Key Measures		
The 13th FYP for Coal Industry Development	 Faster optimization and upgrading of coal structure. Promotion of clean production and efficient use. Energy conservation and emission reduction in main coal-consuming industries. 	 Legal framework improvement. Establishment of a system monitoring coal production capacity. Financial support to competitive enterprises. 		
The 13th FYP for Electric Power Development	 Development of new energy sources, (hydropower, nuclear power and natural gas) to promote clean development. Energy substitution, to optimize the energy consumption structure. Central heating improvement by replacing small coal fired boilers. 	 Adjustment of the Law on Electric Power, the Nuclear Power Management Regulations and the power legal system, in order to regulate government and market behavior. Increase of financial resources for the construction of a project information management system. Enhancement of transparency. 		
The 13th FYP for Petroleum Development	 Construction of crude oil and refined oil pipeline networks. Improvement of oil reserve capacity. 	 Measures for better administration of Oil and Gas planning. Multiplication of investments on 		

	■ Economic use of oil.	 infrastructure to promote connectivity. Reformation of the oil and gas system.
The 13th FYP for Natural Gas Development	 Construction of natural gas pipelines and gas storage facilities. Improvement of natural gas reserve capacity. Encouragement of efficient use. 	Structural improvement of state- owned oil and gas enterprises.
The 13th FYP for Renewable Energy Development	 Development of hydropower, solar power, biomass energy and geothermal energy. 	 Establishment of a clean-oriented management system. Strengthening of the regulation on renewable energy.

Table 2 .1: The 13th FYP's key energy sub-plans $\ensuremath{^{[29]}}$

The 13th Five-Year Plan's Renewable Energy Development stipulated further objectives and measures concerning Renewable Energy:

The 13 th FYP's Renewable Energy Development sub-plans						
Sub-Categories	Main Objectives	Key Measures				
Wind power Development	 Development of wind power use in the Eastern and Southern regions. Improvement of the wind power industry management system. Establishment of a market competition mechanism. 	 Optimization of the consumer regulation supervision. Price and Subsidy Mechanism innovation. 				
Hydropower Development	 Large-scale base constructions, and small and medium-sized river basin development. Hydropower technology and equipment 	 Strengthening of government regulation, as well as tracking analysis and project evaluation. Enhancement of the safety of production and operations. 				

²⁹ (International Energy Charter, 2018)

		development, and environmental protection.		
Solar energy Development	≡	Optimization of the	≡	Establishment of
		plants' layout.		monitoring and
	≡	Industrialization of		evaluation system.
		solar thermal power.	≡	Enhancement of solar
	≡	Promotion of solar		power market
		heating.		mechanisms.
	≡	Technological	≡	Support of
		innovation and		supplementary power
		industrial upgrading.		grid construction.



The financing of clean energy transition is not simple, as it requires large-scale investments, as portrayed in Figure 2.2 2.



Figure 2.2 2: China's estimated demand for clean investment during the 13th Five Year Plan (2016-20) period ^[31]

³⁰ (International Energy Charter, 2018)

³¹ (Global Times, 2017)

2.3. THE CHINESE ENERGY SYSTEM

This section provides an insight of the Chinese energy sector's main components. China's energy sector is mainly based on coal. Even though there are efforts towards a considerably cleaner energy mix, mostly solar and wind energy is used, while the use of geothermal energy, biomass energy, nuclear power and hydropower remains limited. Among the key-concepts that ought to be examined when analyzing the Chinese energy sector are the following: <u>Total Primary Energy Supply, Total Energy Production, Total Final Energy Consumption, Import dependency ratio, and Energy Sectors.</u>

<u>The Total Primary Energy Supply (TPES)</u>, refers to the primary energy a country has at its disposal, including imported and exported energy, as well as energy production. It is considered as the sum of all primary energy sources. ^[32] Regarding the Chinese TPES, it has been steadily rising over the last three decades and, as expected, coal, oil and natural gas are in dominant position, while the energy supply of biofuels and waste has progressively declined since 1995. The energy supply of coal started its sharp increase in the early 2000s (Figure 2.3 1).



Figure 2.3 1: Total primary energy supply (TPES) by source, 1990-2018^[33]

<u>Total Energy Production</u>: China is the largest energy producer in the world. During 2018, the United States and China were the main contributors to the increase in global energy production, together

³² (Energy Education, 2017)

³³ (International Energy Agency, n.d.)

contributing 54% of growth. ^[34] The progress of China's total energy production is of great interest since it sharply increased from 2000 and onwards, almost doubling itself, without appreciably declining ever since. As the largest energy producer in the world, it produced 2,749 mtoe of energy in 2020 (Figure 2.3 2), in which coal, electricity and oil represented the largest amounts produced (Figure 2.3 3).



Figure 2.3 2: Total energy production, 1990-2020^[35]



Figure 2.3 3: Energy production breakdown by source, 2020 [36]

However, despite China's substantial energy resources, its growing energy demands cannot be satisfied by using solely domestic production, since the country's needs exceed the amount of 3,284 million tons of oil equivalent per day, while its domestic production

³⁴ (Enerdata, n.d.)

³⁵ (Enerdata, 2021)

³⁶ (Enerdata, 2021)

can only provide up to 2,749 million tons of oil equivalent per day, as of 2020, 600 mtoe less. ^{[37][38]} Thus, long after reaching -1.2% in 1990, China's total energy imports have sharply increased, reaching more than a billion tons in 2018, while exports have remained considerably lower and steady, at 133,37 million tons throughout the same year. This proves that the domestic energy demand back in the 1990's decade was not as high as in the beginning of the 21st century.





Import dependency ratio: Securing unhampered access to foreign energy supplies is vital for China's economic growth and development. Prior to July 1960, the transfer of oil extraction technologies and knowhow between the Soviet Union and China, as well as the Chinese domestic reserves, such as the Daqing oilfield, helped China become oil self-sufficient in 1963. Nevertheless, since 1996, domestic oil production has steadily decreased, while demand for oil has continuously increased, augmenting the need of imported oil. China's oil import dependency reached approximately 70% in 2019, up from nearly 50% a decade ago. Moreover, the imports of gas rocketed from 0% to 20% within 4 years and have since shown an upward slope. In 2019, more than 40% of the gas consumed was imported. Lastly, China holds the third largest coal reserves worldwide, which justifies the lower imports shown in Figure 2.3 5.

³⁷ (Enerdata, 2021)

³⁸ (Enerdata, 2021)

³⁹ (Wong, S., 2018)



Figure 2.3 5: Oil, gas, and coal import dependency in China, 2007- $2019\,{}^{[40]}$

Crude oil, coal and natural gas imports peaked during the first two months of 2020; however, the Coronavirus pandemic significantly lowered the amounts of energy imported during the rest of the year. Nonetheless, crude oil remained the energy source with the highest demand, coal presented a slight decline from July and onwards, while natural gas imports remained at lower but steady levels.^[41]

<u>Total Final Energy Consumption</u>: Also referred to as Gross final energy consumption, it represents the aggregate of the end use energy, used for providing various energy services. ^[42] In other terms, it represents the total energy consumed by end users, such as private households, industry, agriculture, road and air transport, services etc. Energy used by the energy sector including for deliveries and transformation is excluded.

China is the largest consumer of primary energy in the world since 2009, right above the United States (Figure 2.3 6). Primary energy is taken directly from natural resources called primary fuels, such as crude oil, coal, and wind. According to BP, a 2%-14% increase in the Chinese primary energy is expected between 2018 and 2050. ^[43] As the world's largest consumer, China accounted for 24% of global energy consumption in 2018 and contributed 34% in the global energy demand growth during the same year ^[44], more than twice the

⁴⁰ (International Energy Agency, 2020)

⁴¹ (National Bureau of statistics in China, 2020)

⁴² (Energy Education, 2020)

⁴³ (BP, 2020)

⁴⁴ (BP, 2020)

numbers of India. In regional level, during the 20th century, China was followed by Japan which gave its place as the second largest energy consumer in the Asian continent to India, in about 2006.



Figure 2.3 6: Top 5 largest energy consumers, 2020 [45]

The Chinese energy consumption rate sharply increased between 2000 and 2005 and has since followed a constant rise. Even though the US's consumption rate exceeded China's in the early 1990's, the "Asian Giant's" energy needs increased in 2009 and onwards (Figure 2.3 7).



Figure 2.3 7: Total energy consumption comparison between China and US, 1990-2020 ^[46]

⁴⁵ (Statista, 2021)

⁴⁶ (Enerdata, 2021)

China's total energy consumption reached 3,381 mtoe in 2020, the majority of which deriving from fossil fuels (Figure 2.3 8).



Figure 2.3 8: China's total energy consumption, 1990-2020 [47]

China's primary energy mix has recently shifted from a dominant use of coal to an increase in natural gas and renewable energy sources. Figure 2.3 9 provides an interesting insight of the fluctuations in the Chinese energy consumption by source. In specific, coal has always been the most crucial element of the Chinese energy mix, however, there have been two noticeable declines in its demand, one in the early 2000s and another right after 2015. According to BP, the variations in the fuel mix in different parts of the world until 2050 will have as a result the decline of coal and oil, from 60% and 20% in China's case to less than 10% in both cases respectively. [48] The demand for oil has not yet noticeably altered, rather follows a steady increase. Electricity has become a much-needed element, especially after the President's call for an "energy revolution", a "fight against pollution" and a "service-based economic model", with its demand increasing from 2003 and onwards. Interestingly, even though the demand for biofuels and waste was significantly high, rating them the second most needed element after coal until 2002, their use has progressively decreased. Last but not least, China's growing energy needs are increasingly met by renewables, which have been following an upward path since 2008, as well as natural gas, which has been more present after 2006.

⁴⁷ (Enerdata, 2021)

⁴⁸ (BP, n.d.)



Figure 2.3 9: Total final consumption by energy source, 1990-2018 [49]

Lastly, the sectors requiring the most energy are the industrial, the residential and the transportation system (Figure 2.3 10).



Figure 2.3 10: Total final consumption by sector, 1990-2018^[50]

⁴⁹ (International Energy Agency, n.d.).

⁵⁰ (International Energy Agency, n.d.)

3. ENERGY SECTORS

In the third chapter of this paper, we will explore separately and in depth three energy sectors included in China's energy mix, starting with its main energy sources, coal and oil, and concluding with renewable energy.

3.1 COAL

<u>Supply</u>

China's energy needs have dramatically expanded due to rapid economic growth, with it being, as a result, the world's largest consumer of energy, the largest producer and consumer of coal, and the largest emitter of carbon dioxide. Also, China holds the third largest coal reserves worldwide. As the premier element that dominates the power sector of China, coal has nearly reached 80% of the total production during the last decade. Nevertheless, while coal remains the dominant fuel, its share in the total energy consumption reached historical low levels during the years 2016-2019 (Figure 3.1 1). As expected, coal is closely connected to the country's energy security.



Figure 3.1 1: Coal's proportion to total energy production, 1990-2019 [51]

⁵¹ (China Statistical Yearbook 2020)



Figure 3.1 2: Coal deposits in 2020 [52]

In order to meet strong domestic demand, coal supply has been enhanced by coal imports that have expanded during the last few years (Figure 3.1 3). Much of China's foreign coal supply comes from politically unstable regions. In 2017, its coal imports came from Australia (79.9 million tons), Indonesia (35.2 million tons), Mongolia (33.5 million tons), and Russia (25.3 million tons), while prior to 2017, North Korea was China's fourth largest coal supplier. Due to the implementation of UN sanctions on North Korea, China has suspended all coal imports from the regime, and, as a result, it relies more on Russia and Mongolia to fulfill its coal needs. ^[53] The Chinese coal exports have always been low, especially in the mid-2000.

⁵² (Business Insider, 2016)

⁵³ (China Power, 2016)



Figure 3.1 3: Balance of coal, 1990-2018 [54]

Nevertheless, due to the 2020-2021 Coronavirus pandemic, the monthly import volume of coal has dropped significantly, reaching unprecedented levels (Figure 3.1 4).





<u>Demand</u>

Since 2011, China's domestic coal consumption has exceeded the levels of coal consumed by the rest of the world combined (Figure 3.1 6). The Chinese coal production reached its peak during the 1990s decade and has always represented more than 50% of total energy production. Recently, there has been a noticeable decline in the total

⁵⁴ (China Statistical Yearbook 2020)

⁵⁵ (National Bureau of Statistics of China, 2021)

coal consumption, mainly due to the changes in China's footprint and the rise in the utilization of cleaner energy, alongside the negative repercussions of the Coronavirus 19 pandemic (view Figure 2.3 8: Total final consumption by energy source).



Figure 3.1 5: Mainland China versus Global Coal Consumption ^[56]

The industrial sector is by far the largest coal consumer. Specifically, in 2017, the industrial sector represented approximately $^2/_3$ of China's total energy consumption and consumed about 95% of the country's coal (Figure 3.1 6). ^[57]



Figure 3.1 6: Total coal consumption by sector, 1990-2019^[58]

⁵⁶ (China Power, 2016)

⁵⁷ (China Power, 2016)

⁵⁸ (International Energy Agency, n.d.)

3.2 OIL

<u>Supply</u>

The second largest source of energy in the country's TPES is oil. The domestic oil production reached unprecedented levels in 1980's, representing 23.8% of the total energy production, and has fluctuated between 15%-17%, before decreasing during the last few years. In 2019, oil represented 10% of the total energy production (view Figure 2.3 3: Energy production breakdown by source). China is also the largest importer of oil and in order to satisfy the domestic demand, the Chinese imports sharply increased firstly in 1995 and even more after 2005. The country had an import dependency of approximately 70% in 2019, 20% higher compared to the previous decade (view Figure 2.3 5). ^[59] Similar to coal, oil exports remain considerably low, despite the slight increase from 2010 and onwards.



Figure 3.2 1: Balance of oil, 1990-2019^[60]

In specific, as for 2020-2021, and similarly to coal imports during the same period, the monthly import volume of oil has significantly dropped due to the repercussions of the Coronavirus pandemic. (Figure 3.2 2).

⁵⁹ (International Energy Agency, 2020)

⁶⁰ (International Energy Agency, n.d.)



Figure 3.2 2: Monthly oil imports, January 2020- February 2021 [61]

It is crucial to consider that a country without dependance on energy imports and capable of leveraging its resources for its own economic and political gain is considered as a powerful country. In the opposite case, dependency on foreign resources, either economic or energy related, and vulnerability due to sudden shifts in the energy market, overseas political instability, disruption of access to foreign energy sources, or price increase, restrict policy options, and thereby reduce a country's power of influencing various matters on a global scale. It is evident that both Chinese coal natural gas imports derive mostly from the turbulent region of Middle East and North Africa (MENA), posing an energy security dilemma and challenge to China (Figure 3.2 3).



Figure 3.2 3: Crude oil and natural gas imports by country, 2019^[62]

⁶¹ (National Bureau of Statistics of China, 2021)

As far as oil sectors and products are concerned, the transportation sector is by far the largest in oil consumption and Gas/Diesel are the oil products mostly used.



Figure 3.2 4: Oil final consumption by sector, 1990-2018^[63]



Figure 3.2 5: Oil final consumption by product, 1990-2018^[64]

3.3 RENEWABLE ENERGY

As a fast-growing economy, China is facing challenges concerning energy generation, primarily due to rapid population growth and increasing energy demand. However, these two factors coupled with

⁶² (U.S. Energy Information Administration, 2020)

^{63 (}International Energy Agency, n.d.)

⁶⁴ (International Energy Agency, n.d.)

its heavy reliance on coal, provoke serious environmental issues, with the air pollution problem being the most severe one. In order to cope with the environmental problems, decrease air pollution, protect human health, improve energy security, sustain its economic growth and become more competitive in the global energy market, green energy has been gaining more of the Chinese government's attention in the last decade, making the country a global leader in renewable energy. Namely, according to BP's statistical review, "strong growth of renewable power is the key driver of China's energy transition".

According to IEA, China is the world's largest producer of hydroelectricity, wind and solar energy, as well as the largest investor in renewables.^[65] It also owns 3 of the largest renewable energy companies worldwide: JinkoSolar Holding Co., Hanergy Thin Film Power Group and Motech.



Figure 3.3 1: Leading countries in installed renewable energy capacity, 2019 ^[66]

The total investment value in the clean-tech sector in 2019 declined by 8%, reaching \$83.4 billion, without, however, altering China's position as the biggest player in the industry. ^[67] The renewable energy strategy produces substantial economic returns through exports of relevant technology, since, according to UN Comtrade Statistics, RES trade grew from 139.447 billion US dollars in 2007 to 202.908 billion US dollars in 2017, a 45.51% increase. ^[68] Furthermore, according to the CSIS, the renewables sector stimulated 3 million jobs in 2020.

The installed renewable energy capacity reached 758.63GW in 2019, making China the top first leading country for this year. ^[69] China has

⁶⁵ (International Energy Agency, n.d.)

⁶⁶ (Statista, 2021)

⁶⁷ (Power Technology, 2020)

⁶⁸ (Jing, S. Zhihui, L. Jinhua C. Zhiyao, S., 2020)

⁶⁹ (Statista, 2020)

vast non-fuel resources and great potential for future development and renewable energy is expected to be the second largest source of energy by 2030. The share of renewables in the country's energy mix might be low due to coal's dominance, however, renewables are already rapidly expanding in all three BP's scenarios concerning future primary energy consumption, reaching 48%, 55% and 23% in Rapid, Net Zero and Business-as-Usual (BAU) scenario respectively, from only 4% in 2018. ^[70] In fact, RES consumption has shown a constant rise within a decade, reaching 6.63 exajoules or else 1584 megatons in 2019.



Figure 3.3 2: China's RES consumption in exajoules, 2009-2019 [71]

Of paramount importance is the share of renewables in China's electricity generation since it grew by 330 TWh in 2019. The power plant fleet of China generated 7,325.1 TWh in total during 2019, more than twice the entire European generation, representing 26% of total electricity production. As a result, the 90% share of coal in electricity production fell to below 70% for the first time, as shown in Figure 3.3 3. Interestingly, IEA's "Global Energy Review 2020" report noted that electricity production from renewables has been the only source that showed a growth in demand despite the COVID-19 pandemic, thanks to its low operational cost.

As projected in Figure 3.3 3, solar, wind and hydro constitute the top preferred RES. In fact, China has the highest share of <u>solar</u> energy consumption in the world, reaching more than 223 TWh as of 2019. ^[72] At the same time, it is a leader in the global solar energy markets since its photovoltaic power generation sector is becoming very competitive, with revenues exceeding 900 million U.S. dollars as of 2020. ^[73] Furthermore, the monthly electricity generation from solar

⁷⁰ (BP, 2020)

⁷¹ (Statista, 2021)

⁷² (Statista, 2021)

⁷³ (Statista, 2021)

power in 2021 reaches 14.36 TWh. ^[74] <u>Wind</u> power represents another crucial renewable energy source for the Asian giant, as, between 2004-2018, the accumulated installed wind power capacity doubled itself to almost 190 GW. ^[75] In fact, "*Developing cheap solar and wind* energy to replace fossil energy has become the core energy strategy of China to reduce air pollution," as stated Hong Li, a researcher on solid-state lithium batteries at the Key Laboratory for Renewable Energy in Beijing. ^[76] During 2021, the monthly electricity generation from wind power is 46.95 TWh. ^[77] Besides, the substantial amounts of water resources China owns facilitate the development of <u>hydro</u> power, which plays a crucial role in the switch from fossil fuels to renewable energy. According to Statista, between 2004-2018, the domestic consumption of hydropower increased by almost tripling itself, reaching more than 270 million metric tons of oil equivalent. ^[78]



Figure 3.3 3: RES share in China's electricity mix, 2019 [79]

In other words, the Chinese coal-fired electricity production is expected to flatten, in contrast to previous years, as the energy mix shifts to renewable energy sources, with hydro, wind and solar being at the top of the list of alternatives.

It is thus clear that even though the share of renewables in the Chinese energy mix is still low due to fossil fuels' dominance, China

⁷⁴ (Statista, 2021)

⁷⁵ (Statista, 2021)

⁷⁶ (Nature, 2020)

⁷⁷ (Statista, 2021)

⁷⁸ (Nature, 2020)

⁷⁹ (China Energy Portal, 2020)

has become a keen driver on the development of renewable energy on a global scale by being a major manufacturer, an investor, but most importantly an innovator, especially in solar energy.

4. CONCLUSION

In conclusion, China's energy mix is far from being balanced, as fossil fuels, especially coal, represent more than 70% in the total energy production and dominate in the energy consumption of all sectors. Given its availability, accessibility, lax regulations and highly developed industry, coal is expected to continue to play a strategic role in the Chinese economy.

Coal's share in the TPES of China started its sharp increase in the early 2000s and reached 1979524 ktoe in 2018, while the second most crucial source, oil, remained at 609959 ktoe. Concerning energy generation, as the world's largest energy producer, China produced 2,749 mtoe of energy in 2020, in which coal, along with electricity and oil represented the largest amounts produced. Lastly, coal production and abundant supply may reinforce China's energy security and independence, however they pose challenges in adapting to international standards, aiming at decreasing GHG emissions, and mitigating the adverse effects of climate change.

Despite China's substantial energy resources, growing energy demand cannot be satisfied solely by the domestic production, since the latter can only provide up to 2,749 mtoe per day, while the country's needs exceed the daily amount of 3,284 mtoe. Thus, oil, gas and coal supplies have been supplemented by rapidly expanding imports, often deriving from politically unstable regions. Nevertheless, due to the Coronavirus pandemic, the monthly import volume of energy for the years 2020-2021 has dropped significantly, with coal and oil imports reaching unprecedented levels.

Given that energy security is considered as the uninterrupted availability of energy sources in an affordable price (IEA) ^[80] and that four inseparable preconditions for it to be achieved are its Availability, the physical existence of energy, supply and reserves, Affordability, concerning the cost of energy, Acceptability, in terms of society and environment, and Accessibility to energy resources, potentially hampered by geopolitical factors and upheaval (APERC, 2007) ⁸¹, it is clear that coal is closely linked to the country's energy security, economic prosperity and social development.

⁸⁰ (International Energy Agency, 2019)

⁸¹ (Paravantis, J. A., 2019)

With the aim of coping with severe challenges, such as environmental issues, air pollution, and human health, as well as sustaining its economic growth and counterbalancing its heavy reliance on coal, the Chinese government's attention has been lately shifted towards renewable energy, making the country the world's largest producer of hydroelectricity, wind and solar energy, as well as the largest investor in renewables. The Chinese installed capacity in renewable energy was the greatest worldwide and reached 758.63GW in 2019. Also, the share of renewables in the electricity production is of paramount importance, as 7,325.1 TWh were generated in total during 2019, representing more than twice the entire European generation. Last but not least, the Chinese photovoltaic sector is very competitive and robust, producing revenues over 900 million U.S. dollars as of 2020.

Investing in renewable energy has become a priority for the Chinese government offering a form of independence and a source of revenues. China's leadership in the renewable energy sector has been guided by the ongoing concerns on climate change globally that have turned renewable energy sources into an important component of the world energy consumption portfolio. The country's shift can be interpreted both in terms of ecology and strategy. In the second case, an increased renewable energy capacity for electricity consumption can reduce the state's dependency on unstable regions for fossil fuel imports, as well as reduce the cost of securing oil and gas transportation and transit routes and military presence. The international geopolitical landscape will also be benefited by China's dominance in the renewable energy sector since the greater the share of green energy in its energy mix, the fewer the causes and excuses in broadening its military presence in key-regions.

Overall, BP's projections on China's energy sector for the upcoming years are the following: a 2%-4% increase in primary energy between 2018 and 2050, a -44%- -94% decline in coal consumption between 2018 and 2050, a 34%-55% share of renewables in power generation by 2050, as well as a 35%-99% net decline in CO₂ emissions by 2050. ^[82] As renewable energy distribution continues to follow an upward path across the globe and given the constant availability and more fair distribution of sunlight and wind worldwide in comparison with the finite character of fossil fuels, the Chinese engagement and incentives to invest in this sector promise the country a crucial role in the sector's future.

⁸² (BP, 2020)

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