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CHINA'S ROLE
IN THE ENERGY TRANSITION

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Introduction

In the last two decades, China’s economy has grown at an incredible pace, making the country the second largest economy of the world.

Nonetheless, due to its high coal consumption, China is also the global largets greenhouse gas emitter, accounting for approximately 30% of global emissions. Therefore, China’s plays a crucial role in the energy transition. In the context of the international conferences and negotations such as COP, China, as the world’s largest energy consumer and emitter, plays a pivotal role in shaping the trajectory of the energy transition, facing great pressure to become more ambitious in greening its energy transition.

Verifying China's growing commitment and the reliability of its statistical data is challenging due to the country's dirigiste economy. Even independent studies must extrapolate data on energy transition by comparing official data with information obtained from analyzing certain import and export trends, for istance. This makes it difficult to fully verify the accuracy of the data.

Currently, the most important plan for energy transition is the 1+N, envisaged in the 14th Five-Year Plan. China’s main goal is to reach peak carbon emissions by 2030 and carbon neutrality by 2060: this was one of the largest climate policy announcements in the world, made by Xi Jinping in 2020. However, China still accounts for almost one-third of the world's carbon emissions, and approximately 50% of its energy mix is constituted by coal. Therefore, the possibility that the country can achieve carbon neutrality in less than 40 years is of significant importance.

The pillars of the energy transition are: reducing the use of fossil fuels, decreasing air pollution in Chinese cities (as part of the 'Beautiful China' objective, which combines economic development with environmental wellbeing), and improving energy security. In order to achieve this goals, an increase in technological innovation and manufacturing capacity in clean tech will be necessary; the government is also committed to reducing the carbon dioxide intensity and the energy intensity of its GDP.

By 2025, half of China's installed power generation capacity must come from renewable sources, which is an extremely ambitious goal. It is worth noting that although renewables currently account for a very small share of China's energy mix, China was the world leader in renewable energy installations between 2013 and 2022, accounting for approximately 40% of the world's annual growth, and the percentage is still growing. On a parallel path, a similar growth is ongoing in carmaking, with China becoming the main producer and exporter of fully electric vehicles.

China's leading role in the energy transition would not have been possible if it were not rich in rare earths, which are essential for batteries, wind power, photovoltaic panels and electric vehicles. China has developed a strong industrial sector in this field and a long-term strategy of acquisition of critical minerals in other countries.

Energy transition efforts will take into account also territorial imbalances within China: the east of the country is densely populated, heavily industrialised and hosts a large part of the fossil fuel-fired power stations of the country while the west is largely uninhabited, making it ideal for the installation of renewables such as solar and wind generators, but there is limited interconnection between the electric grids that are mainly regional and provincial, and there is a very low level of interconnection between the grids of the different Chinese regions, which leads to higher costs and lower efficiency, and therefore also to the possibility of blackouts and imbalances between regions, especially coastal regions, where there is often more demand than supply. Thus, there is a gap between production and demand and a geographical mismatch.

China's long-term demographic outlook also needs to be taken into account: the population is thought to have peaked and the declining population will affect negatively economic growth but also the energy transition, paradoxically in a positive way.

Moreover, other challenges include protectionism of provincial governments, which tends to favour local companies in major investment projects, and a lack of coordination between the various stakeholders and institutional levels in the country: initiatives taken at the central government level in Beijing are often not implemented as quickly at the provincial and regional levels.

There is also an issue of energy pricing, i.e. how much subsidies will still be needed for the country's energy development: it will be necessary to move from a centralised energy production model to a hybrid model. In fact, the country has always focused on large plants to supply large industrial and urban centres.

In the last two decades, the fast-growing Chinese economy has become more and more dependent on foreign energy supply and in this time span China has revised its geopolitical stance becoming a strong competitor to the traditional developed economies of the western world grouped in the G7 for coal, oil and gas. Recently, however, the push towards renewables made China the leading global player in the related industrial sector (solar panels and wind turbines) with relevant consequences for the “global South”. Within the Belt and Roads Initiative (BRI), the push for energy transition in Africa and Asia has become more and more one of the main goals, and the BRICS alliance (recently expanded to new countries that are rich in fossil fuels) is another piece of the chinese strategy in the global energy scenario.

The aim of this study is to analyse the multifaceted dimensions of China’s role in the energy transition and the pattern of its energy transition, started in the early 2000, through the country’s historical, economic and political realms.

This is divided in 3 main parts.

The first chapter examines China's energy sector since 2000, focusing on the interplay of various energy sources, particularly coal. The chapter also discusses the evolution of Five-Year Plans in the past two decades. It analyses the role of coal in driving economic growth, its environmental and health implications, and the concurrent development of nuclear, hydroelectric, and oil and gas sectors. Additionally, the chapter discusses China's energy relations with Russia, as demonstrated by projects such as Power of Siberia 1 and 2. It also examines the increasing significance of renewable energy in reducing emissions, addressing pollution concerns, and ensuring energy security.

The second chapter shifts the focus to China's long-term energy development strategies. It analyses the country's various energy sources and initiatives for renewable, nuclear, and hydroelectric power on the global stage. The chapter investigates the tools used to guide the energy framework towards transition, including the role of the Emissions Trading System (ETS) market. Additionally, the thesis explores the electric vehicles sector, highlighting the challenges posed by the crisis within the European Union and constraints arising from the current economic situation and growth imperatives.

The final chapter ventures into China's impact on the international market, specifically in the oil and gas sector, renewable systems components industry, and the availability of rare earths. It also examines the geopolitical landscape, highlighting China's relationships with key players such as Russia, the United States, and fellow BRICS nations. This provides a comprehensive understanding of China's influence in the global energy transition.

Through this comprehensive research, this thesis aims to unravel the intricate dynamics that define China's role in shaping the energy transition landscape, both domestically and internationally.

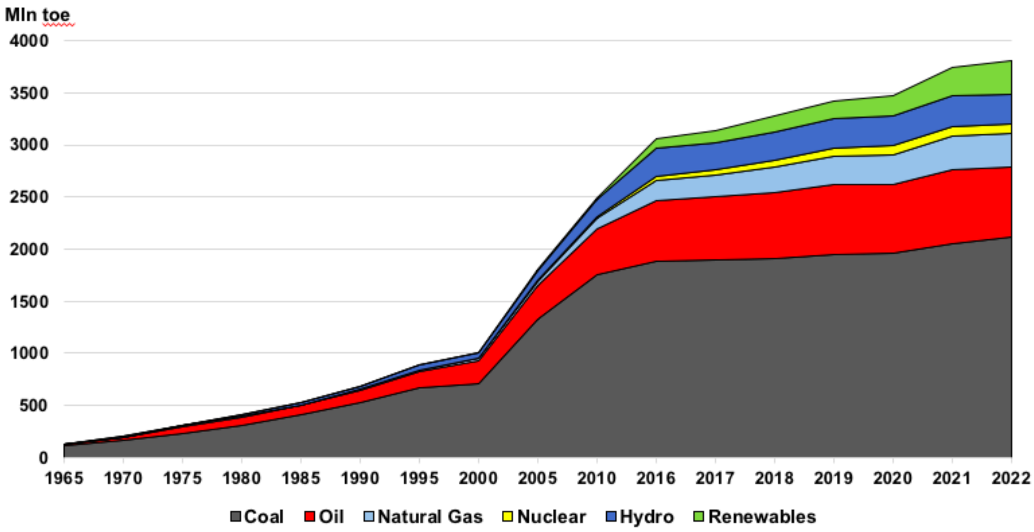
1. The development of the energy sector in China since 2000

1.1 The role of the different energy sources - and of coal in particular - in the Five-Year Plans (FYP)

China's economy has been expanding at a quick pace, and since the country started focusing more on heavy industries in the 2000s, energy consumption has increased. Coal still makes up the majority of the energy consumed today; as of 2019, it made up 57.6% of China's energy mix[1]. It also is the first country in terms of global coal consumption (50.4% of world total) and the first country in terms of global coal production (50% of coal production of the world). Despite this, 7-8% of coal is imported.

Total primary energy consumption in China by fuel type

Source: Statistical Review of World Energy, 2022

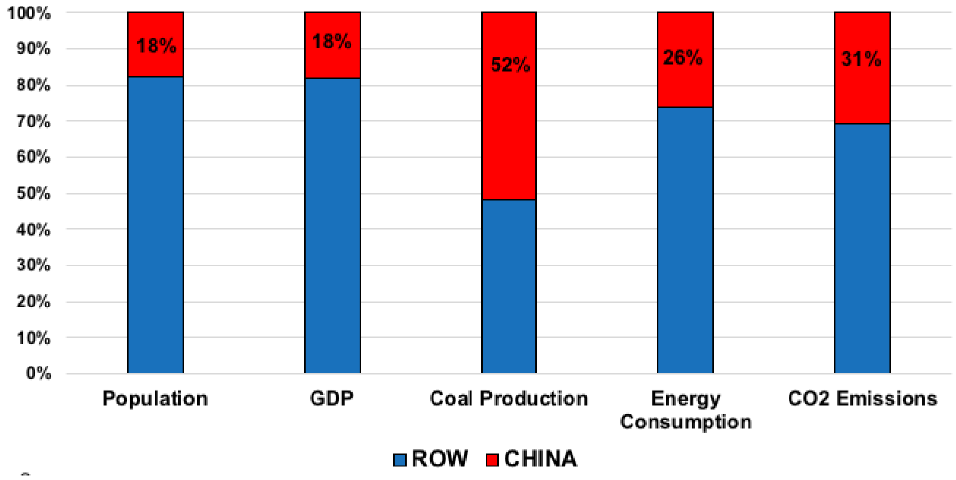


[1] Guilhot, L. (2022). An analysis of China's energy policy from 1981 to 2020: Transitioning towards a diversified and low-carbon energy system. *Energy Policy*, 162. https://doi.org/10.1016/j.enpol.2022.112806

Furthermore, the country is currently the world's biggest energy producer and consumer. China accounted for over 18% of the global population in 2019, consumed approximately 24% of the global energy supply, and produced 20% of it.

China's energy consumption increased dramatically starting in 2001, at a far faster rate than the global average or that of non-OECD (Organisation for Economic Co-operation and Development) nations. This increase was primarily in the country's total final consumption, which is the total of the consumption for both energy and non-energy use[1].

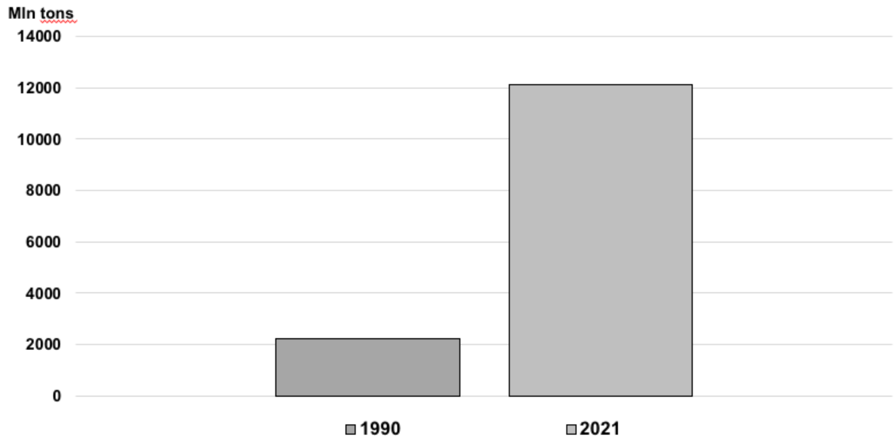
Source:
World Bank for GDP (Current US $);
Statistical Review of World Energy 2023 for Energy Consumption, CO_2 Emissions and Coal Production



China has continuously dominated global rankings for CO2 emissions since 2006. The nation contributed to 30,7% of the world's emissions in 2021, which amounts to 9.9 billion tons of CO2 emissions.

China's CO2 emissions, million tonnes of CO2 (1990–2021)

Source: Author's calculation based on data from Statistical Review of World Energy, 2021.



Chinese President Xi Jinping agreed that China's carbon emissions will peak before 2030 in a 2014 arrangement with US President Barack Obama. This goal was confirmed in China's June 2015 Intended Nationally Determined Contributions (INDC) to the United Nations (UN). China reiterated its commitment to tackling climate change in September 2020 at the UN General Assembly, announcing its aim of becoming carbon neutral by 2060[1].

The Chinese government filed its new Intended Nationally Determined Contributions (INDC) to the UN in October 2021, ahead of the COP 26 (Conference of the Parties) in Glasgow. The INDC calls for a peak in carbon emissions before 2030, carbon neutrality by 2060, a 65% reduction in carbon intensity by 2030, and a 25% share of non-fossil energy sources in the energy mix by 2030[1]. US President Joe Biden and Chinese President Xi Jinping signed a new agreement confirming their collaboration on climate change during the COP 26[2]. Both nations acknowledge the seriousness and immediacy of the climate emergency[1].

The Chinese government is giving the energy industry particular attention in order to fulfill its environmental obligations. Like the rest of the economy, this industry has changed significantly since 1980. The examination of energy policies in the Five-Year Plans (FYP) over the last twenty years, from the Tenth to the Fourteenth Year Plan, can clarify the increasing focus on the environment: the economic planning documents, or FYPs, in fact, are China's most important government documents, drafted by the Chinese government since 1953. They set forth the fundamental objectives and guiding principles of the country's economic development strategy.

At the end of the National People's Congress (NPC) session on March 11, 2021, the Fourteenth Five-Year Plan (2021–2025) was formally adopted.

Moreover, according to Yuan and Zuo[3], a nation's social and environmental characteristics, in addition to its energy development, are greatly influenced by its energy strategy and the Five-Year Plan for National Economic and Social Development outlines the country's agenda for that time.

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[2] Conference of the Parties

[3] Yuan, X., & Zuo, J. (2011). Transition to low carbon energy policies in China: From the Five-Year Plan perspective. *Energy Policy, 39*(7), 3855–3859.

Since the 2000s, there has been a direct correlation between strong industrialization, especially in heavy industries, and rising energy demand. But the need for energy seems to have leveled off since the 2010s. This can be explained by the Chinese economy's sector-specific developments (growth in the service sector reduces energy consumption), a slower rate of economic expansion, and ongoing improvements in energy efficiency[1].

As stated by Laetitia Guilhot[1], taking a look back at the last eight Five-Year Plans (from the Sixth to the Thirteenth Plan, from 1981 to 2020), China's energy policy can be divided into three stages: from 1981 to 2000, it was solely focused on energy efficiency; from 2001 to 2010, it became more involved with energy security while maintaining its interest in energy efficiency; finally, in the period from 2011 to 2020, it included the fight against climate change as a third goal of its policy. This third objective emphasizes how China's energy revolution got underway in 2011.

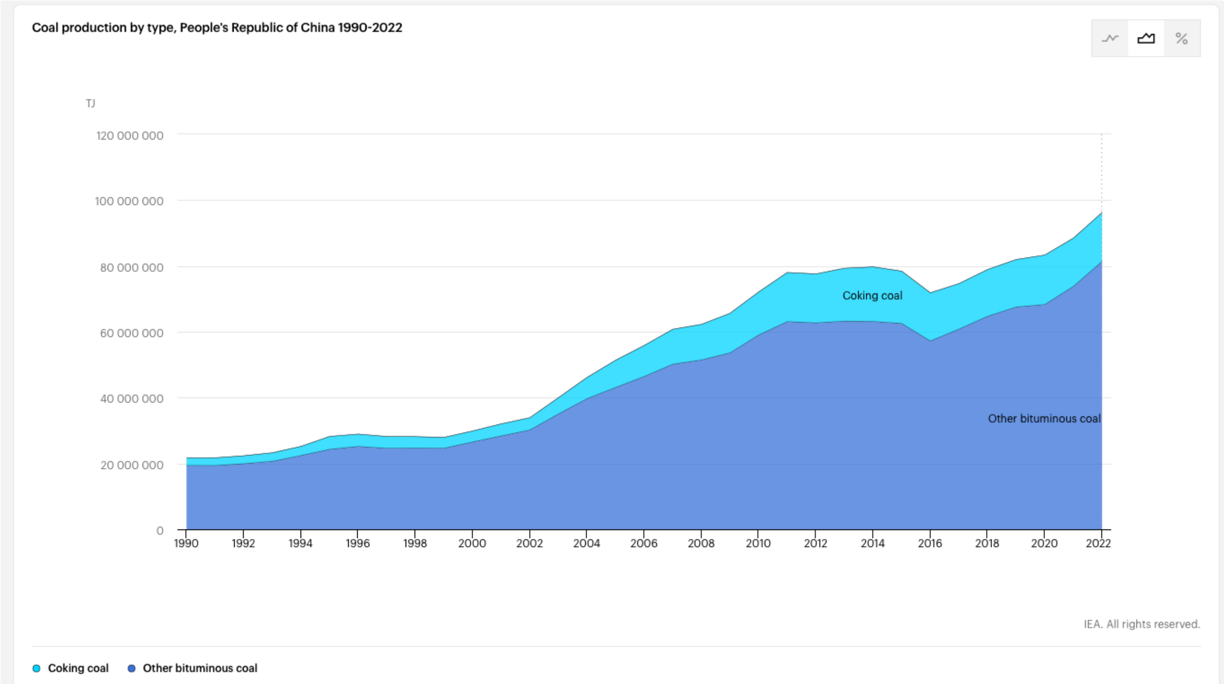
Years	**1981 2000**	**2001 2010**	**2011 2020**
Plans	**Sixth to Ninth**	**Tenth to Eleventh**	**Twelfth to Thirteenth**
Energy policy's objectives	Energy efficiency	Energy efficiency Energy security	Energy efficiency Energy security Climate change **Energy Transition**

In regard to coal, production increased by over six times between 1981 and 2019. In the past few years, there have been several different periods in the production of coal: a sharp rise from 2000 to 2011, a pause from 2012 to 2015, a decline in 2016, and then a subsequent upsurge starting in 2017 that resulted in the extraction of almost 1958 Mtoe of coal in 2019. Nearly half of the world's coal-fired power plant capacity is found in China's territory[1].

Additionally, China kept adding new power plants and in 2017 loosened its prohibition on the building of coal-fired power stations. A 2019 report by the non-governmental organization Global Energy Monitor states that China has already planned the building of new coal plants with a capacity equal to the whole coal fleet of the European Union[1]. This amounts to over 148 GW[4] of generation capacity that is either in the process of being built or has been planned but not yet been put into service.

Coal production by type in China (1990-2022)

Source: International Energy Agency



We will now describe in detail the various Five-Year Plans since 2000.

China's Tenth Five-Year plan (2001-2005) envisaged various goals:

1. The effective use of clean energy sources, such as nuclear, hydropower, and natural gas
2. Endorsing alternative energy sources, such as wind and solar PV
3. Increasing clean coal technologies
4. Decreasing reliance on coal-based targets
5. Achieving sustainable energy development[5]

For what concerns renewable targets, in this plan, the commercialization of solar and wind energy, diesel and battery systems, bioelectricity, geothermal energy,

[4] Gigawatts

[5] IEA. (2021). The 10th Five-Year Plan for Economic and Social Development of the People's Republic of China (2001-2005)

and fuel forests in rural areas are prioritized; furthermore, it includes few wind, solar, and hydropower projects, a total of 500 MW[6] of wind farms are planned for the provinces of Xinjiang, Inner Mongolia, Hebei, Jilin, Liaoning, Hubei, and Guangdong and its electricity production targets consist in the utilization of new and renewable energy sources to produce 13 Mtce of coal of electricity (excluding small hydropower and conventional biomass use). According to the Five- Year Plan, the latter would have resulted in a decrease of 10 Mt of CO2 and at least 0.6 Mt of SO2[7].

For what concerns solar electricity, the goal was to increase solar cell production capacity to 15W per cell, for a total of 53 MW of capacity; for wind power, the plan envisaged the installation of 1.2 GW of grid-connected wind power, with a 150–200 MW manufacturing capacity. Lastly, the plan's target for geothermal energy production also envisaged a slight increase of geothermal energy and bioenergy in order to expand the gas supply.

China's Eleventh Five-Year plan (2006 – 2011), included a number of initiatives aimed at raising China's the role renewable energy in China's energy mix. These included: building thirty very big wind farms with a capacity of 100 MW; making provisions for grid-connected wind and biomass to reach 5 GW and 5.5 GW, respectively; and aiming for more than 5.5 GW of electricity powered by waste and biomass by 2010.

With little regard to environmental concerns, the primary goals of this FYP were to diversify the energy supply and reduce energy intensity. The "Top 1000 Enterprises Energy Conservation Action Program" was one of the Plan's signature programs for reducing intensity. It was created in April 2006 with the goal of pressuring the 1008 energy-intensive businesses to reduce their energy use[8]. In 2004, these businesses were responsible for 33% of the country's energy use and 47% of industrial consumption. During the Eleventh Five-Year Plan, the program aimed to conserve 100 Mtce[9]. This objective was accomplished.

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[6] Megawatts
[7] Sulfur Dioxide
[8] Ke, J., Price, L., Ohshita, S., Fridley, D., Khanna, N.Z., Zhou, N., & Levine, M. (2012). China's industrial energy consumption trends and impacts of the Top-1000 enterprises energy-saving program and the Ten key energy-saving projects. *Energy Policy*, 50, 562–569.
[9] Zhang, Z.X. (2010). China in the transition to a low-carbon economy. *Energy Policy*, 38, 6638–6653.

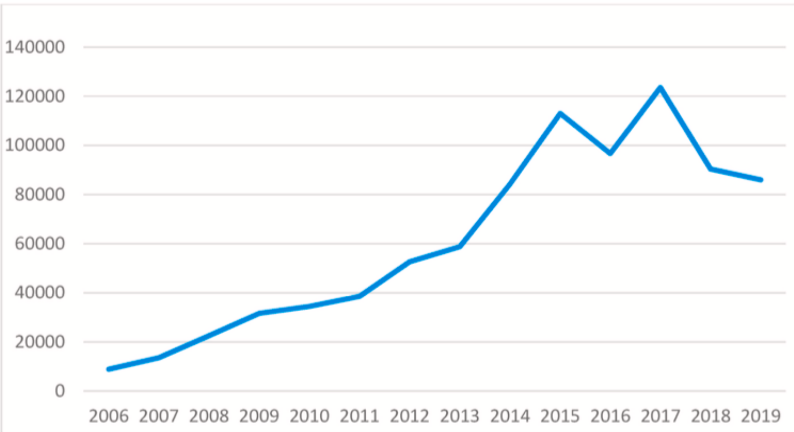
Furthermore, complying with its main objective of diversifying the energy supply, the Eleventh FYP also sought to expand the country's current oil reserves[10] and develop nuclear power, giving highest priority to building new nuclear power facilities.

In 2007, the plan for nuclear energy's – medium and long -term - development was made public. Its goal was to build nuclear power plants with installed capacity of 40 million kW[11] and annual electricity production of 260–280 billion kwh by 2020[12] [1] [3].

Finally, the Eleventh FYP aimed at creating investments in renewable energy: these investments, in fact, increased from $8.9 billion to $34.5 billion - nearly four times - between 2006 and 2010. China's policy to expand renewable energy sources is demonstrated by the 2006 law on renewables. To promote the solar industry, the federal government started the Golden Sun Program in July 2009[1] [3].

Investments in renewable energy projects in China, 2006–2019, Millions $.

Source: Bloomberg NEF (2020), Climatescope 2020, https://2020.global-climates cope.org/



Reducing energy intensity and diversifying energy sources to guarantee energy security were the two main goals of the nation's energy policy during this time. In the Eleventh FYP, the topic of climate change was raised for the first time, but its

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[10] State Council. (2006).

[11] Kilowatts

[12] National Economic, Trade Commission. (2016). The 13 Five-Year Plan for Economic and Social Development of the People's Republic of China. Retrieved from https://en.ndrc.gov.cn/policies/202105/P020210527785800103339.pdf

implications clearly addressed. Nevertheless, climate change was not considered a matter of concern until the following FYP.

Indeed, the issue of tackling climate change has been included for the first time in the Twelfth Five Year Plan (2011-2015) alongside local pollution as a major concern for the Chinese economy. This FYP establishes a carbon intensity target for the first time[13]. The phrase "sustainable development" is gradually being replaced with the terms "green growth" and "green development."[1] [13] According to the State Council[14] (2011), this plan established three climate and environmental targets for 2015: reducing energy intensity by 16% from 2010 to 2011; reducing carbon intensity by 17% from 2010 to 2011; raising the role of non-fossil sources in primary energy consumption from 8.6% (2010) to 11.4% (2015)[1] [13]. The rates at which these three goals were met were respectively 18.2%, 20%, and 12%.

A significant reduction in demand is implied by the fact that there was an absolute cap on energy consumption, with a maximum limit of 4 Gtce. Additionally, the governement planned for 20% of the resources needed to produce electricity to be obtained from renewable sources. The Twelfth Plan's objectives were all ultimately achieved[1]. Thus, through programs like the Top 10,000 Program and, more recently, market-related reforms like increased competition in the electricity market or the establishment of the national carbon market, the Chinese government aimed to slow the increase in CO2 emissions[15]. During this time, energy intensity decreased as well.

The Thirteenth Five-Year Plan (2016–2020) demonstrated a desire to increase energy efficiency and diversify energy sources in favor of low-carbon and renewable energy sources. To become more competitive in the global energy market, China stated the intention to make advancements in nuclear, fossil fuel, and renewable energy technologies as well as mini-, super-, and smart-grid development.

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[13] Li, J., & Wang, X. (2012). Energy and climate policy in China’s twelfth-year plan: a paradigm shift. *Energy Policy*, 41, 519–528.
[14] State Council. (2011). The Twelfthve-year guideline for national economic and social development. Retrieved from http://ghs.ndrc.gov.cn/ghwb/gjwngh/
[15] Zhang, S., & Andrews-Speed, P. (2020). State versus market in China’s low carbon energy transition: an institutional perspective. *Energy Researc & Social Science.*, 66.

Among its five pillars—the others being innovation, openness, collaboration, and inclusive development—was "green development."

The goals included in the outline were: to cut the share of coal in the energy mix to 58% by 2020 with an energy consumption target below 5 billion tonnes of coal equivalent; reduce energy intensity by 15% by 2020; reduce carbon intensity by 18% by 2020; provide funding for innovation in low-carbon technologies; reach a 15% share of non-fossil energy sources in the energy mix[1].

In an effort to reduce coal consumption, the Chinese government implemented a specific policy to improve the performance of coal-fired power plants. In practice, this has resulted in a newer and more efficient thermal power fleet, with a large proportion of plants that are highly efficient in terms of fuel consumption per unit of energy produced. These new plants, known as "supercritical" and "ultra-supercritical", currently account for 19% and 25% of China's electricity generation, respectively. They reduce coal consumption and CO2 emissions per unit of electricity produced[1] [12].

Source: National Energy Administration

China's 2025 Renewable Energy Targets			
Indicators	Unit	2020 level	2025 target
1. Renewable electricity utilization			
Renewable electricity consumption share	%	28.8	33
Non-hydro renewable electricity consumption share	%	11.4	18
Renewable electricity generation	trillion kWh	2.21	3.3
2. Renewable non-electric utilization (geothermal heating, biomass heating and fuel, as well as solar heating)	million tonnes of standard coal	/	^{3}60
3. Total renewable consumption	billion tonnes of standard coal	0.68	1
4. Non-fossil power generation share	%	33.9	39
5. Electrification rate	%	27	30
6. During 2021 to 2025, more than 50% of the country's incremental electricity and incremental energy consumption shall come from renewables.			

Finally, in June 2022, China released the Fourteenth Five-Year Plan on Renewable Energy Development (2021-2025), a comprehensive blueprint to further accelerate China's renewable energy (re) expansion. The plan targets a 50% increase in renewable energy generation (from 2.2 trillion kWh in 2020 to 3.3 trillion kWh in 2025), a 33% share of renewable electricity consumption in 2025 (up from 28.8% in 2020), and mandates that 50% of China's additional electricity and energy consumption in 2021-2025 should come from renewable sources. Achieving the plan's targets will reduce carbon emissions by up to 2.6 gigatonnes per year (equivalent to almost a quarter of China's total carbon emissions in 2020)[16].

1.2 Impact on health and environment

Air pollution is one of China's biggest environmental issues.

China's economic growth and urbanisation have led to a dramatic increase in energy consumption, which in turn has generated a large amount of additional pollutant emissions; this is particularly true of Beijing, Shanghai and the PRD region, which includes Guangzhou, Shenzhen and Hong Kong[17]. For instance, studies found out[18] [19] that PM2.5[20] concentrations in Beijing and Shanghai, the two largest cities in China, were approximately 10 and 6 times the World Health Organization guideline values, respectively.

The improvement of air quality and the decrease of emissions of air pollutants in China's cities, municipalities, and provinces have received a lot of attention. For instance, the Chinese Government developed and published a number of regulations, laws, and guidelines, such as the "National Ambient Air Quality Standards (GB3095-1996)", the "Emission Standards of Air Pollutants for Thermal Power Plants (GB13223-2003)", and the "Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution"[17], and public health and environmental issues are viewed as part of a national

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[16] Energy Foundation. (2022). China's 14th Five-Year Plans on Renewable Energy Development and Modern Energy System.

[17] Chan, C. K., & Yao, X. (2008). Air pollution in mega cities in China. *Atmospheric Environment, 2*(1).

[18] Ye, B., Ji, X., Yang, H., Yao, X. H., Chan, C. K., Cadle, S. H., Chan, T., & Mulawa, P. A. (2003). Concentration and chemical composition of PM2.5 in Shanghai for 1-year period. *Atmospheric Environment, 37*(pp. 499-510).

[19] He, K., Yang, F., Ma, Y., Zhang, Q., Yao, X. H., Chan, C. K., Cadle, S. H., Chan, T., & Mulawa, P. A. (2001). The characteristics of PM2.5 in Beijing, China. *Atmospheric Environment, 35*(pp. 4959-4970).

[20] Fine particulate matter

strategy. Moreover, The "Healthy China 2030 Plan," published in 2016 by the State Council and Central Committee of the Communist Party of China, places a strong emphasis on better handling environmental issues that affect human health[21]. In many cities, daily air quality data and the Air Pollution Index (API) have been accessible since 2000.

For what concerns coal, the health problems are related to exposure to PM2.5, the emission of organic compounds from incompletely burnt domestic coal and the mobilisation of trace metals such as arsenic, fluorine, selenium and possibly mercury. Black lung disease in miners and lung cancer in women are two adverse health effects of inhaling minerals such as pyrite and quartz. Health problems could also arise from China's widespread uncontrolled coal fires. As uncontrolled fires have been eliminated, better coal-burning stoves are available and more people are using alternative fuel sources, the situation has generally improved. However, more needs to be done to reduce the negative impact of coal use on Chinese health[22].

In addition to tracking China's progress on health and climate change, the Lancet Countdown 2023 China report[23] now links human activity to the health risks associated with climate change and offers examples of practical remedies.

The emissions of air pollutants, such as greenhouse gases and particulate matter from industry, transportation, and household energy use, were significantly reduced through the modification the energy mix and enacting air pollution control measures[23].

The highest rate of increase in coal consumption since 2011 does, however, indicate that, in the absence of a bold response to climate change, progress on mitigation may be severely hampered by extreme weather, forcing an increase in the use of fossil fuels.

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[21] Liu, W., Xu, Z., & Yang, T. (2018). Health effects of air pollution in China. *International Journal of Environmental Research and Public Health*, *15*(7), 1471. https://doi.org/10.3390/ijerph15071471

[22] Finkelman, R. B., & Tian, L. (2017). The health impacts of coal use in China. *International Geology Review*, *60*(5–6), 579–589. https://doi.org/10.1080/00206814.2017.1335624

[23] Zhang, S. et al., (2023). The 2023 China report of the Lancet Countdown on health and climate change: taking stock for a thriving future. *The Lancet Public Health*, *8*(12), e978e995. https://doi.org/10.1016/s2468-2667(23)00245-1

China still has a long way to go toward achieving its goal of net zero emissions. Some of these challenges include ensuring a steady supply of electricity coming from zero-emission sources and removing technological barriers in energy storage and long-distance power grid transmission to facilitate the large-scale development of renewable electricity. According to this study, China must urgently find answers to these problems in order to prevent the lock-in effect, risks of stranded assets from prolonged coal investment, the short- and long-term health issues, and more[23].

1.3 The role of coal in the economy growth

"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"[24].

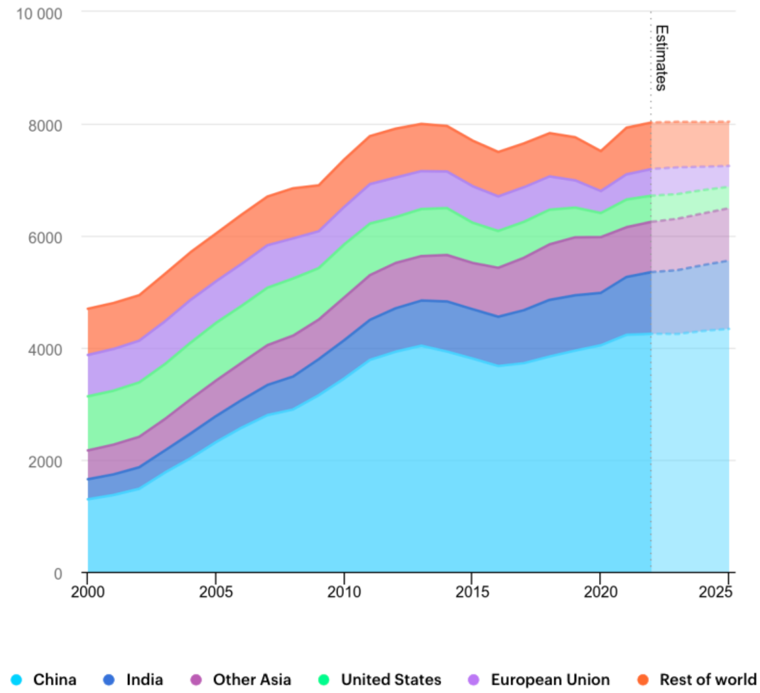
Since the late 1990s, the market has been dominated by the steady increase in coal use, but demand for oil and gas has also increased. Today, coal still has a dominant role in the energy scenario of China. It accounts for over two thirds of the primary energy mix, while gas is responsible for approximately 3%, hydropower for over 6%, and oil for one-fifth.

Approximately 50% of all coal is employed for power generation, making up approximately 80% of the 4.980 TWh[25]/year generated over the past ten years (natural gas and oil production accounted for less than 2% of total generation, nuclear power for 1.2%), with the remaining coal being used for the production of iron and steel.

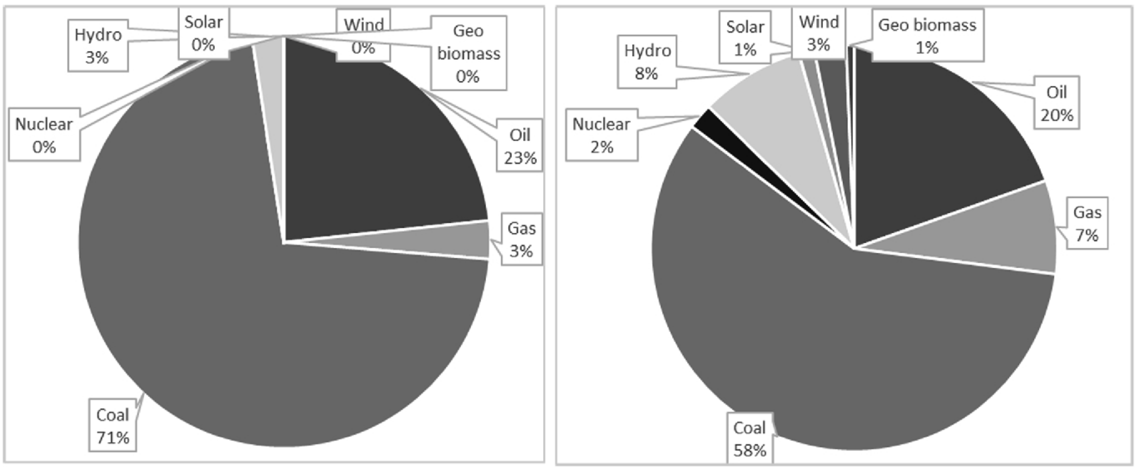
China is the world's biggest producer and consumer of coal, as well as the biggest user of power generated from coal.

[24] Hallding, K., Han, G., & Olsson, M. (Year). *A Balancing Act: China's Role in Climate Change*. Commission on Sustainable Development.
[25] Terawatt/hour

Coal consumption in the world
Source: IEA



China's energy mix 1978, 2018.
Source: BP "Statistical Review of World Energy"



With a seven-fold rise in primary energy consumption from less than 400 million tonnes of oil equivalent (toe) in 1978[26] to 3.27 billion toe in 2018, the nation's fast industrialization and urbanization process is driven by a bursting desire for energy.

In 1978, domestic coal accounted for 70% of the energy mix, while the remaining 23% came from oil. China consumed 1.9 billion tons of coal in 2018, accounting for half

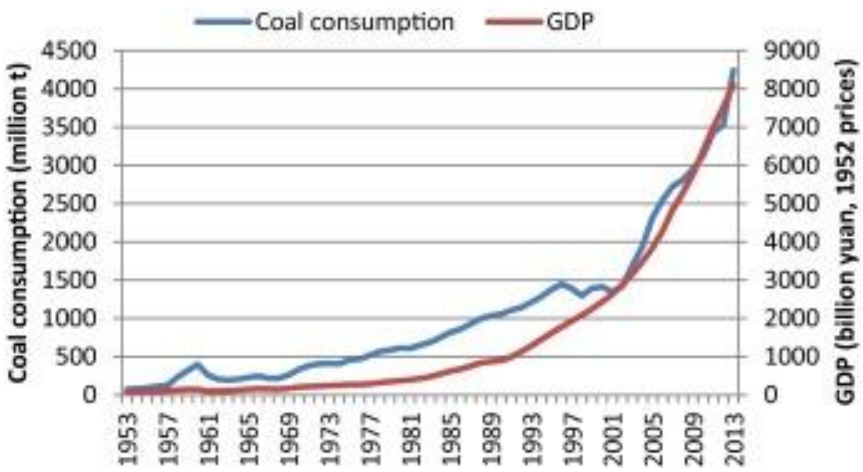
[26] British Petroleum. (2019).

of the global coal consumption, compared to just 17% in the late 1970s[27] [26]. Due to its significant reliance on coal[28], China is now the world's greatest CO_2 emitter since 2006.

Additionally, China is the world's greatest producer of coal, second to the United States in terms of overall coal reserves, but first in terms of coal quality. Nonetheless, the majority of its coal reserves are geographically distant from the heavily populated coastal regions, creating a significant challenge for the transportation and supply of coal. Because of inefficient industrial sectors and transportation facilities that make it difficult to transport coal from the northern to the southern areas, the nation is a net importer of coal.

China's energy consumption has grown significantly over the past few decades. In particular, China's demand for coal expanded so rapidly that it outpaced supply, which prompted more foreign investments and imports. However, domestic coal production has decreased (with a 9% drop in 2016) and the share of coal in the energy mix had decreased following the approval the Thirteenth Five-Year Plan (2016-2020).

Coal consumption and GDP in China.



As shown in this figure, there is a direct correlation between coal consumption and GDP. According to a study on the drag effect of coal consumption on economic

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[27] Meidan, M. (2020). China: climate leader and villain. In *Lecture notes in energy* (pp. 75–91). https://doi.org/10.1007/978-3-030-39066-2_4

[28] Reducing emissions from hard-to-abate industries like cement, petrochemicals, and iron and steel manufacturing, which are frequently energy and carbon-intensive, also is a major challenge due to the vital role of these industries to the overall economic activity in China.

growth in China during 1953-2013[29], coal consumption increased approximately 60 times between 1953 and 2013, from 0.71 million tonnes to 42.44 million tonnes, or an average annual growth rate of 7.95%.

China's heavy dependence on coal use is becoming a major issue due to its huge population and limited resources. The drag effect of coal consumption on the economy has been questioned by numerous academics, given the severe capacity constraints in the coal sector. Although coal is a non-renewable resource that will eventually run out, China has enough coal resources to maintain its high coal consumption percentage for the foreseeable future[29].

However, the supply of coal may not be enough to meet demand if inefficient coal consumption persists. Controlling high coal consumption is crucial for China and the rest of the world due to the growing global warming crisis and the need to maintain the domestic environment. Therefore, limits on coal usage are likely to hamper China's development and economic growth. The question at hand is whether the availability of coal resources will impede GDP growth[29].

A significant amount of literature examines the correlation between coal and economic development. In particular, there are 5 main hypothesis regarding the link between the two:

(i) The growth hypothesis: it suggests coal consumption can boost economic growth[30 31].

(ii) The energy-saving hypothesis: it suggests a unidirectional Granger causality from economic growth to coal consumption[30 32 33].

[29] Xu, J., et al. (2018). The drag effect of coal consumption on economic growth in China during 1953–2013. *Resources, Conservation and Recycling*, 129, 326-332.

[30] Wolde-Rufael, Y. (2010). Coal consumption and economic growth revisited. *Applied Energy*, *87*(1), 160–167. https://doi.org/10.1016/j.apenergy.2009.05.001

[31] Bhattacharya, M., Rafiq, S., & Bhattacharya, S. (2015). The role of technology on the dynamics of coal consumption–economic growth: New evidence from China. *Applied Energy*, *154*, 686–695. https://doi.org/10.1016/j.apenergy.2015.05.063

[32] Lei, Y., Li, L., & Pan, D. (2014). Study on the relationships between coal consumption and economic growth of the six biggest coal consumption countries: with coal price as a third variable. *Energy Procedia*, *61*, 624–634. https://doi.org/10.1016/j.egypro.2014.11.1185

[33] Li, R., & Leung, G. C. (2012). Coal consumption and economic growth in China. *Energy Policy*, *40*, 438–443. https://doi.org/10.1016/j.enpol.2011.10.034

(iii) The feedback hypothesis: it suggests a bidirectional causality between coal consumption and economic growth[30 34 35].

(iv) The neutrality hypothesis: it suggests no causal link between coal consumption and economic growth[36].

(v) The environmental Kuznets curve (EKC) hypothesis: it suggests an inverted U-shaped relationship between coal consumption and economic growth.

Overall, coal consumption contributes to economic growth to some extent[37].

For what concerns China, the conclusions of the studies are mixed and conflicting. A study[32] confirms the energy-saving hypothesis in the country, while another study[38] from Govindaraju and Tang shows a feedback effect between coal consumption and economic growth. Furthermore, a study[31] from Bhattacharya et al. detect a unidirectional causality from coal consumption to economic growth in China. Finally, Hao et al[37] support the EKC hypothesis and predict that coal consumption will continue to increase with a decreasing growth rate by 2020.

China's annual economic growth, according to a research based on Romer's growth drag hypothesis, is 0.0252, with a 2.52% decline attributable to coal consumption. This indicates that after ten years, the pace of economic growth will drop to 74.8% of the current rate: due to coal shortages, the growth rate in 2013 was 7.7%[29].

Controlling coal consumption below 62% of the energy mix and increasing coal use efficiency are critical for China's continued economic growth. Chinese coal production may peak between 2025 and 2039, according to Wang et al.[39], but it might happen sooner, according to other scholars[37], if the fight against climate change has to be effective.

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[34] Apergis, N., & Payne, J. E. (2010). Coal consumption and economic growth: Evidence from a panel of OECD countries. *Energy Policy, 38*(3), 1353–1359. https://doi.org/10.1016/j.enpol.2009.11.016

[35] Yoo, S. (2006). Causal relationship between coal consumption and economic growth in Korea. *Applied Energy, 83*(11), 1181–1189. https://doi.org/10.1016/j.apenergy.2006.01.010

[36] Jin, T., & Kim, J. (2018). Coal Consumption and Economic Growth: Panel Cointegration and Causality Evidence from OECD and Non-OECD Countries. *Sustainability, 10*(3), 660. https://doi.org/10.3390/su10030660

[37] Hao, Y., Zhang, Z., Liao, H., & Wei, Y. (2015). China's farewell to coal: A forecast of coal consumption through 2020. *Energy Policy, 86*, 444–455. https://doi.org/10.1016/j.enpol.2015.07.023

[38] Govindaraju, V. C. a. L., & Tang, C. F. (2013). The dynamic links between CO2 emissions, economic growth and coal consumption in China and India. *Applied Energy, 104*, 310–318. https://doi.org/10.1016/j.apenergy.2012.10.042

[39] Wang, J., Feng, L., & Tverberg, G. E. (2013). An analysis of China's coal supply and its impact on China's future economic growth. *Energy Policy, 57*, 542–551. https://doi.org/10.1016/j.enpol.2013.02.034

According to the study[29], the government should regulate population growth to prevent unjustified consumption and exploitation of coal in order to promote long-term sustainable development. Prioritizing productivity gains and industrial structure optimization over capital use is crucial. The elimination of inefficient production capacity and the transition from an extensive to an intensive economy growth are the necessary steps to achieve a low-carbon economy.

The prudent use of coal should be more heavily emphasized, along with research and development expenditures that support low-carbon technology. China's energy system needs to be optimized, with a focus on using new and renewable energy sources including hydro, solar, and wind power as clean and cheap alternatives to coal[29].

Finally, it is worth mentioning a study[40] that examines the relationship between coal consumption and real GDP in China using a panel cointegration and error-correction modelling framework. The study includes twenty-three provinces of China, and examines causality between the variables. The results of the causality tests show that there is unidirectional causality from GDP to coal consumption in the Western region, but bidirectional causality between GDP and coal consumption in the entire panel, the Coastal region, and the Central region[40].

Considering the differences in economic growth, industrial composition, and coal consumption patterns between the Coastal and Central areas and the Western region, it is expected that the causal links will vary regionally. Specifically, more coal consumption indicates increased activity in the manufacturing and industrial sectors, which will ultimately result in higher GDP since coal is the primary energy source for these sectors[40]. While efforts to limit the use of coal may be able to lower GHG emissions, the Coastal and Central regions' economies might be impacted negatively by the reduction of coal consumption.

[40] Li, R., Leung, G.C.K. (2012). Coal consumption and economic growth in China. *Energy Policy*, 40, 438-443.

1.4 The role of nuclear

The primary incentive for starting the civil nuclear power program in the 1980s was the necessity to develop long-term solutions for the country's energy security[41]. Furthermore, in light of growing concerns about air quality, climate change, and the depletion of fossil resources, the government has given nuclear power development top priority in recent years. In fact, nuclear power plays an important role in coastal regions that are isolated from the coalfields and where the economy is growing quickly, in addition to being relatively clean in terms of carbon dioxide emissions and air pollution, even if it contributes to a small portion of the country's energy mix[47]: the combined capacity of the 54 operational reactors was 55.8 GWe of electric power (GWe) as of June 2022[42] . By the end of 2022, an additional 23.5 GWe of capacity—nearly 40% of the global total—was under construction and an additional 43.6 GWe scheduled. In 2021, nuclear power accounted for approximately 4.8% of China's electricity supply, 2.3% of primary commercial energy supply, and 25% of non-hydro, low-carbon electricity.[47] [42]

According to a report[43] by BMI Research, China is expected to become the largest nuclear power country by 2026, as coal share in total power supply will decrease.

Currently, four major state-owned enterprises control the majority of the country's nuclear power industry: China National Nuclear Corporation (CNNC), China General Nuclear Power Group (CGN), State Power Investment Corporation (SPIC), and China Nuclear Engineering and Construction Corporation (CNECC)[42] [44].

The National Development and Reform Commission (NDRC) and the National Energy Administration (NEA), which administer more general energy policy, are also in charge of developing nuclear power policy. They issue the strategic and five-year plans

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[41] Ping, Z. (1987). Nuclear power development in China. *IAEA Bulletin*, 2/1987, 43-46.
Xu, Y.-C. (2010). *The Politics of Nuclear Energy in China*. Palgrave Macmillan.

[42] The Oxford Institute for Energy Studies. (2023). *Nuclear Power in China: Its Role in National Energy Policy*.

[43] Sina Finance. (2017). BMI: China Is Expected to Become the Largest Nuclear Power Country by 2026.

[44] Operating in several areas of civil nuclear power, such as uranium production, fuel manufacturing, research, reactor design, reprocessing, and waste disposal, CNNC has traditionally played a key role in both civilian and military nuclear programs. CNNC had about 20 GWe of nuclear power capacity in operation as of August 2022. In August 2022, CGN, formerly known as China Guangdong Nuclear Power Group, had approximately 30 GWe of capacity and was rapidly expanding its market position. Established in 2015, SPIC's primary function is to invest in nuclear power and has big goals, even if its capacity is only expected to reach 2.2 GWe in August 2022. In 2018, CNNC and CNECC, China's only company building civil nuclear power reactors, merged again.

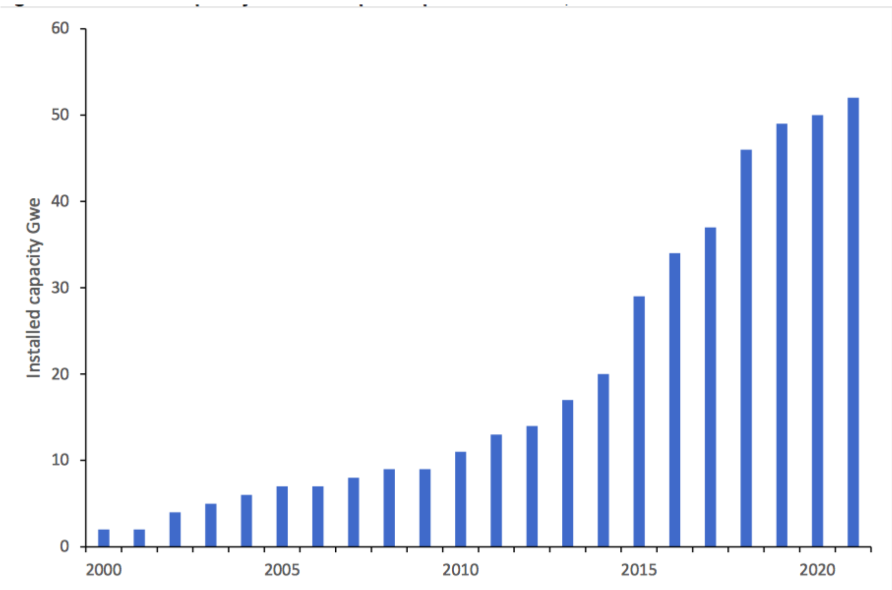
for energy, including nuclear power. Furthermore, in order to build and run a new nuclear power plant in China or abroad, approval from both of these organizations and the State Council is required. The National Nuclear Safety Administration is the most significant agency in charge of nuclear safety regulation (NNSA)[42 45].

With regard to its civil nuclear power program, the Chinese government has four policy goals: increasing energy supply security, cutting carbon dioxide emissions, fostering advanced industrial and technical growth, and increasing technology exports[42].

The draft of the 14th Five-Year Plan (2021-2025), released in March 2021, outlines the government's goal to achieve 70 GWe of nuclear capacity by the end of 2025. In 2019, electricity generation increased by 5% compared to the previous year, reaching 7.3 PWh[4746]. In 2018, global electricity generation from various sources was 7.2 PWh. Fossil fuels accounted for the majority of this, with 5045 TWh (69%), followed by hydro with 1302 TWh (18%), wind with 406 TWh (6%), solar with 224 TWh (3%), and nuclear

Installed capacity of nuclear power plants in China (2000–2021)

Source: World Nuclear Association



[45] Other crucial agencies that regulate nuclear affairs are The State Administration of Science, Technology and Industry for National Defence (SASTIND) and its subsidiary, the China Atomic Energy Authority (CAEC).
[46] PetaWatt/Hour

with 349 TWh (5%). China's nuclear generation in 2019 was 18% higher than in the previous year, reaching 295 TWh. This represents just over 4% of the total gross generation[47]

Nevertheless, China embarked on a concerted expansion in its nuclear sector already in the Tenth Five-Year Plan, led by the National Development and Reform Commission (NDRC) with an emphasis on self-reliance. This initiative included the construction of eight nuclear power plants, but due to extended timelines, the final two projects were incorporated into the subsequent Eleventh plan. The following Eleventh Economic Plan set more ambitious goals, focusing on third-generation reactors like the Sanmen and Haiyang plants and advancing CPR-1000 technology[56]. Environmental objectives were also prioritized, aiming for a 20% reduction in energy required per unit of GDP. The Twelfth Economic Plan saw the start of the construction phase on various projects, with a target of 25 GW of new capacity and a potential addition of 45 GW by the subsequent Thirteenth Economic Plan. Plans for demonstration nuclear plants, including CAP1400 and HTR-PM, were outlined in the Twelfth Five-Year Science & Technology Plan, but construction delays ensued after the Fukushima accident, leading to a suspension of inland plant developments. During the Twelfth Five-Year Plan, over 16 provinces expressed intentions to build nuclear power plants, submitting proposals to the NDRC for approval, with many deferred to the Thirteenth Five-Year Plan[56].

Under the latter, implemented in 2016, six to eight nuclear reactors were to be approved annually. So that, the share of non-fossil primary energy supply should increase to from 9.8% in 2013, to 15% by 2020 and 20% by 2030[56].

Indeed, by 2020, coal capacity had to be limited to 1100 GW, gas capacity has to reach 110 GW, hydropower 340 GW, wind 210 GW, and solar power 110 GW, of which distributed PV was expected to account for 60 GWe. The goal of installed nuclear capacity of 58 GW was reaffirmed for 2020.

The action plan's goal was to reduce the percentage of primary energy derived from coal, from 72.5% in 2007 to 62% by 2020. 2018 saw the achievement of this target, primarily the replacement of goal with natural gas[56].

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[47] World Nuclear Association. (2023). Nuclear Power in China.

Through an analysis of both short-term and long-term developmental trajectories of China's nuclear power sector, a study[48] discerns that, in the existing context of surplus power, the generation cost of third-generation nuclear power is anticipated to be significantly higher. This is attributed to factors such as the elevated investment costs, reduced utilization hours, and additional expenses related to ancillary service obligations. Consequently, the economic returns are projected to fall below the benchmark level, thereby dampening enthusiasm for nuclear power investments. However, as technological learning accelerates, it is anticipated that by 2030, nuclear power could competitively contend with coal power, attaining full market competitiveness[48].

Furthermore, the greenhouse gas (GHG) reduction costs associated with nuclear power are expected to be more competitive compared to coal power with carbon capture and storage (CCS)[48]. Consequently, nuclear power emerges as a pivotal option for China in achieving a long-term transition towards low-carbon energy. To foster the enduring and robust development of China's nuclear power sector, the study recommends the

[48] Xu, Y., Kang, J., & Yuan, J. (2018). The prospective of nuclear power in China. *Sustainability*, *10*(6), 2086. https://doi.org/10.3390/su10062086

sharing of early commercialization stage technical learning costs through the provision of clean technology subsidies[48].

Globally, China's civil nuclear power program is the most ambitious. The nation will most likely surpass the United States in terms of installed nuclear power reactor capacity by 2030. This electricity supply will improve the country's energy security and help lower CO_2 emissions from power generation. By 2050, aggregate installed capacity may reach 300 GW[42].

Projections of China’s installed civil nuclear power (GW)

Source: Oxford Institute for Energy Studies

	June 2022	2025	2030	2035	2040	2050
Chinese sources						
State Council[102]	55.8					
14th Five-Year Plan[103]		70				
Nuclear Energy Association[104]			110			
CNNC[105]				180		
CGN[106]				200		
Tsinghua ICCSD[107]						327
Jiang et al. 2018[108]						554
International sources						
IEA World Energy Outlook 2020[109]					135–164	
EIA International Energy Outlook 2021[110]						143

Chinese engineers designed and made the majority of the components for the recently put into service Hualong One reactors. A wide range of reactor technologies, such as nuclear fusion, high-temperature gas-cooled reactors, molten salt reactors, small modular reactors, and maritime nuclear reactors, are also being developed by China's nuclear industry. It has significantly increased its capacity for uranium enrichment and fuel production in an effort to ensure supply security[42].

The nation is expanding its capability for spent fuel reprocessing since it lacks sufficient uranium resources. Chinese businesses have the potential to be significant players in the global civil nuclear power market due to their size and extensive technological competence. But up until now, many businesses have been too busy working on local projects to dedicate much effort to looking for opportunities abroad. Furthermore, China's government has not yet provided significant diplomatic or financial backing for such international endeavors, with the exception of Pakistan. According to the abovementioned study issued by The Oxford Institute for Energy Studies, Chinese businesses have the potential to overtake other global suppliers of nuclear power technologies if these two variables shift[42].

1.5 The role of hydropower

With over 29% of the world's hydroelectric capacity, China is the leader in the deployment of hydropower globally. China accounted for almost 80% of the world's newly added hydropower capacity in 2021[49] [50].

In the 21st century, China must focus on developing hydropower in order to reduce environmental pollution and boost the economic growth of rural areas. China's rapid hydropower development over the last 50 years has been made possible by abundant hydropower resources, which offer previously unknown benefits and opportunities. With 320 GW of built hydropower capacity as of 2018, China's hydropower growth made a significant contribution to the net growth of global output[51].

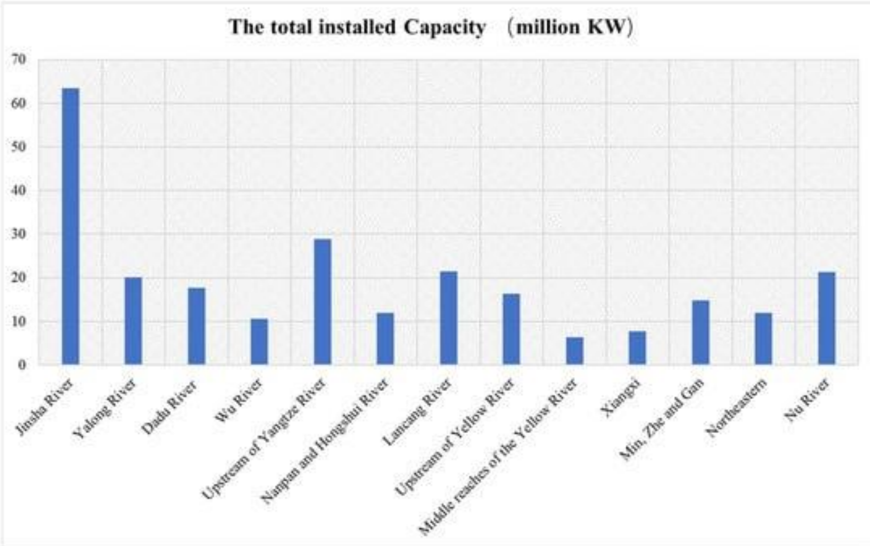
China developed its hydropower industry later than other nations. It can be said that hydropower received attention in various countries, including North America and Europe,at the end of the 19th century. China's first hydroelectric facility, Shilong Dam Hydropower facility, was founded in 1910 and is located in Yunnan Province, outside of Kunming; the installed capacity of this hydroelectric station is 6000 kW, after seven upgrades in 1958[51].

China's hydropower sector underwent significant development, starting with landmarks like the Xin'An River Hydropower Station, China's first large station with local design, equipment, and construction. Major projects included the Guangdong Xinfeng River, the over 100m high Hunan Zhexi dam, and the groundbreaking Fujian Gutian Creek Station, the first cascade hydropower station with an underground powerhouse. The Sanmenxia Hydropower Station, initiated simultaneously with Xin'An, laid the foundation for China's systematic hydropower development. The First Five-Year Plan marked the start of Liujiaxia Hydropower Station, known as the "Yellow River pearl." The Second Five-Year Plan emphasized hydropower, leading to projects like the Gezhouba Dam Hydropower Station (1971) and the iconic Three Gorges project (1994). China's hydropower industry achieved substantial advancements through technology

[49] Oxford Institute of Energy Studies. (2022). Guide to Chinese Climate Policies, A: Hydropower.
[50] IRENA. (April 2022). Renewable Capacity Statistics 2022, pp. 5-7.
[51] Li, X., Chen, Z., Fan, X., & Cheng, Z. (2018). Hydropower development situation and prospects in China. *Renewable & Sustainable Energy Reviews*, *82*, 232-239. https://doi.org/10.1016/j.rser.2017.08.090

transfer, digestion, absorption, and independent innovation, resulting in the manufacturing of large equipment with enormous capacity and extensive use of new materials in hydropower engineering[51].

Total installation capacity of thirteen large hydropower bases[52]
Source: Chinese Government



In the 21st century, China has witnessed a rapid expansion of its hydropower sector, achieving the status of the world's largest hydropower producer by surpassing 100,000 MW in installed capacity in 2004. Following the construction of the Three Gorges Hydropower Station, China's hydropower capacity surpassed 300,000 MW by 2015. With the largest hydropower installed capacity globally, China has emerged as a leading hub for hydropower innovation, demonstrating substantial growth from 2000 to 2015. The current state of hydropower development in China focuses on the distribution of resources, influenced by factors such as rivers, evaporation, and precipitation: that is why different regions have different hydropower resources[51].

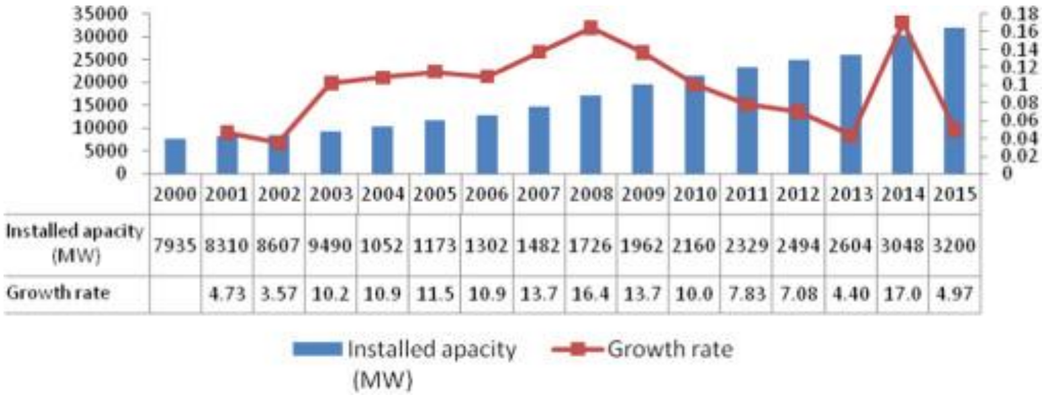
In fact, the allocation of water resources in China is extremely unequal and does not match the level of regional economic development. Hydropower is difficult to maximize and utilize because the resource is primarily in the west, while market demand is higher in the east. Moreover, China has a highly unequal distribution of precipitation, which causes significant seasonal variations in river discharge. Therefore, since less than

[52] https://www.stats.gov.cn/tjsj./ndsj/

30% of the technically exploitable hydropower capacity has been built, China has a low level of hydropower exploitation and plenty of room for development.[54]

China's hydropower installed capacity from 2000 to 2015.

Source: National Bureau of Statistics.



The development of hydropower resources is one of the key pillars supporting China's power industry and helps cut greenhouse gas emissions. The National Bureau of Statistics[53] published data showing that, as of the end of 2019, the total hydropower generation was 1339.00 billion kWh, or 17.38% of the total power generated[54].

At the end of 2021, there were approximately 46,785 hydropower stations in China, generating 391 million kW of hydropower with a total installed capacity of 2377 million kW. Among them, 20,866 have been completed and have an installed capacity of 217 GW, while 1324 are presently under construction and have an installed capacity of 110 GW. These numbers surpass the cumulative values of the USA, Canada, and Brazil, which ranks just after China in terms of installed hydropower capacity[55].

[53] Chang, X., Liu, X., & Zhou, W. (2010). Hydropower in China at present and its further development. *Energy*, *35*(11), 4400–4406. https://doi.org/10.1016/j.energy.2009.06.051

[54] Xiao, L., Wang, J., Wang, B., & Jiang, H. (2023). China’s hydropower Resources and Development. *Sustainability*, *15*(5), 3940. https://doi.org/10.3390/su15053940

[55] Xin-Gang, Z., Lu, L., Liu, X., Wang, J., & Liu, P. (2012). A critical-analysis on the development of China hydropower. *Renewable Energy*, *44*, 1–6. https://doi.org/10.1016/j.renene.2012.01.005

According to IEA[56], nearly three-quarters of the world's hydropower capacity additions in 2022 occurred in China; China and India are the two nations that are most expanding hydroelectricity.

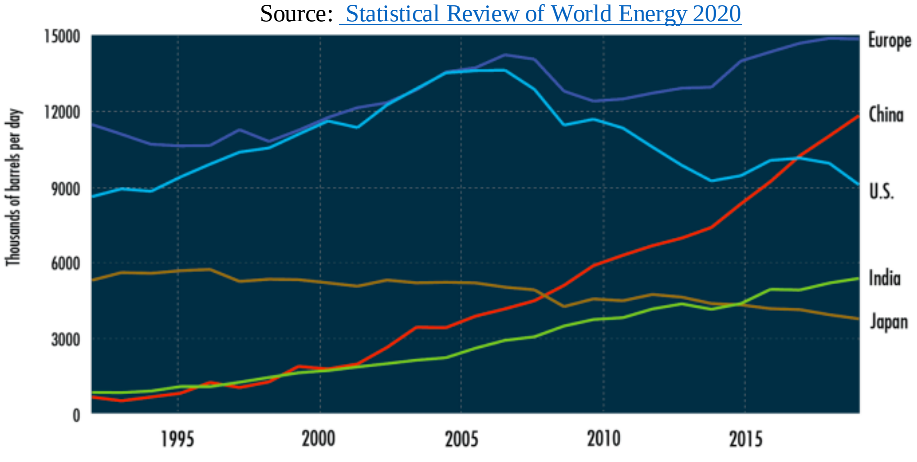
In terms of adding capacity, China continues to be at the forefront, accounting for 24 GW in 2022—approximately three-quarters of all worldwide expansion, even if capacity additions have decreased in the last decade. The Fourteenth Five-Year Plan for Renewable Energy, issued in 2022, still includes hydropower as a major component, with the goal of having hydropower generate 17.4% of China's electricity by 2025 (compared to 16% in 2021)[49] but capacity increases are anticipated to slow down in the upcoming years due to a declining number suitable sites and environmental restrictions[56].

Indeed, wind and solar energy are prioritized over hydropower in the Fourteenth Five-Year Plan[49].

1.6 Oil supply

China became a net importer of oil in 1993. As the world's largest oil net importer and second-largest oil user, shifts in China's reliance on foreign oil have a major impact on both the domestic and global oil markets[57].

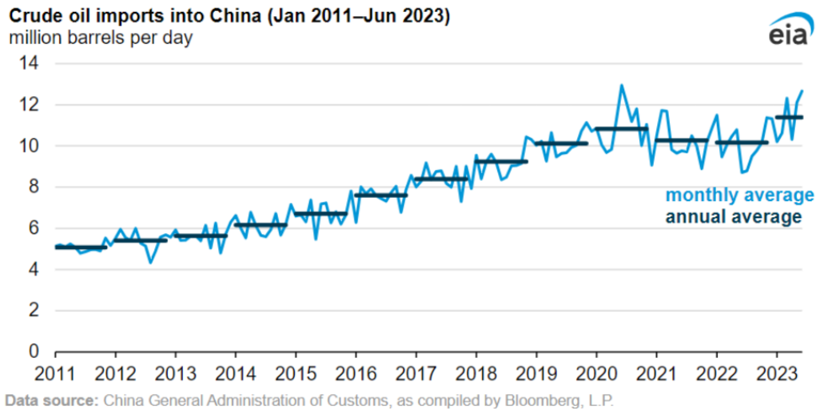
Source: Statistical Review of World Energy 2020



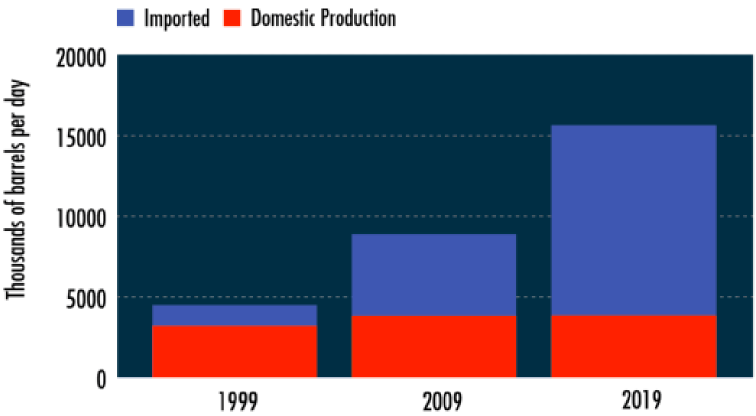
[56] https://www.iea.org/energy-system/renewables/hydroelectricity

[57] Wang, Q., Li, S., & Li, R. (2018). China's dependency on foreign oil will exceed 80% by 2030: Developing a novel NMGM-ARIMA to forecast China's foreign oil dependence from two dimensions. *Energy, 163*, 151–167. https://doi.org/10.1016/j.energy.2018.08.127

Nonetheless, China is not the biggest oil consumer in the world: the US ranks first with its daily consumption of roughly 20.5 million barrels, while China's daily consumption is around 14 million barrels[58] [59]. With regard to refining capacity, the nation ranks second in the world and accounts for 16.2% of global refinery throughput (second only the United States, which accounts for 20%). Furthermore, China has been importing more oil and increasing its refining capacity partially so that it can sell to other nations, especially in Asia[58].



Source: Statistical Review of World Energy 2020.



Within its own borders, China is also extracting oil. According to British Petroleum, China's domestic crude oil production was 3.994 million barrels per day in

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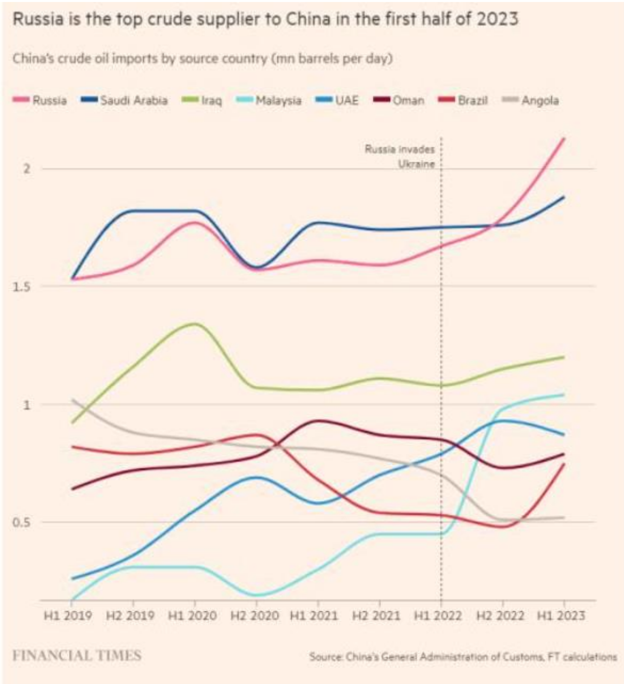
[58] Center on Global Energy Policy at Columbia University, School of International and Public Affairs. (2020). Where Does China Get Its Oil?

[59] Another explanation for China's persistent need for oil is that it is the world leader in the manufacture of petrochemicals, which are derived from natural gas and oil.

2021, ranking it 7th worldwide. China's domestic crude oil production has only slightly increased over the past 20 years, from 3.257 million barrels per day in 2000.

China has always emphasised the diversification of suppliers and routes. In recent years, China's main oil suppliers have been Saudi Arabia and Russia. In the first nine months of 2023, China imported a record 2.765 million barrels per day (bpd) of crude oil by sea from Iran[60], Russia[61], and Venezuela according to data provided by tanker trackers Vortexa and Kpler[62]. Reuters' analysis indicated that the three nations accounted for a quarter of China's imports between January and September, up from approximately 21%



in 2022 and double the 12% share in 2020. This caused the Middle East, West Africa, and South America to become less competitive[62 63]. Thanks in part to the Eastern Siberia–

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[60] China does not formally recognize buying oil from Iran, which is subject to severe international sanctions as it seeks to develop nuclear weapons. However, industry experts have extensively documented its purchases. Indeed, China's imports from Iran tripled in 2 years and China buys 87% of Iran's oil exports. In contrast, Malaysia is listed as one of China's top oil suppliers in official data, despite Malaysia's aged oil reserves producing less and less oil.

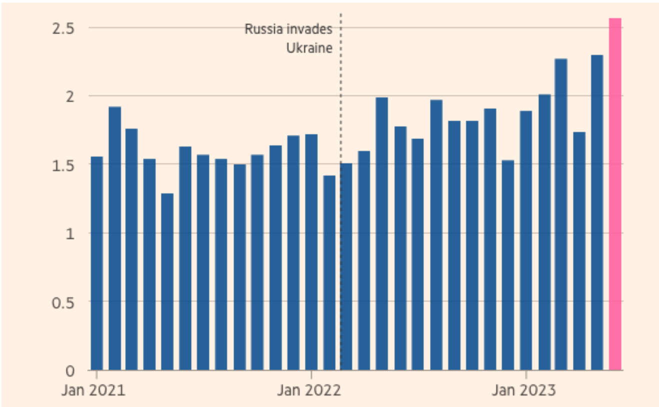
[61] Based on the average of data provided by Vortexa and Kpler, Russia supplied 1.3 million barrels per day of seaborne crude throughout January to September. Chinese trading sources also state that China imports approximately 800,000 barrels per day of ESPO petroleum through pipelines.

[62] Chen, A., & Xu, M. (2023). China saves billions of dollars from record sanctioned oil imports. *Reuters*.

[63]An unforeseen result of sanctions placed by the United States and others on Russia, Iran, and Venezuela has been to cut the costs of oil imports for refiners in China. According to the same Reuter's analysis (from

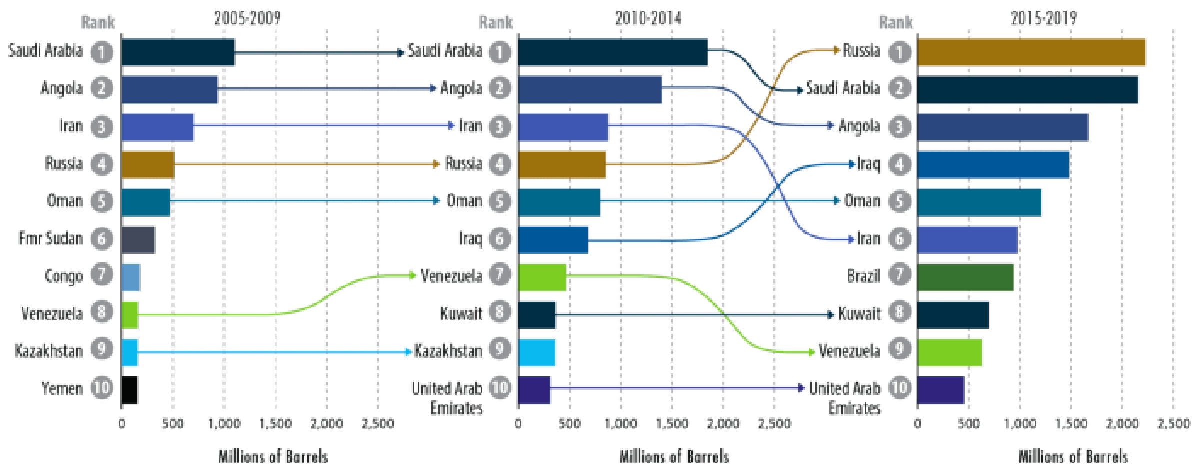
Pacific Oil (ESPO) Pipeline, which currently connects Mohe, on the Russian border, with the Chinese city of Daqing, a transfer hub, Russia rose from fourth place to the top barely fifteen years ago[58]. Indeed, China's main crude supplier in 2023 was Russia, with 2.13 million barrels of oil per day imported in the first half of the year, surpassing Saudi Arabia's 1.88 million barrels per day.

China’s crude oil imports from Russia (mn bpd).
Source: China's General Administration of Customs, Financial Times calculation



Furthermore, since 2015, China has permitted its independent refineries to import oil on their own initiative. Because these refineries have limited financial resources than state-run companies, they frequently choose to import oil from sources closer to home, for instance Russia, in order reduce the cost on transportation.

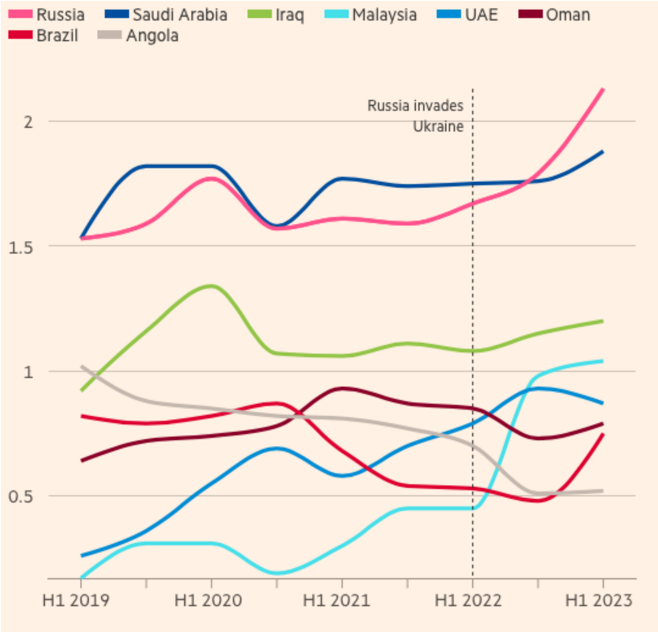
Where China’s oil supply comes from and how it evolved through the decades.
Source: IHS Markit (2019) and UN Comtrade (other years).



calculations using information from traders and shiptrackers), China has saved about $10 billion this year by buying record quantities of oil from nations that are subject to Western sanctions.

Currently, China depends on foreign oil for approximately 72% of its oil needs. According to a study[57] China's reliance on foreign oil by 2030 will be over 80%, and the country's average annual growth rate of oil demand is projected to be around 2% between 2017 and 2030.

China’s crude oil imports by source country (milion barrels per day)
Source: China's General Administration of Customs, Financial Times calculations



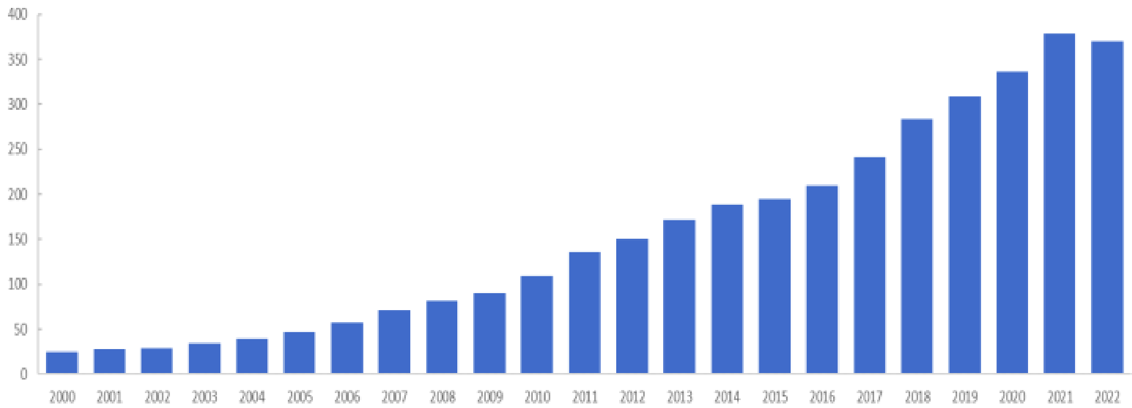
According to the forementioned study[57], China would be extremely alarmed if it were to become 80% dependent on foreign oil. In order to address this, according to the abovementioned paper, Chinese policymakers and stakeholders of the oil market ought to prioritize their efforts on enacting pertinent policies, such as: (i) oil security alerts; (ii) build a new pattern of diverse oil imports; (iii) construct a reliable foreign oil supply base and actively engage in the development and usage of the world's petroleum resources. China should perhaps learn from the US experience[57], adopting a transnational business strategy, and promoting and assisting domestic oil businesses to engage in overseas oil exploration and development in addition to directly importing oil. (iv) Use energy conservation techniques along with energy-structure adjustment techniques to substantially improve energy efficiency. (v) In order to guarantee the security of the oil supply, the strategic oil reserve should keep expanding[57].

1.7 Gas supply

With a 2022 gas consumption of 364.6 billion cubic meters (bcm), China is the third-largest gas market in the world, second only the United States (881 bcm) and Russia (408 bcm)[64].

China gas consumption, bcm

Source: Oxford Institute for Energy Studies based on National Bureau of Statistics, China Customs, NDRC and OIES data



The objective of the Chinese government is to meet over 50% of China's gas demand with domestic production. The China Natural Gas Development Report 2023[65],

China's gas demand and supply, 2021-2022.

Source: China Gas Report 2023.

	2022	2021	Change
Domestic consumption (bcm)	364.6	369.0	-1.2%
Domestic production (bcm)	220.1	207.6	6.0%
Pipeline import (bcm)	62.7	59.1	6.1%
LNG import (bcm)	87.6	108.9	-19.6%
Total supply (bcm)	**370.4**	**375.6**	**-1.4%**
Foreign Import dependency	41%	45%	4% point decrease

[64] Center on Global Energy Policy at Columbia University, School of International and Public Affairs. (2023). Inside China's 2023 Natural Gas Development Report.

[65] Institute of Economics and Research of China National Petroleum Company. (2023). China Natural Gas Development Report. Petroleum Industry Press. Retrieved from http://www.nea.gov.cn/2023-07/21/c_1310733569.htm.

released in July, offers insight into the perspectives of leading Chinese government agencies on Chinese and global gas markets. Domestic upstream investment achieved a new record of $51.2 billion (RMB 370 billion), a 19% increase from the previous year[64]

Furthermore, China made progress in building its "national network" of gas infrastructure, adding approximately 5 billion cubic meters to the capacity of gas storage and over 3,000 kilometers to the overall length of long-distance natural gas pipelines. Moreover, the nation made progress on a number of significant LNG projects, such as the construction of the Beijing Gas and Caofeidian LNG terminals and the opening of the Binhai LNG terminal[64].

China was the main importer of LNG globally in 2021, but lagged behind Japan in 2022. However, in the first half of 2023, China once again overtook Japan as the top importer (H1 23).

China's imports of LNG fell by 19.5% in 2022 to 87.6 billion cubic meters, or 63.5 million tons, although they still made up more than half (58.3%) of all imports of natural gas. Since China started importing LNG in 2006, this was the most significant annual decline, probably due to the COVID-19 restrictions, slower economic growth, and high LNG spot prices[64]. On the contrary, China's pipeline imports increased annually by 7.8% in 2022 to reach 62.7 billion cubic meters, or 41.7% of all-natural gas imports[66]. The country imports natural gas from three sources: Central Asia, predominantly Turkmenistan, as well as Russia and Myanmar[67].

In 2022, imports by pipeline accounted for 17% of China's gas consumption[67]. The 54% increase in imports from Russia, from 10.4 bcm to 16 bcm, was one source of this growth, as Russia continues to increase supply to China through the Power of Siberia pipeline, which is expected by Moscow to achieve its capacity of 38 bcm by 2025[68]

We will now analyse more specifically China’s main import gas pipelines.

Since 2008, China has built three trunklines—at an estimated total cost of over $14 billion—that link Turkmenistan's gas reserves to the country's northwest Xinjiang region. Beginning at the Turkmenistan-Uzbekistan border, Lines A and B travel via

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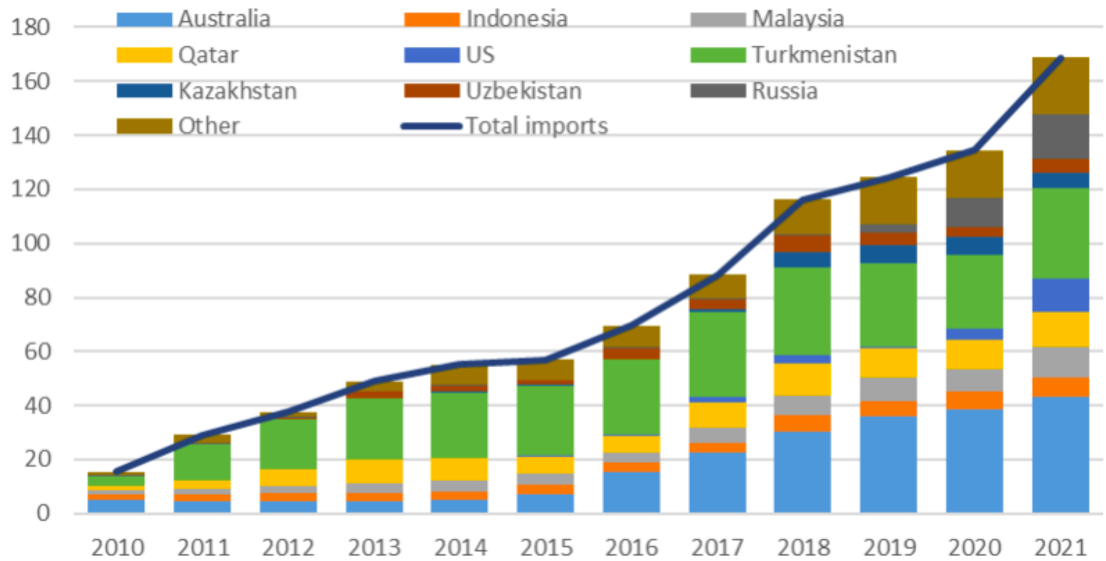
[66] Institute of Economics and Research of China National Petroleum Company. (2023). China Natural Gas Development Report, ibidem.
[67] Reuters. (2023). China’s Main Import Gas Pipelines.
[68] TASS. (2023). Russia to Supply 22 Bln Cubic Meters of Gas to China over Power of Siberia – Novak.

Kazakhstan and Khorgos, the border town, before entering China. Alltogether, the two pipelines (1,833 kilometers of each) enable to transport 30 billion cubic meters of gas annually[67]. Line C, which runs parallel to A and B, began supplying gas to China in 2014 with a planned yearly capacity of 25 bcm; however, due to a lack of domestic pipeline infrastructure, the line has been running below capacity[67]. Line D, the most recent, begins at the vast Galkynysh field in Turkmenistan, which has reserves exceeding 21 trillion cubic meters, making it one of the world's largest gas resources. With an annual carrying capacity of 30 bcm, the line would be 966 km long and the first to connect Uzbekistan, Kyrgyzstan, and Tajikistan. In 2013 and 2014, countries signed preliminary agreements with China. However, the difficult price negotiations between China and Turkmenistan, technical issues in developing the Galkynysh field, and challenges in laying pipelines over the mountainous terrains have all contributed to the project's delayed completion[67].

China's gas imports by country, bcm
Source: Oxford Institute for Energy Studies based on China Customs data
Notes: includes both pipelines and LNG imports



Furthermore, the 3,000-km Power of Siberia project, which connects Siberian reserves with northeastern China, resulted in the Russian gas giant Gazprom start supplying gas to China in late 2019. With plans to ramp up to achieve 38 bcm by 2025, supplies reached 16 bcm last year. The pipeline will allow the imports of huge volumes of gas for a total of $400 billion, based on a 30-year contract that was signed in 2014 and signaled Moscow's diversification of exports away from its principal customer, Europe[67].

China also agreed in February 2022 to buy gas from Sakhalin, an island in Russia's Far East, via a new pipeline (Far East Sakhalin Project) that would encompass the Japan Sea and reach northeast China by 2026. Deliveries could total 10 billion cubic meters annually[67].

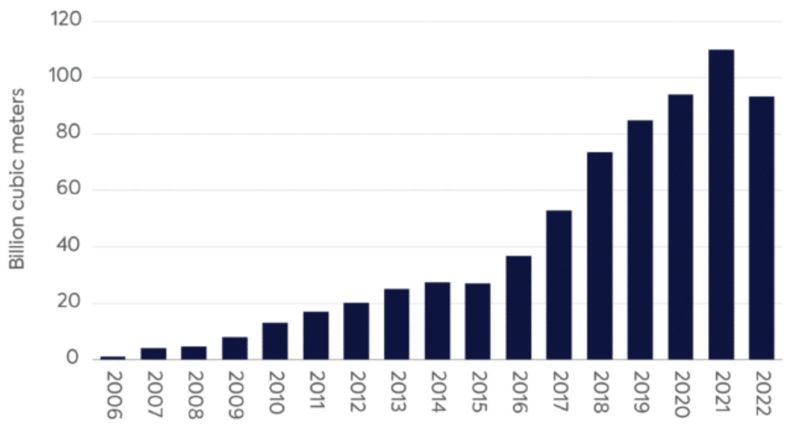
Moreover, in September 2022, Putin started reviving Power of Siberia 2, a project that was first proposed years ago, to compensate for the now-defunct Nord Stream 1 and Nord Stream 2 pipeline. The projected 2,600 km pipeline would supply 50 bcm of gas from West Siberia's vast Yamal peninsula deposits; the project's feasibility assessment was started by Gazprom in 2020, and in late March 2023, Russian Deputy Prime Minister Alexander Novak stated that Moscow intended to finalize contracts soon[67].

Lastly, there is the 793-km Myanmar-China Gas Pipeline, which started running in 2013, which connects the Chinese border city of Ruili in the southwest of Yunnan Province with Ramree Island on the western coast of Myanmar; its intended use is for 12 bcm annually[67]. Chinese customs estimate that the pipeline will supply 3.8 bcm of gas to China in 2022, but the pipeline has been operating below capacity for years due to low output from offshore Myanmar gas sources[67].

After the zero-COVID limits were eliminated and Asian spot prices began to fall in H1 23, China's LNG imports grew by 7.2%, whereas pipeline imports decreased by 6.4% to 31.2 bcm (from 33.2 bcm in H1 22)[64].

China's liquified natural gas imports between 2006 and 2022.

Source: Energy Institute "Statistical Review of World Energy".



According to the current "Fourteenth Five-Year Plan," natural gas production should increase up to 230 bcm annually by 2025, and the country's storage capacity should be between 55 and 60 bcm[69]. The primary objective of this plan is to secure the supply chain by means of domestic energy generation, while concurrently advancing the transition to green energy. It calls for the advancement of energy storage technologies as well as the accomplishment of advanced industrial chain modernization[64].

1.9 The role of Renewables

In the midst of China's shift to green energy, renewable energy emerged as a significant instrument to guarantee the country's energy independence by lowering reliance on fossil fuels, while mitigating the impact of climate change. In fact, renewables can help cutting down greenhouse gas emissions and addressing the harmful impacts of air pollution and encouraging innovation. Currently, China is without a doubt the world leader in the expansion of renewable energy.

Between 2020 and 2060, the Chinese government plans to invest $13.7 trillion to achieve carbon neutrality[70], generating 33% of its electricity from renewable sources, up from approximately 30% in 2023.

2022 has seen a boom in photovoltaic investments: +233% ($39.2 billion)[70]. China ranks third in the world in terms of investment attractiveness for renewables, after the US and Germany, but there are still issues to be solved: limited interconnection between grids, protectionism by provincial governments, lack of coordination. In addition, long-term contracts with foreign suppliers limit the flexibility of the system[70].

In late 2021, the government released the 1+N Plan, which outlined a number of points to achieve peak emissions around 2030 and carbon neutrality around 2060 in accordance with the new five-year plan. Currently, the country is responsible of more than 30% of the world's carbon emissions (Statistical Review of World Energy).

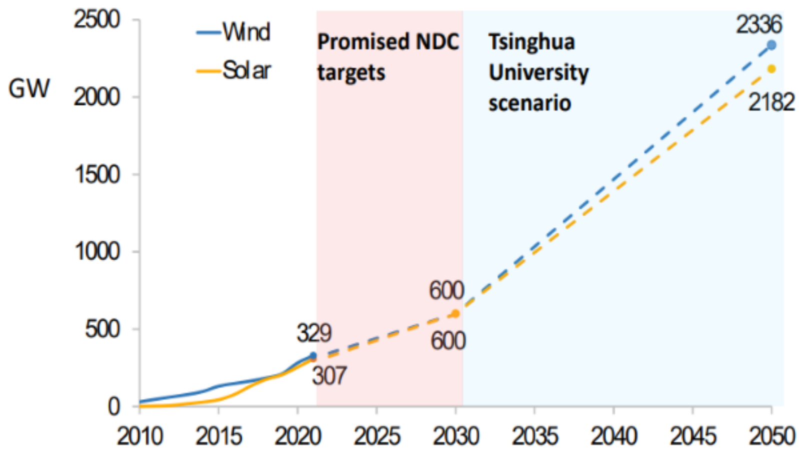
The plan focuses on reducing the share of fossil fuels, decreasing air pollution, and increasing energy security. It is important to note that coal reduction will only occur if there is an increase in renewable energy sources, but also technological innovation and

[69] National Energy Administration. (2022). Clean, Low-Carbon, Safe and Efficient '14th Five-Year Plan' Modern Energy System Built this Way.
[70] Reuters. (2023). China's power sector investments may top $13.7 trillion by 2060.

greater manufacturing capacity in clean tech and renewables. The government has committed to reducing energy intensity by 13.5% and carbon intensity by 18% between 2021-2025.

Additionally, according to IEA projections, by 2028, half of the installed capacity each year must be from renewable sources. The government plans to have 1200 GW of installed solar/wind power by 2030, which is an increase of 100 GW per year.

China wind and solar additions, 20230 targets, and Tsinghua 2050 carbon neutral scenario. Source: Anders Hove, GIZ 2022



Between 2013 and 2022, China has been the global leader in renewable energy installation, accounting for approximately 40% of annual increases.

As of 2022, China's renewable capacity, including hydropower, reached 1200 GW, which is one third of the world's installed renewable capacity.

According to IRENA[71], renewables will be able to meet 90% of China's energy demand by 2050, with solar and wind energy accounting for 60% of the total.

To achieve this, a transition from a centralised energy production model to a hybrid model with multiple distributed plants is necessary. Additionally, a more flexible interregional energy market is required[71].

Furthermore, according to the IRENA paper, the issue of energy pricing needs to be addressed. It is also important to note the significant regional variations in energy resources and demand, highlighting the need for increased regional interconnections. 70% of hydroelectric production occurs in the southwest, while 80% of wind production takes place in the north, and 60% of solar production is located in the west. In contrast,

[71] IRENA. (2022). China’s route to carbon neutrality: Perspectives and the role of renewables.

70% of consumption is concentrated in the central and eastern regions. To partially address this issue, China has built high-voltage transmission lines to transmit 66 billion kwh across the country since 2019[71].

Conclusions

China's energy policies have evolved significantly, transitioning from a focus on energy efficiency to a more holistic approach that includes energy security, environmental sustainability, and climate change mitigation. Although coal has historically dominated China's energy mix, recent Five-Year Plans (FYPs) have increasingly prioritised renewable energy and low-carbon technologies. The Tenth and Eleventh FYPs began the expansion of renewable energy, although with less emphasis on environmental concerns. The Twelfth and Thirteenth FYPs incorporated climate change mitigation into China's energy strategy, establishing goals to decrease energy and carbon intensity and encourage innovation in low-carbon technologies. The Fourteenth FYP prioritises the acceleration of renewable energy expansion and reduction of carbon emissions to achieve peak emissions by 2030 and carbon neutrality by 2060. However, China still faces challenges in balancing economic growth with environmental sustainability, particularly in reducing coal consumption and addressing regional disparities. Indeed, the prominent position of coal in China's energy mix presents considerable health and environmental hazards, requiring immediate action to reduce its use and encourage cleaner alternatives.

Furthermore, China's ambitious civil nuclear power programme exemplifies its commitment to diversifying its energy mix and reducing carbon emissions. The programme aims to achieve 70 GWe of nuclear capacity by 2025. The focus is on increasing energy supply security, reducing CO2 emissions, and fostering technological growth: China's nuclear industry is thus poised for significant growth and innovation in the coming years.

Simultaneosly, China is a leader in hydropower, accounting for over 29% of the world's capacity. This has helped to meet the country's energy demands, especially in remote and rapidly developing regions. However, it is essential that hydropower development is carefully planned and managed to maximise its benefits while mitigating its impacts.

China's dependence on imported oil and gas, especially from Russia, highlights the need to diversify its energy sources and strengthen domestic production capabilities. To enhance energy security and stability in the face of global uncertainties, it is critical to implement initiatives that increase natural gas production and storage capacity, as well as establish strategic partnerships with key suppliers.

Moreover, China's focus on renewable energy, exemplified by its ambitious targets for solar and wind power installations, reflects its proactive approach to combating climate change and transitioning to a more sustainable energy future. Investments in renewables, along with progress in energy storage and grid infrastructure, are crucial for achieving carbon neutrality and reducing dependence on fossil fuels.

Overall, China's energy policies and initiatives demonstrate a comprehensive and multifaceted effort to address the complex challenges of energy security, environmental sustainability and economic development. China leverages its technological prowess, strategic partnerships, and commitment to innovation to play a leading role in the global energy landscape.

2. Long-term development

2.1 China's role in the global framework

China is currently leading the way in securing resources for the energy transition.

The geopolitics of renewable energy will see a new kind of competition for sources and technologies: indeed, access to critical minerals and rare earths for the manufacturing of high-tech and renewable energy systems (wind turbines, solar panels, efficient lighting) will be essential. Rare earths include 17 elements of the periodic table, most of which are found in high geographical concentration. China covers both the production and processing of rare earths and controls a significant share of the relevant global supply chains; moreover, the country is leading in renewable technologies and battery manufacturing to[72].

It now produces more than 70% of the world's solar panels and accounts for nearly half of the global wind turbine manufacturing capacity [72].

Although rare earths can be sourced outside China's territory, the economic viability and toxicity of mining and processing make it difficult to develop alternative supply chains. The most important rare earth mining company outside China, Lynas, is based in Australia; Beijing's attempt to purchase a 51% share in the company was blocked by the Australian government in 2009 on strategic grounds. China has strengthened the position of its six state-owned critical minerals companies, and continues to enjoy lower material costs and greater "tolerance" for the high environmental impact of mining[72].

Lithium and cobalt are chemical elements essential for the energy transition as well. Lithium is employed in lithium-ion batteries found in EVs, portable electronic and grid storage devices. Lithium is primarily located in the so-called "lithium triangle"

[72] Siddi, M. (2021). The Geopolitics of the Energy Transition. Finnish Institute of International Affairs.

composed by Argentina, Bolivia and Chile, as well as Australia (now the largest producer of lithium) and China, which plays a pivotal role in both processing and supply[72].

The increasing sales of electric cars have led to competition in the development and production of lithium-ion batteries between China, the US, and Europe. At present, China is ahead of its competitors in the building of new battery gigafactories[72].

For what concerns cobalt, the Democratic Republic of the Congo (DRC) accounts for half of the world's supply of cobalt. Approximately 80% of China's imports of cobalt come from the DRC, but China has also practically created a monopoly on DRC output, including intermediate and refined cobalt[73] [74].

As aforementioned, having access to abundant raw material resources, control of supply chains, and occupying a strong position in the processing of critical minerals - as well as the development of photovoltaic and wind turbine technology - China holds a privileged position in the geopolitics of renewables and the energy transition and is involved in several investments worldwide too.

Indeed, China has announced its Belt and Road Initiative (BRI) in 2013, a major investment project aimed at linking Eurasia and Africa (and possibly Latin America) into a shared space of trade, infrastructure and digital connectivity. In order to do this, The BRI requires large amounts of critical minerals[72].

Furthermore, China's investments in power grids along the BRI have the potential to significantly impact the geopolitics of energy. While the US has historically influenced and protected fossil fuel trade routes, China's investments in power networks could lead to new and profound changes in the global energy landscape. Infrastructure links and the Internet may become new areas of battleground for influence and control between rival powers (IRENA, 2019), with interstate electricity disconnections becoming a foreign policy tool similar to pipeline politics or sanctions[75].

However, electricity trading is generally more reciprocal than oil and gas. Therefore, cross-border electricity trading will create possibilities for regional cooperation and the establishment of "grid communities" [75].

[73] Meidan M., ibidem
[74] Gulley, A. L., et al. (2019). China's domestic and foreign influence in the global cobalt supply chain. Resources Policy, 317–323.
[75] Meidan M., ibidem

The US and other traditional industrial powers have taken a critical stance towards the BRI, mainly because it poses a significant geopolitical challenge[72].

With China as the primary investor, the BRI is aiding Beijing in creating a worldwide network of partnerships. However, there are concerns that China's partners may be forced into debt and become overly reliant on Beijing, despite Chinese authorities referring to the BRI as a “win-win” initiative[72].

On the other hand, Western economic policies have occasionally left Global South countries indebted and economically dependent: China, however, offers an alternative to poorer nations that do not wish to rely exclusively on Western finance and institutions.

As the BRI marks its 10th anniversary, the project faces two major problems. On the one hand, China's economic growth is slowing down, which may impact Beijing's ability and desire to invest abroad. On the other, some politically motivated investments have not resulted in development and have instead led to countries falling into a “debt trap”. The World Bank predicts that in the coming years, more money will be flowing back to China from the rest of the world than Beijing is willing to invest abroad.

Even before the official launch of the BRI, China had a particular focus on Africa and on its energy sector. China is becoming a major player in Africa's energy sector too. This is due to the “going out” strategy of the Chinese government, which has led to Chinese companies participating in various activities such as greenfield investment, EPC + financing contracts, and the production and supply of energy technologies[76].

For decades, China has provided loans and grants to Africa, funding a big infrastructure-building programme. This expenditure defined China's role in what has been described as a "new scramble for Africa". However, due to soaring debt and the coronavirus pandemic, China's financial aid has diminished. As a result, energy companies have taken up the lead. Currently, Chinese CNPC, CNOOC and Sinopec are

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[76] The Africa Climate Foundation. (2021). Scaling China’s Green Energy Investment In Sub-Saharan Africa: Challenges And Prospects.

together the fourth largest energy investors in Africa, following BP, Shell and Eni, respectively[77] [78].

China has been heavily investing in oil and gas exploration and production in Africa. According to reports, over 25% of China's imported oil and gas is sourced from Africa, making it the second biggest regional supplier after the Middle East. The China National Offshore Oil Corporation and France's TotalEnergies are the primary investors in a crude oil pipeline project in East Africa, despite concerns about displacement of residents and environmental damage. Supporters of the project highlight Africa's need for electricity. However, according to a 2022 report by the Boston University Global Development Policy Center, the majority of planned projects are low-carbon energy sources, including 11 GW of hydropower and 5 GW of solar and wind power[79].

China's Global Energy Finance (CGEF) stated that, between the 2000-2021 period, the China Development Bank (CDB) and Export-Import Bank of China (CHEXIM) committed $49 billion in loans to African governments for 128 energy projects. Over a third of their overseas energy projects were directed to Africa. 56 power plants with a combined capacity of 25 gigawatts for power generation capacity have been financed in Africa through foreign direct investment and Chinese policy bank loans. The loans mainly supported projects related to oil ($18 billion), hydropower ($13 billion), and coal ($6 billion), with a smaller portion allocated to gas/LNG ($3 billion), wind ($611 million), geothermal ($480 million), and solar ($367 million). The study shows that the policy banks have a prevailing focus on fossil energy, despite a significant share for hydropower[80].

On the other hand the majority of projects is constituted by hydropower (60%); gas (17%) and coal (9%) are next, and solar and wind electricity account for a smaller percentage (8%). When considering foreign direct investment, the power sector alone is mainly constituted by hydropower projects, with coal being just 9%. According to a research conducted by Boston University, although China has made progress in greening

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77 S&P Global. (2023). China replaces African loans with energy investments amid faltering economy.

78 Chinese investments include, for instance, Mozambique's 3.4 million mt/year Coral Sul LNG project, the 160,000 b/d East African Crude Oil Pipeline (EACOP), and Niger's Agadem oil project and pipeline. The completion of these projects will increase Niger's oil output from 20,000 b/d to 130,000 b/d.

79 VOA. (2023). Why China Is Investing in Africa's Green Energy Future.

80 Boston University Global Development Policy Center. (2022). Towards a Solutions-Oriented Approach: China, Africa and Energy Transition Narrative Building.

its Belt and Road Initiative, more effort is still required to help African countries expand their renewable energy industry[80].

Despite this, since the beginning of the 21st century, China has been the largest investor in renewable energy in Africa. Its investments are mainly in hydropower across Sub-Saharan Africa, with increasing investments in solar in West and Southern Africa, wind in North Africa, and geothermal power in East Africa[81].

By the end of the century, Africa is projected to accommodate 40% of the world's population. Meeting 40% of the world's renewable energy capacity by then poses a significant challenge. Chinese exports of solar and wind products will likely continue to flow to Africa until a significant technological breakthrough renders current solar and wind technologies obsolete. De-risking Chinese renewable supply chains on a systemic scale is neither feasible nor realistic for Africa[81].

Amid Africa's shift towards renewable energy, China and the continent have emerged as enthusiastic collaborators. China's proficiency in constructing infrastructure, maintaining reliable renewable supply chains, providing inventive financing solutions, and facilitating government-led training for renewable energy jobs aligns well with Africa's substantial potential in renewable energy. This partnership is particularly valuable given Africa's extensive energy infrastructure needs and the shortage of skilled professionals. China is actively participating in Africa's renewable energy revolution, and regardless of geopolitical considerations, its commitment to this endeavor seems enduring[81].

2.2 The role of different sources and the plans for renewables, nuclear and hydropower.

As mentioned above, the Fourteenth Five-Year Plan (2021-2025) was officially adopted on 11 March 2021 at the end of the National People's Congress (NPC) session.

[81] The London School of Econimics and Political Science. (2023). China has quietly joined Africa’s renewable energy revolution.

The plan has 20 quantitative targets, 8 of them binding[82], under five categories: economic development, innovation, people's well-being, green development, and food and energy security[83].

The FYP major priorities underscore a comprehensive shift towards sustainable growth and development. These major priorities include:

1. Early peaking of emissions: China has set an ambitious goal to peak carbon dioxide emissions by 2025, rather than 2030, and hopes to achieve carbon neutrality by 2060. Accelerating policies and investments during the 14th Five-Year Plan period will be critical to achieving these ambitious goals. This acceleration during the Five-Year Plan period would allow China to reap the economic benefits of these actions and investments sooner[84].
2. Clean energy transition: Priorities include reducing coal consumption, increasing investment in cleaner energy sources, and greening its largest multi-country infrastructure and development project - the Belt and Road Initiative, accelerating the clean energy transition[84].
3. Geographic rebalancing and new urbanisation: China intends to shift to a "dual circulation" strategy, emphasising domestic economic reliance and fostering smaller cities and peripheral regions. Urbanisation will play a crucial role in this rebalancing, with the focus shifting from export-oriented megacity "hubs" to "clean, compact and connected" (CCC) cities in the hinterland. By promoting this sustainable urban transition, China will create jobs and ensure a cleaner and healthier environment[84].

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[82] The eight binding targets of the plan are: to increase the average years of education of the working-age population to 11.3 years; to reduce energy consumption per unit of GDP by 13.5% from the 2020 level; to reduce carbon dioxide emissions per unit of GDP by 18% from the 2020 level; to increase the proportion of days with good air quality in cities at the prefecture level and above to 87.5%; to increase the proportion of surface water with a quality of III or better to 85%; to increase the forest cover to 24.1%; comprehensive grain production capacity (>650 million tons); and comprehensive energy production capacity (>4.6 billion tons of coal equivalent).

[83] Asian Development Bank. (2021). The 14th Five-Year Plan of the People's Republic of China — Fostering High-Quality Development.

[84] Hepburn, C., Ye, Q., Stern, N., Ward, B., Xie, C., & Zenghelis, D. (2021). Towards carbon neutrality and China's 14th Five-Year Plan: Clean energy transition, sustainable urban development, and investment priorities. *Environmental Science and Ecotechnology*, *8*, 100130. https://doi.org/10.1016/j.ese.2021.100130

4. Investment in technology infrastructure: Through this initiative, China aims to develop an information-based, digital and innovative R&D infrastructure to drive economic growth. The focus will be on 21st century technologies to avoid investments in traditional infrastructure that could lead to stranded assets and to improve energy efficiency[84].
5. Local public finances and sub-national revenues: Fiscal reforms are needed to ensure sustainability and to avoid production patterns that are harmful to the environment. Moreover, clarification of government responsibilities and improvement of fiscal transparency are essential for future growth and stability[84].
6. Enhancing governance to deliver strong, sustainable and inclusive growth: Delivering a new form of sustainable growth and development will require administrative reform, both regionally and across government. In particular, there needs to be clarity on local spending allocations, and high-quality strategies for sustainable and resilient investment and innovation need to be managed coherently across government. Institutions such as the National Development and Reform Commission and the Ministry of Finance will play a critical role in this process[84].
7. Encouraging positive behavioral changes post-pandemic: The pandemic has led to positive changes such as better use of urban space, increased investment in public transport, reduction of local air pollution and adoption of new technologies. These changes should be encouraged and extended to improve well-being and promote sustainable growth by creating an attractive environment for highly skilled workers[84].

Overall, China's 14th Five-Year Plan aims to establish a sustainable economic model that prioritizes environmental protection, innovation, and inclusive growth.

A few months before the adoption of the 14th FYP, during the 2020 United Nations Climate Ambition Summit, President Xi Jinping expressed China's commitment to addressing climate change by setting goals, such as achieving a total installed capacity of 1200 GW of wind and solar energy by 2030, that were considered ambitious. The subsequent provincial plans and deployment rates, showed that this target could be reached as early as 2025[85].

But the pace of transition to renewable energy is accelerating: indeed, according to an analysis published on Wall Street Journal, international climate experts anticipate that China's greenhouse-gas emissions will peak earlier than expected, possibly as soon as this year. At the end of 2023 China wind and solar capacity accounted for 1050 GW and China Electricity Council forecasted that this capacity would reach 1300 GW by the end of 2024, six years earlier than planned[86].

China has experienced a significant increase in renewable energy deployment, with a 60% rise from approximately 530GW in 2020 to around 860GW in just two and a half years[85].

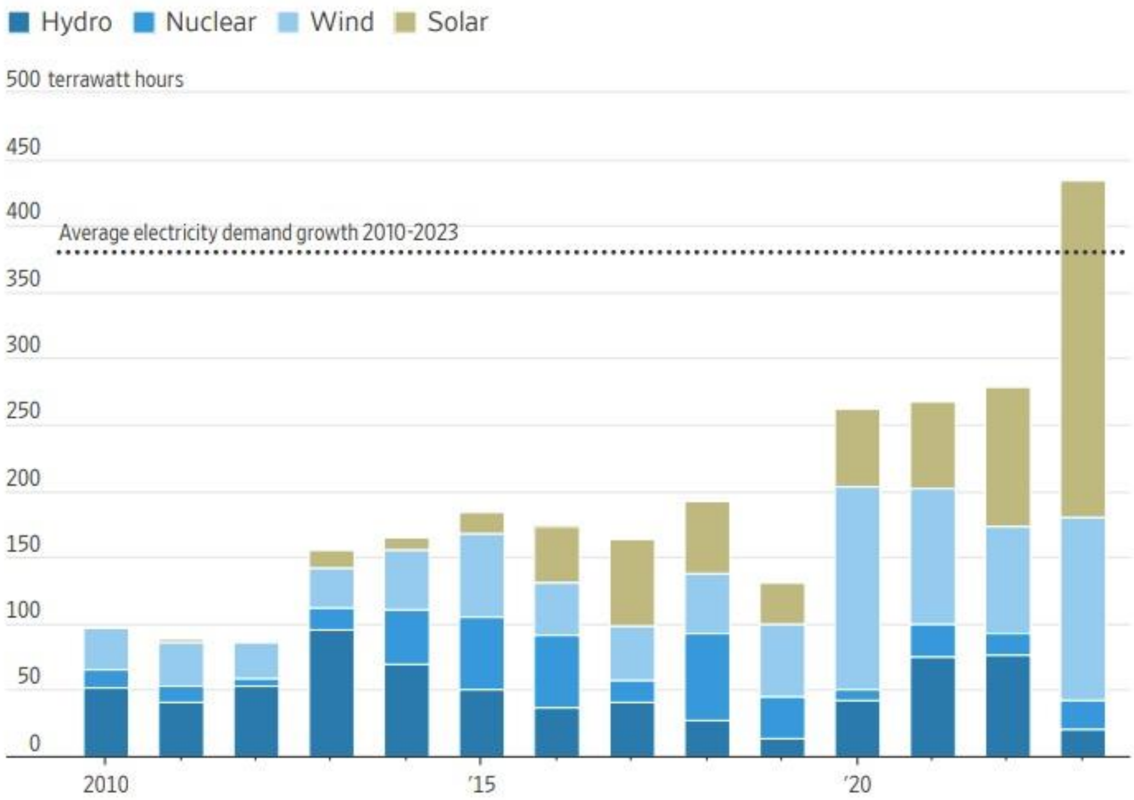
Last year, China installed 217 gigawatts of solar power, a 55% increase, according to new government data[86]. Last year, China installed over 500 million solar panels, surpassing the total installed solar capacity of the United States. These panels were installed in various locations, including the deserts of Inner Mongolia, the mountains of southwest China, and rooftops across the country. Notably, solar panels were even installed on the Great Hall of the People on the edge of Tiananmen Square[86]. In addition, China added 76 GW of wind-energy installations, which is more than the rest of the world combined. This resulted in over 20,000 new turbines.

Low-carbon capacity additions, including wind, hydropower, and nuclear, were added across China to meet the country's increasing electricity demand. Analysts suggest that the power output from these additions was large enough to cover the entire annual increase in demand. According to the Paris-based International Energy Agency and the Centre for Research on Energy and Clean Air in Helsinki, it is suggested that coal-fired generation, which accounts for 70% of overall emissions for the world's biggest polluter, is set to decline in the coming years[86].

[85] AFRY. (2023). China expects to achieve its 2030 wind and solar ambitions ahead of schedule in 2025.

[86] Wall Street Journal. (2024). China’s Carbon Emissions Are Set to Decline Years Earlier Than Expected.

Clean-energy growth vs. average electricity-demand growth 2010-2023
Source Centre for Research on Energy and Clean Air



According to AFRY analysis, renewables are expected to account for more than 70% of the energy mix by 2025. Additionally, the analysis suggests that China's total installed capacity will reach at least 3200GW, exceeding the government's 3000GW target by the end of the Fourteenth FYP[85].

Currently, China's installed capacity for solar PV and onshore wind is almost 1 terawatt, a significant increase from near-zero less than two decades ago. This success can be attributed to China's proactive policies that have encouraged deployment and improved manufacturing efficiency, using economies of scale to accelerate deployment.

The government has launched various support schemes to promote renewable energy deployment since 2009. The initial growth of renewable energy in China was spurred by the Feed-in-Tariff (FiT). However, as renewable technology costs dropped, the FiT no longer provided value to Chinese consumers and has since been replaced by a range of policies. Currently, new solar and wind projects are either grid-parity projects, receiving provincial regulated prices equivalent to those paid to coal generators, or market-based projects trading through forward markets, green power markets, or the spot market, depending on provincial liberalisation progress[85].

Moreover, according to Carbon Brief, although emissions have increased in 2023, there has also been a significant expansion of low-carbon energy installations[87]. Some analysts predict that emissions will plateau instead of rapidly decreasing in the following years. This poses a problem, as scientists argue that the world's major emitters must significantly reduce global emissions this decade - by 43% compared to 2019 - in order to meet the goals of the Paris agreement[86].

According to the scientific consortium Climate Action Tracker, China's current policies are rated as “highly insufficient” to meet the 1.5 degrees Celsius goal. The consortium's latest analysis, published in November 2023, suggests that China's emissions should peak by 2025; moreover, according to the consortium, if wind and solar installations can maintain an average of 300 gigawatts per year, as they did in 2023, China's emissions are expected to decrease significantly by the end of the decade, and could decrease projected global warming by approximately 0.3 to 0.4 degrees Celsius[86].

Carbon Brief forecasts in November 2023 stated that the new installed solar, wind, hydro and nuclear capacity alone will generate approximately 423 TWh per year. Half of the solar panels installed in 2023 will be placed on rooftops, primarily due to China's “whole county solar” approach: this involves a single auction to cover a specific proportion of a county's rooftops with solar panels in a one-time deal**Error! Bookmark not defined.**. Developers negotiate with building owners and arrange contracts for grid connection, financing, procurement, contracting, and installation. This model enables the deployment of rooftop solar at a vast scale through centralised development of distributed solar. The second half of solar installations will be in large utility-scale projects, particularly in the gigawatt-scale "clean energy bases" in western and northern China largely desert areas**Error! Bookmark not defined.**.

For what concerns hydropower, in 2024, China is expected to experience a significant annual increase in output from its large fleet, together with the electricity generated by the new capacity additions. The utilization of this fleet reached historical lows from August 2022 until July 2023 due to record droughts and heatwaves in the

[87] Carbon Brief. (2023). Analysis: China’s emissions set to fall in 2024 after record growth in clean energy.

summer of 2022, followed by low rainfall in 2023. The decrease in power generation from one year to the next was exacerbated by hydropower plant operators saving water in the spring and early summer of 2023, building up water levels in their reservoirs for the peak demand season in August.

CREA analysis of hydropower generation data and water levels at 13 major hydropower stations across China, as reported by Wind Financial Terminal, highlights this behaviour, showing water levels approaching historic highs while generation remained low until July. This was considerably different from 2022, when there were abundant rains in the spring and early summer and hydropower was generating at very high rates**Error! Bookmark not defined.**.

Hydropower companies in China's strictly regulated power system have little financial incentive to schedule their output for the season of highest demand. But after summer 2022's power outages, it appears that government intervention has taken the role of financial incentives, forcing generators to keep reservoir levels high. In China's tightly regulated power system, hydropower operators lack economic incentives to schedule their output to coincide with peak demand season. However, following the electricity shortages of summer 2022, government intervention seems to have replaced economic incentives, forcing generators to maintain high reservoir levels. As a result, water levels in reservoirs have now risen to or above their seasonal averages, according to data from Wind Financial Terminal**Error! Bookmark not defined.**.

If the long-term weather forecasts, which indicate above-average rainfall until February, are accurate, hydropower utilization will not only recover but exceed historical averages in 2024. Additionally, 29GW of hydropower capacity has been added from the beginning of 2022 to September 2023, representing a 7% increase in capacity**Error! Bookmark not defined.**.

In this scenario, according to a forecast by an industry body in January 2024, China's installed wind and solar capacity will surpass that of coal for the first time this year.The China Electricity Council (CEC) predicts that by the end of 2024, wind and solar power will make up approximately 40% of installed power generation capacity, compared to coal's expected 37%[88] [89].

[88] Reuters. (2024). China's wind, solar capacity forecast to overtake coal in 2024.
[89] The Economic Times. (2024). China's wind, solar capacity set to outshine coal in 2024.

In comparison, at the end of 2023, wind and solar combined accounted for approximately 36% of capacity, while coal accounted for just under 40%. However, the report did not provide a forecasted breakdown for actual power generation, which is still predominantly fueled by coal, providing nearly 60% of the electricity consumed last year[88].

According to a recent study by Tsinghua University, China would need to significantly transform its energy mix by increasing its use of non-fossil fuel energy to 84% and completely eliminating coal-fired power plants by 2060. This raises concerns about the future of numerous power plants that are currently being built or planned, which could either result in decades of pollution and high greenhouse gas emissions or become stranded assets.

In numerous instances, the pressure to pursue coal mining comes from local governments dependent on royalties from mining operations. Addressing this dependence requires a collaborative effort to establish alternative tax assignments for local governments, as well as tax and pricing policies. These reforms should be implemented concurrently with decisions to cease constructing additional coal-fired plants, while promoting the generation of renewable energy. There is an urgent need to support coal communities affected by the transition and ensure a 'just transition' for workers. This should involve transparent and comprehensive policies on compensation and medical support, as well as a professional retraining programme to help affected coal workers build a future. Jobs in coal are a thing of the past and are therefore insecure. Workers in China, like those in other countries, would benefit from their government pursuing 21st-century employment opportunities. China's top priorities should be national energy security together with the reducing emissions target. China's Two Sessions ('Lianghui') was held in May 2020 and placed energy security at the top of the sector's priorities, to be achieved primarily through the development of production, supply, storage and distribution of all energy sources, including coal, renewables, oil, natural gas and electricity. Additionally, there was a focus on the need to develop reserve systems to respond to shocks in the energy sector and reduce dependence on imported energy, as well as on better regulation of the activities of energy companies. However, the renewed focus on energy security has raised concerns that energy industry lobbyists may seek extra support in the name of 'promoting energy security' and creating a fundamental role for coal in securing future energy supplies[84].

China government answered the critics stating that the new power plants will be more efficients and less CO2 emitters than the old ones they will replace. Moreover, they will run below full capacity and mainly as a backup power source also necessary to mantain electric grid stability[86].

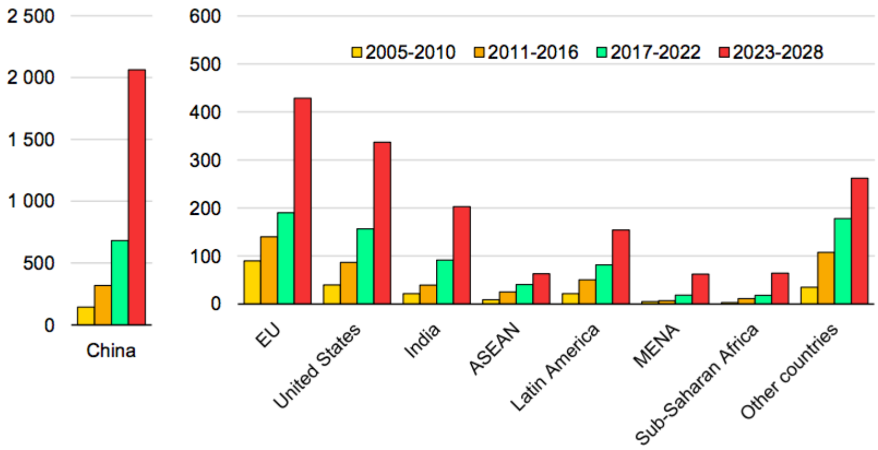
The management of the grid presents a significant obstacle to the widespread adoption of renewable energy sources in China. The operation of the existing grid system suggests that there is a cap on the proportion of renewables that can be integrated into the grid. As electricity production from renewables rises, balancing mechanisms like storage (e.g. batteries, pumped storage or hydrogen) or generation from other sources, including coal-fired power, must also rise in order to ensure the necessary flexibility to respond to the intermittency of renewable supply. This is possibly the reason why there has been an increase in generation capacity from coal-fired plants alongside the growing supply from renewables to meet the rising demand for electricity[84].

On a global scale, marking the level of chinese effort in this field, The International Energy Agency stated in its Renewables 2023 Report that China is expected to contribute 56% of the total renewable energy capacity added between 2023 and 2028[90].

According to IEA data, China is projected to increase its renewable capacity by 2,060 GW during the forecast period, with solar PV accounting for three-quarters of the increase, while the rest of the world is expected to add 1,574 GW[90].

Renewable electricity capacity growth by country/region, main case

Source: IEA



The IEA report highlights China's emergence as the leading force in renewable energy, driven by supportive policies that have led to a significant increase in expected capacity additions since the previous report in December 2022, with China accounting for almost 90% of the global upward forecast revision, mainly in solar photovoltaic (PV). Indeed, IEA stated that the solar PV manufacturing capabilities of the country have nearly doubled since last year, leading to a global supply glut[90].

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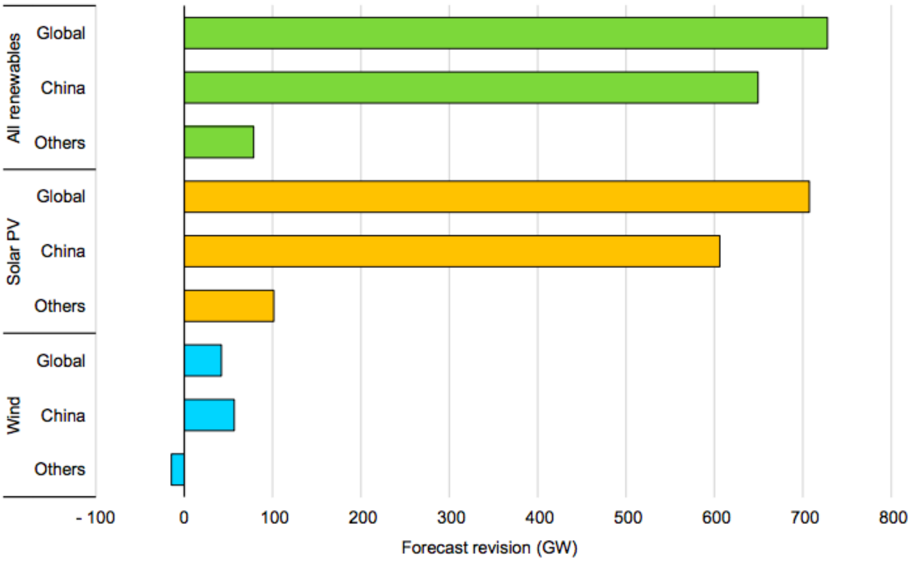
[90] Reuters. (2024). China dominates renewable energy and coal power forecasts.

Renewable electricity capacity forecast revisions, Renewables 2023 vs Renewables 2022

Source: IEA



All these developments will be reflected in the next FYP. According to The State Council of PRC, the National Development and Reform Commission (NDRC) has commenced its preliminary study of China's 15th Five-Year Plan (2026-2030)[91].

During a meeting held in December 2023, the commission has started sorting through and summarising major issues that require early planning and research during the 15th Five-Year Plan period: in this occasion, NDRC Director stated that the economic planner will conduct intensive and in-depth research work on significant theoretical and practical issues related to promoting Chinese modernization. The focus will be on exploring new concepts and measures, solving major shortages, and identifying key tasks that will be important for the overall planning in 2026-2030[92].

During this time span, significant progress is expected in the industrial application of green and low-carbon technologies. The aim is to establish an industrial system that prioritises green, low-carbon, and circular development, as outlined in the plan[93].

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91 The State Council of the People's Republic of China. (2023). China's top economic planner begins preliminary study of 15th Five-Year Plan.

92 Xinhua.(2023). China's top economic planner begins preliminary study of 15th Five-Year Plan.

93 National Development and Reform Commission of the People's Republic of China. (2022). China to further promote green growth in building materials.

As per the new target, petroleum consumption is expected to reach its peak plateau during the 15th Five-Year Plan. The target also includes a reduction in domestic coal consumption during the course of the same FYP.

Newly constructed coal power projects will face severe restrictions and must meet the most advanced international standards for coal consumption[84].

An urgent need exists for a modern and more intelligent grid system. This requires not only an upgrade of the grid infrastructure but also the provision of technical guidance and standards that determine how the grid operates. In late 2019, China released a new standard and technical guidance document, the 'Code on Security and Stability for Power System (GB38755-2019).'[84] Entered into force in July 2020, it replaced the previous standard (DL755-2001) that had been followed by the grid for two decades. National guidance and local implementation are necessary for managing the grid, enabling advanced technologies and eliminating institutional barriers to large-scale integration of renewables into the electricity market. The electricity market also presents a barrier. China's generation dispatch is primarily determined by the annual generation planning conducted by provincial governments, due to the incomplete forward electricity market[84]. The provincial governments set out long-term unit commitment plans that specify whether each generation unit serves as the base load generator or marginal generator. Generators of the same kind (e.g. coal-fired, wind, solar) are usually allocated approximately the same number of annual operating hours to ensure a fair opportunity for cost recovery. However, the 'fair dispatch' rule is increasingly challenged by the rapid progress of low-cost renewable sources and digital transformation in power systems.

The Chinese government should implement market-based economic dispatch, prioritising the generation unit with the lowest costs to meet electricity demand. This approach could lower the overall expenses of providing services to consumers and enhance the integration of renewable energy by capitalising on the near-zero marginal cost of wind and solar generators[84].

2.3 Supports to the energy transition

China has certain advantages that are not always available in other countries. These include the ability to approve and construct transmission grids and renewable energy projects more quickly than in countries where democratic processes and local community objections can hinder infrastructure development. Additionally, China can more easily finance projects than in countries where money is lent or raised based on expected returns rather than policy priorities. The manufacturing base of the country enables economies of scale in the production of PV panels and wind turbines. This is supported by China's efforts over the past few decades to establish a leading position in the supply and processing of minerals such as copper, nickel, and lithium[90].

It is important to note that investments in renewable energy have become a significant driver of the Chinese economy. Last year, the country's spending on clean energy totalled $890 billion, a 40% increase. Without this growth, investment in China would have been stagnant due to the slump in the real estate sector, according to the Centre for Research on Energy and Clean Air.

The investments comprise of clean-energy installations and the construction of large factories to produce solar panels, wind turbines, batteries, and electric vehicles, making the country the leading manufacturer of clean technology. The factories in these sectors currently have surplus capacity. It is worth noting that the adoption of electric vehicles is happening so rapidly that analysts suggest peak gasoline demand in China was already reached in 2023[86].

While renewable energy technologies are becoming more cost-competitive, policies continue to play a crucial role in attracting investment and enabling deployment. It is expected that policy schemes will stimulate approximately 87% of global renewable utility-scale capacity growth between 2023 and 2028. Policy-driven deployment refers to situations where government policy is the primary driver for investment decisions. This can include, for instance, policies that affect power remuneration, reduce tax liability, or introduce purchasing obligations to meet government targets[94].

The two most notable policies have been competitive auctions, in which the government puts a set amount of capacity up for bid and sets a limit on what it will pay for the contracted power, and administratively set tariffs for remuneration, in which the government offers developers a fixed tariff or premium. Two-way fixed contracts for difference, which are solely driven by Europe and contribute for more than one-third of the growth in utility-scale renewables in that region, are the primary source of auction-driven growth. A third policy option are tax credits, which considerably increase a project's economic attractiveness by lowering the developer's tax liability. A fourth type of policy-based deployment involves utility-owned projects in regulated markets, whereby the regulatory environment by default influences the investment decision[94].

[94] IEA. (2024). Renewables Report 2023.

In contrast, market-driven procurement is projected to represent only 13% of the worldwide growth in renewable capacity. Market-driven deployment refers to investment decisions that are not directly influenced by government policy.

The majority of policy-driven deployment is concentrated in China, where policies support 95% of the country's growth. For example, China is expected to deploy approximately 1,285 GW of capacity, primarily through administratively set fixed tariffs for 15-20 years based on the provincial benchmark electricity price, which is largely determined by coal generation. Competitive auctions were held at the national level in 2020 with a budget cap[94]. However, they have since been stopped as the government phased out subsidies for utility-scale wind and solar PV. Market-based deployment, which accounted for 5% of the expansion, is expected to grow due to the new green certificate regulations introduced in both 2022 and 2023. These regulations facilitate interprovincial trade and track progress in meeting provincial renewable energy targets[94].

2.4 The electric vehicles industry and the crisis with the EU

China became the second-largest automobile exporter in the world in 2022, accounting for nearly 60% of global EVs purchases[95] and one-fourth of domestic ones (a 93.4% increase from 2021)[96] [97]. China dominates the battery market as well, accounting for 75% of total production worldwide.

Moreover, in the first seven months of 2023, Chinese automakers sold nearly as many electric cars in Europe as they did in the entire year of 2022[98], surpassing Germany and distinguishing itself from its rivals in the automotive export market in at least two ways. Firstly, a substantial amount of its exports are automobiles manufactured by foreign companies as opposed to Chinese companies. Second, the rise in exports is being driven by a new technology concerning electric vehicles (EVs)[100].

Two-thirds of all EVs batteries are currently made by Chinese companies, and they also lead the market for the extraction and processing of key mineral components. This is partly because of China's decentralized political economy, which has made it

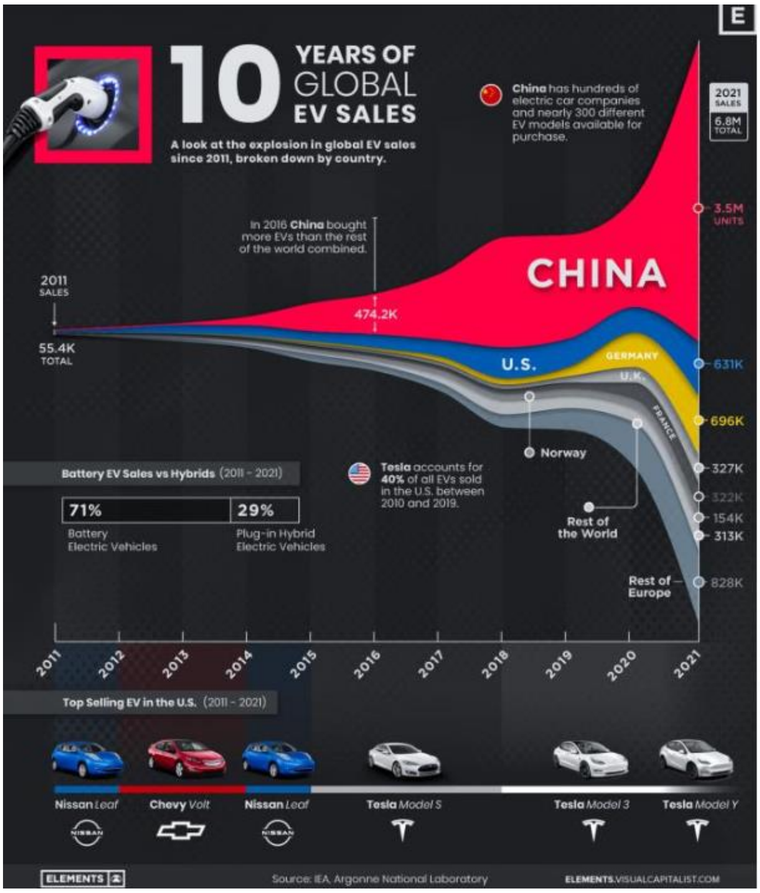
[95] Harvard Business Review. (2024). 3 Drivers of China’s Booming Electric Vehicle Market.

[96] It also owns 65% of the public charging stations installed worldwide (1.15 million charging points).

[98] Ling L., Rakoto B. (2023). The Rapid Rise of Chinese Electric Vehicles in Europe: Challenges and Implications, in “Ducker Carlisle”.

possible for the domestic EVs industry to compete fiercely, with banks and local governments willing to lend low-cost capital and land in order to support local EV employers[99].

Source: IEA, Visual Capitalist



An article published on "Centre for Strategic & International Studies Briefs" (CSIS)[100] highlights the challenges that China's dominance in electric vehicle manufacturing poses for the United States and particularly for Europe. Moreover, it formulates assumptions on what policymakers should focus on, highlighting the need for careful policymaking to strike a balance between protecting domestic industries and promoting competition. The analysis of the differing approaches of the United States and the European Union to Chinese investment and EVs exports highlights the complexities and potential consequences for their respective industrial landscapes. Indeed, the

[99] World Politics Review. (2023). Electric Vehicles Are Roiling EU-China Relations.

[100] Mazzocco I., Sebastian G. (2023). Electric Shock: Interpreting China's Electric Vehicle Export Boom. *Centre for Strategic & International Studies Briefs.*

European Union has been more receptive to Chinese greenfield investment and EVs exports, making it a primary target for Chinese-made EVs: this benefits consumers, but it also poses a potential risk to the EU's industrial base[100].

The CSIS article's thorough examination of trade and investment data exposes two trends:

firstly, the success of Chinese automakers in the electric vehicle sector. Thanks to creative innovation, economies of scale attained by Chinese automakers, and sustained government support, China's EV companies are starting to compete on a global scale.

In the second place, China's importance as a global hub for EVs production. China is being used by more and more Western companies as a platform for EVs manufacture because of its large manufacturing capacity, friendly policies, and affordable production capabilities.

Key policy consequences result from these developments[100].

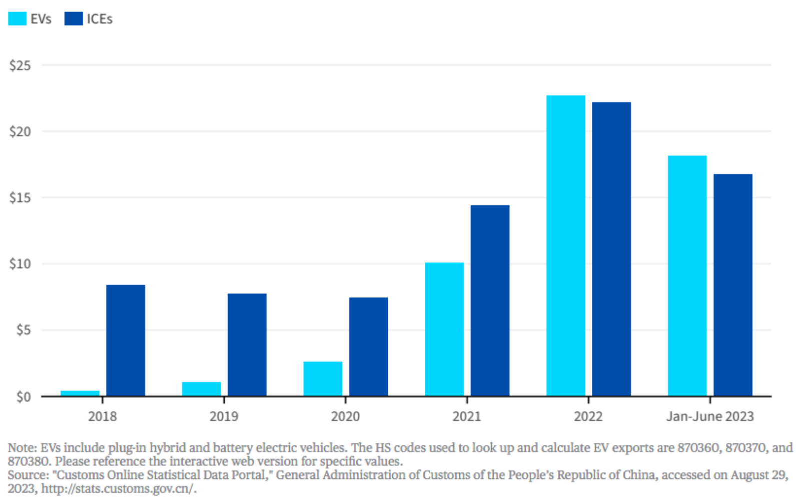
Countries that have traditionally exported automobiles, such as Germany, Japan, and the United States, are at risk of losing investment and value added to China.

The automotive industry is a new focal point for tech competition with China since it is large-scale, accounting for 3% of the global GDP, and has been traditionally controlled by developed economies[100]. As Chinese brands increase their foreign direct investment to gain a larger part of international markets, emerging economies might be able to attract more Chinese investment at the same time. Although traditional carmakers must contend with increased competition from China, they can benefit from exporting to China and its alluring manufacturing ecosystem if they are willing to take on the associated political risks. Lastly, increased competition may result in lower costs, which would hasten the shift and benefit customers[100].

The EVs market shift has been advantageous for both Chinese and foreign original equipment manufacturers (OEMs) producing in China. For instance, Tesla is believed to have accounted for 49% of EVs exports from China between January 2021 and March 2022. This is a departure from previous years when European automakers, particularly German ones, concentrated on selling internal combustion engine cars to China. The shift in technology has led to a levelling of the playing field between foreign and Chinese OEMs, with competition now focused primarily on price and vehicle content rather than technology. This shift has resulted in increased competition from Chinese-made EVs in global markets, which is changing the market dynamics. European OEMs, such as Volkswagen, are also facing this increased competition[98].

With the goal of becoming a global leader in the electric vehicle industry, China's Ministry of Science and Technology has been implementing measures to grow the country's EV industry since 2009[101]. After initially concentrating on replacing foreign manufacturers in the domestic market, the approach evolved to encourage internationalization. The 2017 blueprint for the automotive industry established targets for Chinese EVs brands to export by 2020, with the aim of being in the world's top 10 globally by 2025. Recent data shows progress in the achievement of these targets[100].

Chinese Auto Exports by Type of Vehicle (Electric Vehicle vs. Internal Combustion Engine Vehicle)
Source: China Government



Since October 2021, China has become a net exporter of automotive thanks to its EV exports, which have significantly reduced the nation's automotive trade deficit.

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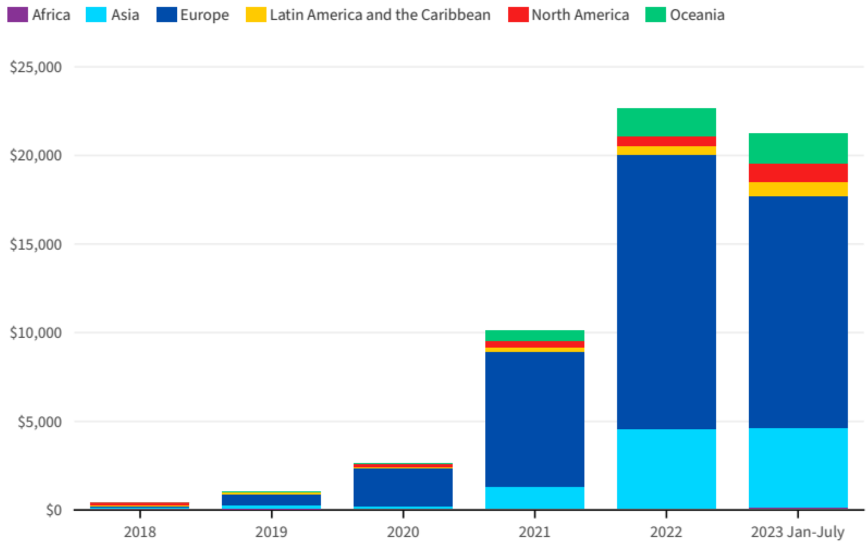
[101] The Chinese automotive industry has rapidly expanded due to the government's decision to shift investment from the property sector to the manufacturing sector. This aligns with Xi Jinping's goal of supporting the "real economy" over the financial sector and funding production by firms rather than consumption by households.

Battery Electric Vehicle Exports from China by Region, 2018–2023
Source: China Government



Note: EVs include plug-in hybrid and battery electric vehicles. The HS codes used to look up and calculate EV exports are 870360, 870370, and 870380. Please reference the interactive web version for specific values.
Source: "Customs Online Statistical Data Portal," General Administration of Customs of the People's Republic of China, accessed on August 29, 2023, http://stats.customs.gov.cn/.

This shift was influenced by EVs exports as well as a spike in the export of internal combustion engine vehicles to Russia; the market share of non-Chinese carmakers in Russia has been impacted by the increasing popularity of Chinese brands such as Great Wall and Chang'an[100].

However, the EVs industry's growth is thought to have greater global significance than this development. In terms of volume, EVs make up one-third of China's automotive exports, but they account for 52% of their value, meaning that they are essential to closing the country's auto trade deficit. Due to increasing demand, low tariffs, and government incentives on all electric vehicles, regardless of origin, the majority of Chinese EVs are sold to Europe. On the other hand, high tariffs on Chinese automotive imports and local content requirements for EVs tax credits limits exports to the United States. Government agreements to meet European safety standards benefit Chinese automakers; EVs arrive in European ports and are later sold in Scandinavia, Germany, or UK[100].

Chinese automakers, particularly those focused on EVs, have made significant strides in the international market through various strategies.

1. Expanding international presence: Businesses are capitalizing on domestic success to grow worldwide. BYD, a prominent EV manufacturer, is one such

business that exports electric buses worldwide and plans to export passenger vehicles to Europe, Southeast Asia, and Latin America[100].

2. Acquisition of Foreign Brands: Western brands have been purchased by Chinese companies SAIC and Geely (which have purchased MG and Volvo, respectively). These acquisitions provide access to established markets, while joint ventures such as Polestar and Lynk & Co. are focused on producing EVs[100].
3. Joint Ventures: Joint ventures between Chinese carmakers and foreign manufacturers are now common, facilitating exports. For example, the Dongfeng-Renault joint venture produces the Dacia Spring in China for the European market, which is a notable example of a European brand shifting production to China for the European market. Additionally, European brands such as Smart are also shifting production to China, with Mercedes-Benz and Geely collaborating to develop new models[100].
4. Technology collaboration is also on the rise. Western automakers such as BMW and Volkswagen are partnering with Chinese firms to gain access to technology and know-how. For instance, Volkswagen has acquired a stake in Xpeng, a Chinese EVs start-up, and is exploring collaborations. Additionally, there are reports of collaborations that allow Volkswagen to use a platform from Chinese company Leapmotor for its electric Jetta models.

This expansion demonstrates China's changing role from a low-cost manufacturing centre to a significant participant in the worldwide automotive industry, with Chinese firms impacting technology and know-how exchange[100].

According to Harvard Business Review[95], three primary factors have contributed to the expansion of China's EVs industry: experimenting in adjacent industries, encouraging operational solutions, and doubling down on core technology.

1. Experimenting in adjacent industries. In their early EVs stages, Chinese automakers BYD and Geely experimented through indirect methods by working on related industries, namely electric buses and motorbikes. Buses require more battery power and storage since they are heavier than commercial automobiles, are able to carry more passengers, and operate for approximately

18 hours per day[102]. On the contrary, Geely faced the challenge of creating batteries for motorbikes, which have to be lighter than batteries for cars. Consequently, the indirect approach of BYD and Geely has allowed for innovation and development on the two extremes of the EVs manufacturing strategy[95].

2. Encouraging Operational Solutions: China worked with regional groups to identify solutions after realizing that EVs adoption presented operational issues. In order to solve battery constraints and flatten the power grid consumption curve, the government partnered with major city taxi companies to develop operational solutions in 2009 and provided subsidies for the acquisition of electric vehicles[95].
3. Double Down on Core Technology: Chinese automakers, who have lagged behind in the development of combustion engines technology in the past, acknowledged a window of opportunity in battery technology. Moreover, battery companies were capable of controlling the supply chain bottleneck due to their proximity to critical raw material supplies, including rare earth. Cooperation with other automakers and IT firms improved EVs manufacturing skills. Companies such as BYD and Geely were involved in collaborations, acquisitions, and ecosystem building[95].

Despite the fact that the majority of European-brand cars in China are produced locally, EU-China trade in automobiles remains significant, accounting for approximately 10% of EU exports to China. However, there is a significant shift in dynamics from 2022 onwards, with the EU running a trade deficit in cars with China, mainly due to the increase in EVs exports from China to Europe[100]. This trend could continue, leading to a permanent auto trade deficit by 2024, unless local EVs production increases or trade defence instruments are used. While this is beneficial for some European carmakers (some, such as BMW, Mercedes-Benz and Renault, are already exporting from China), this change may disrupt value chains and have an impact on economies that largely rely on the automotive industry, like Germany, as well as on the EU's automotive sector and industrial base[100]. The increasing amount of Chinese-manufactured electric vehicles

[102] 90% of electric buses and 95% of electric trucks are produced and sold in China.

affects trade between the EU and China as well as trade between the EU and the rest of the world: indeed, European car manufacturers will face increasing competition from China in third markets. The increasing number of European producers using China as an export hub indicates a change in the alignment of national and firm-level interests. This may lead to discrepancies between the business sector and European governments in the future. Some governments have acknowledged these discrepancies and have taken measures to limit support, such as investment guarantees, for companies operating in China; nevertheless, recent visits to Beijing by high-level executive delegations following German Chancellor Olaf Scholz and French President Emmanuel Macron indicate that, for the foreseeable future at least, support for investment in China endures[100].

Chinese EVs have received significant subsidies, giving them a competitive edge in foreign markets. However, this has limited foreign EVs access to the Chinese market. Consequently, China has manufactured EVs that, together with being on average €10,000 cheaper than their EU competitors, are more compact and manoeuvrable[103]. Furthermore, China's access to rare earths and other critical materials and components, as well as the number of EVs manufacturing patents it holds, gives Beijing a significant cost advantage over countries that largely rely on imported components and raw materials.

These factors are increasingly viewed as a significant threat to the development of other markets. This is particularly true for the EU, which has its own growing requirements for electric vehicles. Barriers to domestic production of EVs in the EU could also have repercussions on sectors that are essential to the Union's efforts to minimise strategic vulnerabilities, for instance the electric battery industry.

It is important to note that foreign car manufacturers still dominate Chinese EVs exports, with Tesla accounting for 49% of 2021 exports, European joint ventures and Chinese-owned European brands accounting for another 49%, and mere 2% being “purely” Chinese brands. However, cheaper and lighter EVs sourced from China appear to be more in line with the objectives of the “Fit for 55” framework.

Nevertheless, in September 2023, the European Commission initiated an ongoing anti-subsidy investigation into Chinese-made EVs due to concerns that Chinese EVs manufacturers are receiving unjust subsidies at the expense of European competitors[98].

[103] The Diplomat. (2023). China, Europe, and the Great Electric Vehicle Race.

The investigation is looking into whether the Chinese government is allowing their EVs manufacturers to sell their vehicles at artificially low prices in the EU, which could be considered as dumping. The Commission is expected to issue a decision by early 2024. If the Commission concludes that Chinese EVs are being dumped on the EU market, it could impose tariffs on these vehicles[104], which would make them more expensive and benefit European EVs manufacturers, or at least help them re-establish competitiveness. Eventually, this could boost the European EVs industry and create jobs in the automotive sector[98].

However, while imposing tariffs on Chinese EVs could be instrumental in protecting Europe's industry from a surge of Chinese car exports, it could also result in higher prices for consumers and businesses, potentially reducing demand for EVs and slowing the transition to clean energy transport[98].

The European Union's anti-subsidy investigation into Chinese EVs has been criticized by the Chinese government, which claims that the EU is engaging in a protectionist behaviour[98]. China has issued threats of retaliation if the EU continues its investigation, threatening to impose taxes on European goods, limit market access for European businesses, and conduct anti-subsidy investigations into European exports, among other measures. Given that the EU is a significant sales market for Chinese automakers and that China is a vital export market, the possible repercussions could be detrimental for European automakers doing business in China. Authorities in Germany and France hold different opinions; the German automotive industry has expressed concern about potential hazards, while the French government is supportive of the investigation in order to safeguard their market and preserve fair trade laws[98].

The scenario could result in collateral damages impacting different European industries that have trade ties with China, highlighting the need - according to Ling et al.[98] - for policymakers to develop favorable circumstances that facilitate the industry's transition beyond the anti-subsidy investigation.

[104] Discussions about tariff-style countermeasures were already ongoing before European Commission President Ursula von der Leyen announced in her recent State of the Union (SOTEU) speech a Commission-led investigation into Chinese electric vehicles in the EU market and their allegedly distorting effects on the industry. The investigation's outcome could determine whether the Union opts to raise tariffs on Chinese EVs, which are currently taxed at just 10 per cent, well below the 27.5 per cent levied by the United States. The debate has intensified since the announcement, and many members of the EU are still undecided.

The challenge posed by China's EVs industry is not merely an economic or technological issue. It represents a clash between the social and political institutions that underpin China's economic achievements and the EU's fundamental liberal principles and values. However, according to the World Politics Review[99], Western governments and companies are woefully late to the green EVs transition, limiting the EU's ability to counter China's competitive advantage[99].

Recently, the EU has aimed to promote EVs autonomy by tackling excessive dependence on imported materials through policy and regulatory proposals, for istance the proposed Critical Raw Materials Act and circularity-oriented policies like the Battery Recycling Regulation, which came into effect in August 2023. Nonetheless, European EVs still struggle to match the robust subsidy programmes and funding in place in China to support the growth of the sector[103].

According to The Diplomat[103], The European Union's response to a possible increase in Chinese electric vehicles reflects concerns about the broader China-EU relationship, including trade dependencies, the definition of a “free market”, and the future of the European industry. The way in which both sides handle this issue will be indicative of the future of China-EU relations.

Apart from foreign policy issues, China will have to address an internal issue, that of production overcapacity.

By 2025, Chinese production will be 3 times greater than that of the rest of the world as a whole. Furthermore, by 2027, production will be almost 4 times higher than domestic demand. With approximately 8 million EVs sales in 2023, China will be selling twice as many EVs as Europe and the US combined.

The issue of production overcapacity raises questions on where China will export EVs, considering the United States’ high tariffs and the fact that already three-quarters of vehicles sold in Soth-East Asia are Chinese.

2.5 The role of the ETS market

Carbon trading is an important institutional arrangement to control greenhouse gas emissions putting a price on them.

Carbon pricing is a powerful tool in the fight against climate change, helping to decouple economic growth and emissions. China has already established the world's largest Emission Trading System (ETS) and its successful implementation will not only drive the country's energy transition and industrial decarbonization but also serve as a role model for other countries in Asia and around the world.

Under an ETS, companies purchase allowances to release a specific amount of pollutants. These allowances can be traded, and, at the end of each compliance cycle (generally every year), companies are expected to surrender allowances equal to their certified emissions. Surplus allowances may be sold, and any shortfall can be covered by purchasing additional allowances. Penalties are imposed on companies that fail to surrender sufficient allowances[109].

The Chinese government has been interested in emissions trading since the late 1990s. In 2005, Chinese companies were enabled to join the Clean Development Mechanism (CDM) for CO2 and other gases.

China became a significant global supplier of CDM credits. In 2011, the country announced plans for a domestic CO2 emissions trading market and began pilot programmes in eight cities and provinces[105]. In 2014, the National Development and Reform Commission (NDRC) issued policies to develop standards for a national carbon trading market. Nevertheless, the launch has been delayed several times. In 2017, NRDC announced a three-phase plan for the National Carbon Market Development, focusing on power generation sector. Further delays were caused by challenges such as data collection and government restructuring[106]. In April 2021, President Xi referred to the ETS in a speech, linking it to China's carbon peaking and neutrality targets[109].

In late 2020, the Ministry of Ecology and Environment (MEE) of China released its power sector allocation plan. As of 2021, China's national ETS has been officially implemented, encompassing the power sector (electricity and power generation), which is responsible for nearly 5Gt of CO2 emissions per year (approximately 45% of China's and 15% of the world's CO2 emissions)[107] [108] [109].

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[105] Zhang, D., Karplus, V. J., Cassisa, C., & Zhang, X. (2014). Emissions trading in China: Progress and prospects. *Energy Policy*, *75*, 9–16. https://doi.org/10.1016/j.enpol.2014.01.022

[106] Honqiao Liu. (2021). In-depth Q&A: Will China's emissions trading scheme help tackle climate change? CarbonBrief.

[107] IEA. (2022). Enhancing China's ETS for Carbon Neutrality: Focus on Power Sector.

[108] Carbon Emission Accounts and Datasets (CEADs) project, IPCC Sectoral Emissions database

[109] Oxford Institute for Energy Studies. (2022). Guide to Chinese Climate Policy, 10: Emissions Trading.

The first annual implementation cycle began on 1 January 2021[110], alongside the MEE's publication of the Interim Rules for Emissions Trading Management in February 2021. These rules defined criteria for major emitting entities, procedures for determining and allocating allowances, verification methods, reporting and information disclosure, and monitoring and penalties for non-compliance. The first compliance cycle included 2,225 “major emitters” entities from the power sector, who were required to report their 2019 and 2020 emissions[109].

The emissions allowances in China's ETS were calculated on the basis of the actual output of coal- and gas-fired power plants, using CO2 emission intensity benchmarks, and represent the right to emit one tonne of CO2. The entities included in the ETS were those with yearly emissions above 26,000 tonnes of CO2 per year[106]. The original 2,225 participants, were selected on the basis of their greenhouse gas emissions from 2013 to 2018[109].

Indicative of China's power fleet, the largest percentage of power plants are coal-fired, with a small number being gas-fired.

Approximately one third of the regulated enterprises in the initial phase of China's ETS were captive power plants. Nearly half of these units served the chemical industry, while the remaining ones provided metals and pulp and paper industries[106]. The ETS would had thus result in a quicker phase-out of these plants due to their smaller size and inferior efficiency[111] [109].

The MEE considered the first compliance cycle a success due to the large compliance rate, estimated at 99.5%. The China Emission Allowance (CEA) has traded between RMB 40 and RMB 60 per tonne of CO2 for most sessions and remained close to RMB 60 per tonne of CO2 in May 2022[109] [112].

The initial allowances covered approximately 4.5 Gt of CO2, making China's ETS the biggest in the world[107] [109]; moreover, the Chinese government has announced plans to expand the ETS to other sectors in the next few years[113]. It is probable that the

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[110] Ministry of Environment and Ecology. (2021). Interim rules for carbon emissions trading management [in Chinese].

[111] IEA. (2020). China’s Emissions Trading Scheme, p.12

[112] China Ministry of Ecology and Environment. (2021). Completion of first compliance cycle of national ETS.

[113] National Center for Climate Change Strategy and International Cooperation. (2023). Administration of China’s ETS.

allocation will be restricted and an absolute cap may be implemented to replace the intensity target, although this is more likely to occur after 2025[109].

However, China's ETS currently adopts intensity-based targets, which measure compliance obligations in terms of emissions per unit of production or electricity generated. While the EU ETS and California's Cap-and-Trade Program hold participating entities responsible for their absolute emissions and set the overall emissions cap several years into the future, China's ETS does not set a cap on total emissions[109].

Nonetheless, the benchmarks for the initial compliance phase have been set higher than the average CO2 emission factor of the coal-fired fleet, so that most power plants will have sufficient allowances to cover their compliance obligations in the first cycle[109].

The ETS aims to improve efficiency in coal-fired plants by penalising outdated and inefficient plants that exceed emission intensity benchmarks. Thermal plants that are more efficient and have surplus allowances can generate revenue by re-selling them on the market. This emissions-based allocation is in line with China's growing energy demand and expanding industrial capacity, and supports its climate intensity target envisaged in the 14th Five-Year Plan (2021-2025)[114] .

According to the National Center for Climate Change Strategy and International Cooperation, the next step of China's ETS is to consistently foster the healthy development of the national carbon emissions trading market. This will be achieved by consolidating the foundation of laws and regulations, strengthening the supervision of data quality, and continuously intensifying the construction of market functions[113].

[114] Qin, Y. (2022). China’s ETS: Performance, Impact, and Evolution. *Oxford Energy Forum (132)*

2.6 The constraint of the current economic situation and growth

The Chinese economy, which has grown relentlessly for four decades, may now be facing some serious problems as it faces an economic slowdown. The property market is struggling, which is having a big impact on consumption.

China's old strategy of boosting growth by spending heavily on infrastructure isn't working as well as it once did. Moreover, imports are falling in many sectors and there's a serious youth unemployment problem that modern China has never had to deal with, and the decline of the population (symbolized by India overcoming China as the most populated country in the world) may forecast a bigger problem of a huge aging population whose retirement costs and welfare will rely on a shrinking workforce.

According to some scholars, President Xi Jinping's prioritization of political control over rapid economic growth may be responsible for the current slowdown in the Chinese economy. While economic growth has historically been prioritised by the Chinese leadership, Xi considers security and technology to be at least as important, if not more so. The Chinese government has shifted its priorities from property and infrastructure to high-tech industries, despite their potentially lower immediate returns. This reallocation of capital aligns with the emphasis on security and indigenous innovation[115].

According to scholars, China's debt problem will continue to hamper the growth of the advanced sectors by diverting resources away from an aggressive industrial policy, but it will not be fatal. Looking to the future, this may result in a slower but more sustainable economic path for China, with an emphasis on technological progress and security rather than rapid growth[115].

Arthur Kreuber provided insights into the future of China's economy during his lecture at Harvard University, highlighting several key points.

1. Not Collapsing, but Facing Structural Issues: China's economy is not on the verge of collapse, but it is facing structural challenges such as debt and persistently low consumption levels. Secondly, despite these hurdles, there are indications of underlying strength[115].

[115] Harvard University. (2023). China’s Economic Growth Is Slowing Down—as Arthur Kroeber Tells It, That Was Always Part of Xi’s Plan.

2. Kroeber discusses the changing outlook for private entrepreneurs. Private entrepreneurs in China may have a different outlook compared to the reform era under Deng Xiaoping due to politics exerting greater influence over economic policymaking. This may lead to a more cautious approach, which could impact innovation and dynamism[115].
3. Continued Technological Success and Trade Surpluses: It is expected that China will continue to maintain its technological advancements and sustain trade surpluses in key industries. To mitigate the risk of following Japan's economic trajectory in the 1990s, it is crucial to emphasize technologies that are essential for the green energy transition. The demand for Chinese manufactured goods in essential sectors is expected to endure[115].
4. Slowing Growth as China Matures: As China becomes wealthier, its economic growth rate is likely to decelerate, similar to the trajectories of South Korea, Singapore, and Taiwan. In contrast to the 'Asian tiger economies', China's economy relies less on exports and more on domestic production and consumption. This could result in a more significant slowdown due to reduced external demand[115].
5. Xi's Emphasis on Technology Leadership and State-led Growth: President Xi Jinping is expected to prioritize technology leadership and drive state-led growth in high-tech sectors, aligning with the Party's emphasis on security and national self-sufficiency in critical technologies. Xi may continue centralising authority to achieve these objectives[115].

Although there is speculation about China's economic slowdown, Kroeber suggests that it may not be as severe as some anticipate. External factors, including US policies and the geopolitical environment leading up to the 2024 presidential election, could negatively impact China's trajectory. Nevertheless, China has demonstrated resilience, dynamism, and adaptability, challenging assertions of an impending collapse[115].

Conclusions

In conclusion, China's dominance in securing resources for the energy transition positions it as a key player in the geopolitics of renewable energy. The control over critical minerals, rare earths, and the manufacturing of high-tech and renewable energy systems puts China at a strategic advantage. The Belt and Road Initiative (BRI) extends China's influence globally, especially in regions like Africa, where it has become a major player in the energy sector.

The 14th Five-Year Plan demonstrates China's dedication to sustainable growth and development, with a significant focus on transitioning to clean energy, reaching peak emissions by 2030, and achieving carbon neutrality by 2060. The swift implementation of renewable energy sources, specifically wind and solar, highlights China's advancements in meeting its ambitious goals. However, there are still concerns about the peak in emissions, and experts suggest that further efforts are needed to align with the goals of the Paris Agreement.

Furthermore, China's investments in Africa's energy sector, although affected by the economic slowdown and the pandemic, indicate its continued involvement in shaping the global energy landscape. The collaboration between China and Africa in the renewable energy sector is seen as a valuable partnership, given Africa's substantial potential in this field.

Despite the progress made in renewable energy, challenges still exist. These include the need for a more intelligent grid system and addressing issues related to coal dependency in some regions. The transition away from coal is crucial for reducing emissions, and careful planning is required to manage the impact on local economies and communities.

Looking ahead to the 15th Five-Year Plan, China is expected to focus on industrial applications of green and low-carbon technologies. The commitment to reducing oil and coal consumption aligns with the global shift towards cleaner energy sources. Nonetheless, in order to achieve a more sustainable and efficient energy sector, essential steps include the modernization of the grid system and the implementation of market-based economic dispatch.

A comprehensive overview of China's energy transition, is provided with a focus on its advantages, policies, and challenges in renewable energy and the electric vehicle (EV) industry. China's ability to quickly approve and construct infrastructure, coupled with its financial capacity and manufacturing prowess, positions it as a global leader in clean technology. Investments in renewable energy not only promote environmental sustainability but also stimulate economic growth, particularly during times of sectoral stagnation.

The discussion then shifts to the electric vehicle industry, where China's dominance is evident in both manufacturing and technology. The rapid growth of Chinese-made EVs presents challenges for Western automakers, with implications for trade dynamics and potential disruptions in traditional automotive hubs. The EU's response, including an investigation into anti-subsidy measures started in September 2023, reflects the complex interplay between economic interests and geopolitical considerations.

Additionally, China's ambitious Emission Trading System is discussed, highlighting its importance in promoting energy transition and industrial decarbonisation. The article portrays the successful implementation of the ETS as a potential model for other countries, demonstrating China's commitment to addressing climate change through market-based mechanisms.

However, the analysis also highlights the economic challenges that China is facing, including struggles in the property market, a shift in growth strategies, and concerns about an aging population. It is suggested that President Xi Jinping's prioritization of political control over rapid economic growth is a factor contributing to the economic slowdown, indicating a strategic shift towards technology and security.

The complexity of China's energy and economic landscape is analysed, depicting a country that is leading the way in green technology but also facing new challenges. In order to achieve sustainable development, China must balance economic priorities, technological innovation, and environmental sustainability; moreover, comprehensive and collaborative approaches are required both domestically and internationally to ensure a sustainable and inclusive energy future.

3.China’s role in the international market

3.1 The impact on the oil and gas market

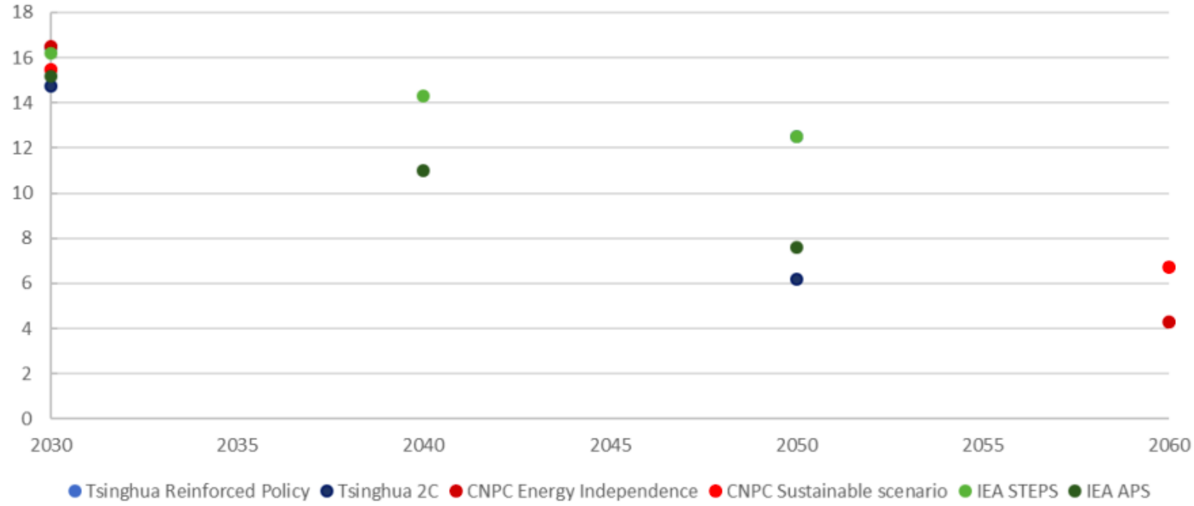
Since China heavily relies on oil and gas imports, the transition towards cleaner energy and the subsequent decrease in fossil fuel consumption could significantly impact the global oil and gas market.

Various scenarios developed by Tsinghua’s ICCSD, CNPC, and IEA predict that China's oil demand will continue to grow over the next decade, with consumption ranging between 14 and 17 million barrels per day (mb/d). Some predict a decline from the current 15 mb/d in 2021. More ambitious mitigation paths lead to demand falling to approximately 10 mb/d in 2040 and 6 mb/d in 2050. By then, the range of outcomes is wider, with the higher demand estimates still assuming that China's oil consumption will be around 12 mb/d[116].

Although most estimates agree that Chinese oil demand will remain flat or increase slightly over the next decade, Chinese oil demand could fall by as little as 2 mb/d or as much as 10 mb/d between 2030 and 2050. Even with lower demand needs, China will continue to import oil due to the expected fall in domestic oil production by 2050[116].

[116] Meidan M. (2023). The Outlook for China’s fossil fuel consumption under the energy transition and its geopolitical implications. *The Oxford Institute for Energy Studies.*

China's oil demand scenarios
Source: ICCSD Tsinghua (2022), CNPC ETRI World Energy Outlook 2060, 2022 edition; IEA (2022b)



The IEA World Energy Outlook 2022 confirms that China will remain the world's largest consumer and importer of oil in all scenarios[116].

Oil trade by region in IEA scenarios
Source: IEA (2022b)

	STEPS						APS			
	Net imports (mb/d)			Share of demand			Net imports (mb/d)		Share of demand	
Net importer in 2021	2021	2030	2050	2021	2030	2050	2030	2050	2030	2050
China	12.3	13.0	10.6	78%	75%	76%	12.2	6.9	75%	82%
European Union	9.7	8.9	5.7	93%	95%	92%	7.6	2.0	95%	93%
Other Asia Pacific	6.4	10.0	13.5	70%	82%	87%	9.3	7.9	83%	87%
Japan and Korea	5.8	5.5	4.1	96%	98%	98%	5.0	2.3	98%	97%
India	4.1	6.2	8.0	87%	89%	92%	5.4	3.8	90%	90%
Other Europe	0.3	0.9	2.2	7%	25%	67%	0.7	0.9	21%	60%

According to Shell's Sky 2050[117], which aims to achieve net zero emissions by 2050 and limit global warming to 1.5°C by the end of the century, China is projected to become a net crude oil exporter by 2050 (Figure 8). Nevertheless, China will continue to be a significant consumer and importer of oil for about two decades[116].

In summary, China is projected to remain the world's largest consumer and importer of oil until 2050, although its future oil requirements may differ depending on

[117] Shell. (2023). The Energy Security Scenarios: Full Report, Shell International Limited.

the scenario. The following discussion will focus on how China perceives and handles the vulnerabilities linked to this dependence, which will be influenced by various domestic and international factors. Despite the size of China's import needs, its oil imports will remain closely linked to the Middle East and the USA. This suggests that the maritime chokepoints of Hormuz and Malacca will continue to be significant[116].

China is already developing naval capabilities and a presence in global ports. Additionally, it is building a merchant fleet to mitigate vulnerabilities associated with US financial sanctions. As China's influence in global governance and energy trading increases, it is uncertain whether China will assume the role of a security provider for global shipping routes, including other commodities besides oil and gas, since China relies on critical materials from various countries[116].

Although China is still susceptible to crude oil supply shocks, it has developed significant downstream capacity, making it almost entirely self-sufficient for oil products. China does import some petroleum products, but its main reliance is on imports of petrochemical feedstocks like naphtha, liquefied petroleum gas and ethane. Currently, China's refining capacity is second only to that of the USA, and as the country continues to build new refineries, it is facing a surplus of oil products and petrochemicals. Consequently, China is expected to remain a significant player in the refined oil product markets, with most forecasts predicting that it will continue to be the world's second-largest refiner[116].

Beijing's current policies aim to restrict new refining additions and gradually decrease product exports, instead prioritising chemical and petrochemical production to meet domestic demands. If China were to reverse its current policies and continue or even increase its exports of oil products and/or chemicals, it would directly compete with Saudi Arabia and India, both of which are expanding their global exports of these products. Additionally, as African countries are expected to consume more oil products, Chinese exports may be shipped further afield than their current export markets, which mainly consist of Asian buyers. If China were to emerge as a crude oil or product and chemicals exporter, it would still remain a large importer of crude oil while also exporting products and petrochemicals to new markets. This could potentially alter the direction of oil and oil product flow, as well as its exposure to global oil and product markets.

Even though oil trade routes may change, China's dependence on maritime trade routes for critical materials, food, and grain imports will persist. Therefore, concerns about maritime security are unlikely to diminish[116].

As China's power and global presence continue to grow, its perception of vulnerability is likely to change. In light of the Russian invasion of Ukraine and subsequent sanctions, as well as financial restrictions on trade with Iran and Venezuela, Beijing is taking steps to reduce the potential impact of sanctions through various market and diplomatic measures[116]. However, it is uncertain how successful China's attempts to make its economy immune to sanctions will be, and whether they will alleviate its feeling of vulnerability. China's evaluation of its strategic vulnerabilities will depend on perceptions both within and outside of China. China has already built up significant crude oil forward cover, giving it the ability to ration supplies domestically and substitute fuels in the event of an outage or sharp price spike, suggesting that Beijing has tools to mitigate the economic impact[118].

Therefore, while a protracted oil supply outage would have a negative impact on the Chinese economy, it is unlikely to cripple it[116].

Regarding gas, China's gas demand is projected to increase from 366 Bcm in 2022 to between 550 and 620 Bcm in 2030 (Figure 14) and peak in 2040, although at different levels, according to various scenarios, including CNPC and ETRI (2022), ICCSD Tsinghua (2022), IEA (2022a), and Fulwood (2021). However, by 2050, the difference between scenarios is approximately 300 Bcm. The share of gas in China's energy mix is unlikely to exceed 15% in any of these scenarios[116]. The IEA's World Energy Outlook 2022 is conservative in its estimation of China's future gas demand; it predicts that the demand will peak at around 440 Bcm in 2030. At the same time, with Chinese domestic production expected to peak at around 300 bcm in the mid-2030s, China will become increasingly dependent on imports by 2050, and the majority of the increase in LNG imports is expected to come from the USA and Qatar. Additionally, Australian LNG outflows are also expected to decline post-2030[116]. Restrictions on Russia's access to

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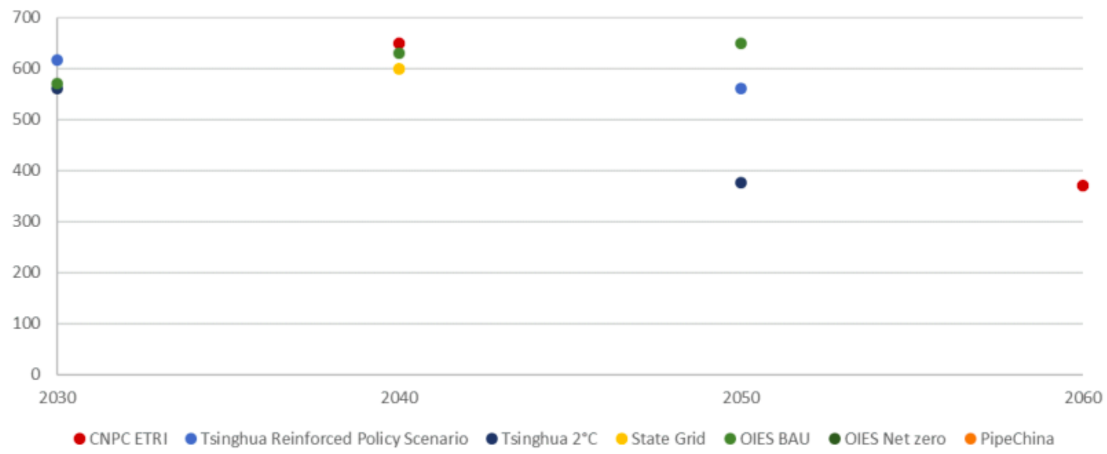
[118] Collins, Gabriel. (2018). A Maritime Oil Blockade Against China—Tactically Tempting but Strategically Flawed. *Naval War College Review*, 71(2), Article 6. https://digital-commons.usnwc.edu/nwc-review/vol71/iss2/6

Western technology and funding are expected to constrain Russian LNG exports until 2030. The limits on new LNG projects in Russia will also impact the volumes available to China. However, China still stands to benefit from Russia's growing isolation. Chinese companies could gain new contracts in the Russian energy sector and will continue to import available Russian LNG[116].

Estimates of China’s future gas demand, Bcm
Source: CNPC ETRI (2022); ICCSD Tsinghua (2022); State Grid Energy Research Institute; OIES research



Although China aims to diversify its import sources, it will still heavily rely on a limited number of gas exporters. The majority of its LNG supplies will come from Australia, Qatar, the USA, and Russia. Additionally, as abovementioned, China and Russia started negotiations for another pipeline deal (Power of Siberia 2) – currently in a standstill -which, if concluded, will result in Russia and Turkmenistan dominating pipeline flows[116]. If the China-Russia Power of Siberia 2 deal is agreed, pipeline imports from Russia alone will exceed 100 bcm in 2030; depending on the demand outlook and the amount of LNG flowing from Russia to China, Russia could represent about a third of China's total imports. Failure to reach a pipeline supply deal would likely result in higher dependence on LNG. Geopolitics is not the only factor that determines Chinese companies' supply deals. Although they are aware of government goals and strategies, and the risk of sanctions, their contracts are also influenced by commercial considerations. For example, in 2021 and 2022, Chinese buyers signed over 20 million tonnes of new LNG supply contracts with US sellers[116].

The future of China's gas demand is uncertain, since its consumption will grow, but its growth speed and scope will be driven by policies and prices. However, all scenarios indicate that China will continue to be a major global importer, despite gas will still account for a small portion of its primary energy consumption.

In summary, China's significance in the global gas market may overshadow its importance in domestic energy use. A gas outage could have a significant impact on the Chinese economy, particularly on industrial users. However, the availability of coal could partially offset this impact and limit any severe damage to China's economic activity. It is worth noting that gas is considered a transitional source due to its lower level of emissions, which could make it more attractive compared to coal's affordability[116].

At present, approximately half of China's gas supplies are expected to come from domestic production, with the remainder being made up of pipeline flows and seaborne LNG. Despite attempts to diversify land-based and seaborne flows, as well as efforts to increase gas stocks, China's perception of its gas security (or insecurity) will be influenced by both market dynamics and subjective perceptions. This will also have implications for the geopolitics of oil and gas[116].

3.2 Rare earths and critical minerals

Clean energy technologies require more minerals to be developed confronted with traditional fossil-fueled counterparts.

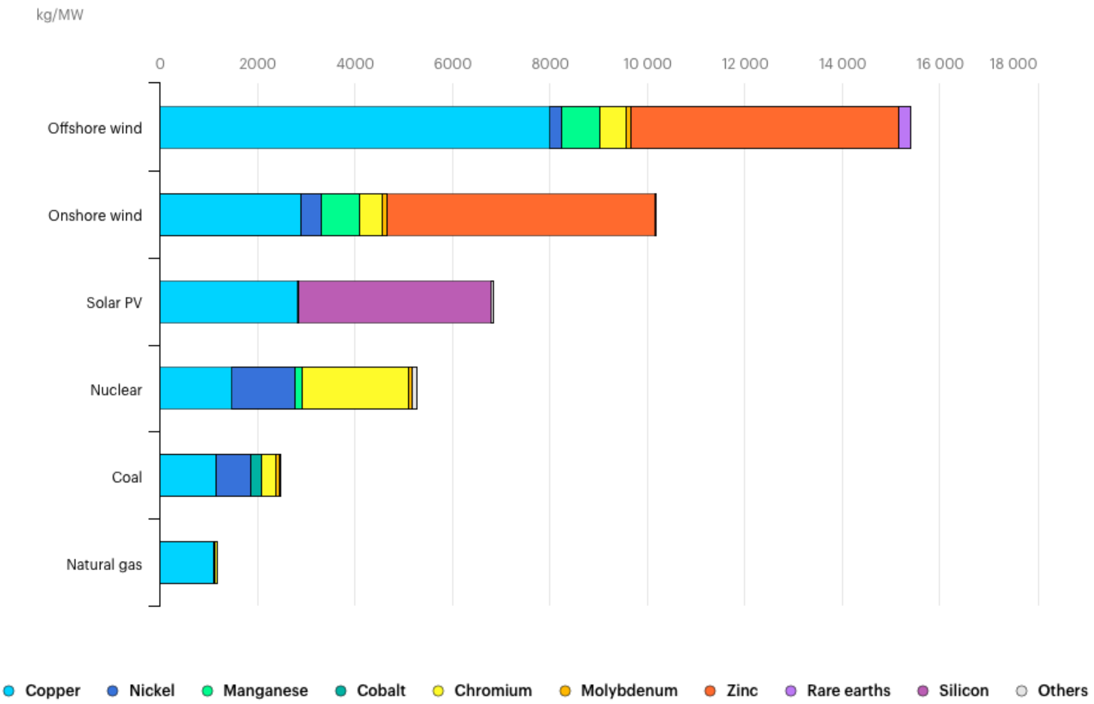
The use of the terms "strategic" and "critical" to describe non-fuel minerals in the industrial era dates back to 1939, when the US passed the Strategic and Critical Mineral Stockpiling Act in response to the start of World War Two. These minerals were identified based on their importance to the military and the wider economy. In 1979, the Department of the Interior published a list of 35 minerals and mineral groups considered critical. However, most of the pre-existing mineral stockpile had already been sold to private businesses by this time. In 2014, the European Commission began publishing lists of critical minerals, which were updated in 2020 to include 30 minerals. In the context of the low-carbon energy transition, the International Energy Agency published a study in 2021 that demonstrated the criticality of 12 minerals and mineral groups[120].

Since 2010, the average amount of minerals required for a new unit of power generation capacity has increased by 50%. This is due to the increasing share of renewables in new investments. The types of mineral resources used vary depending on the technology. Lithium, nickel, cobalt, manganese, and graphite are crucial for battery performance, longevity, and energy density. Rare earth elements are indispensable for permanent magnets, which are essential for wind turbines and electric motors. Electricity networks require significant amounts of copper and aluminium, with copper being a fundamental component of all electricity-related technologies[119].

Therefore, shifting to a clean energy system will create a huge rise in in the requirements for these minerals, that already now represent a huge segment of demand.

Minerals used in clean energy technologies compared to other power generation sources

Source: IEA



In a scenario that meets the Paris Agreement goals, such as the IEA Sustainable Development Scenario (SDS), the share of total demand for copper and rare earth elements rises significantly over the next two decades to over 40% of the global demand, while for nickel and cobalt it rises to 60-70%, and for lithium it rises to almost 90%. Electric vehicles (EVs) and battery storage have already displaced consumer electronics as the largest consumer of lithium and are expected to surpass stainless steel as the largest end user of nickel by 2040[119].

[119] IEA. (2021). The Role of Critical Minerals in Clean Energy Transitions.

Minerals present different challenges from fossil fuels, but their growing importance in a decarbonising energy system requires energy policymakers to broaden their horizons and consider potential new vulnerabilities[119].

According to IEA, the energy transition may face challenges that lead to market tightness and price volatility for critical minerals. These risks are contributed to by factors such as:

(i) High geographical concentration of production. For lithium, cobalt, and rare earth elements, more than three-quarters of global output is controlled by the top three producing nations in the world. In 2019, the Democratic Republic of Congo (DRC) and China were responsible for approximately 70% and 60% of global cobalt and rare earth element production, respectively. Moreover, China has a dominant presence in the processing sector, where concentration is even higher. For instance, China accounts for approximately 35% of nickel refining, 50-70% of lithium and cobalt refining, and almost 90% of rare earth element refining. Additionally, Chinese companies have made substantial investments in refining assets overseas, including in Australia, Chile, the DRC, and Indonesia. High levels of concentration, combined with complex supply chains, increase the risk of physical disruption, trade restrictions, or other developments in major producing countries[119].

(ii) The extended duration of project development, averaging 16.5 years, raises concerns about the supply's ability to increase output quickly in response to a sudden increase in demand[119].

(iii) Additionally, the decrease in resource quality, particularly in ore grades, increases pressure on production costs, emissions, and waste volumes[119].

(iv) Growing focus on environmental and social performance requires sustainable and responsible sourcing of minerals to meet consumer and investor demands[119].

(v) Mining assets are more exposed to climate risks, such as water stress for copper and lithium production. It is crucial to manage these risks to ensure the reliability, affordability, and sustainability of mineral supply in the context of clean energy transitions[119].

The response of policy makers and companies will determine whether critical minerals are a vital enabler for clean energy transitions or a constraint in the process.

China's significant role in numerous mineral supply chains gained widespread attention in 2009 when the government imposed export controls[120].

Since then, China has progressively expanded its presence in the supply chains of various non-fuel minerals. These minerals are crucial to the low-carbon energy transition as they are used in the production of electric vehicles, wind turbines, solar panels, and other devices. Some minerals are also required by the defence industry. The urgency and required scale of the energy system transformation have drawn the attention of policymakers around the world to projections of future demand for key minerals. China's strong presence in these supply chains is seen as a key threat, and industrialised governments have begun taking steps to reduce their dependence[120].

The Oxford Institute for Energy Studies analysed China's position in the upstream sections of the supply chains for the 12 minerals and mineral groups identified by the IEA, as well as the metal tellurium, which is a component of cadmium-tellurium photovoltaic (PV) cells. China refines over 50% of the global supply of tellurium[120].

The paper highlights that China's strong position in these supply chains is not due to abundant geological reserves. Out of the 13 minerals presented in the table below, China holds a significant share of global geological reserves for only two: rare earths and molybdenum. Moreover, China is currently the sole major producer of heavy rare earths, which are highly sought after for permanent magnets. Accumulations of heavy rare earths in high concentrations are relatively uncommon and typically found in weathered surface materials, such as clays, which are abundant in southern China. In contrast, rare earth accumulations in hard rocks are typically abundant in light rare earths[121] but deficient in heavy rare earths[120].

[120] Andrews-Speed, P. (2023). Critical Minerals For The Low-Carbon Energy Transition: Why China Matters. *The Oxford Institute for Energy Studies,* pp. 10-14.

[121] According to the Massachusetts Institute of Technology, Rare Earths include two groups: the "light" REEs (LREEs) such as lanthanum, cerium, praseodymium, neodymium, samarium, europium, and the "heavy" REEs (HREEs) gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, scandium and yttrium. The chemical behaviour of the two groups is responsible for the differences between them, which in turn affects their usage. The heavy rare earth elements are crucial for various critical defence and energy applications, but they are less abundant than the light rare earth elements.

China's proven geological reserves and output from mines and processing plants as shares of global totals in selected supply chains. Data from different years 2020-2022. All numbers are approximate.

Source: IEA, The Oxford Institute for Energy Studies

	Technology	Reserves	Mine output	Processing and refining output	Mining interests overseas
Rare earths	Wind, EV	34%	70%	90%	
Molybdenum	Wind	31%	40%	?	
Silicon	PV		68%	69%	
Graphite	EV	16%	65%	100%[a]	
Zinc	Wind	15%	32%	46%	Australia
Manganese	EV, wind	16%	5%	95%	Gabon
Cobalt	EV	2%	1%	73%	DRC
Lithium	EV	7%	15%	55%	Australia, Latin America
Tellurium[b]	PV	9%		53%	
Copper	EV, wind, PV, networks	3%	8%	42%	DRC, Zambia
Nickel	EV, hydrogen, geothermal	2%	3%	35%	Indonesia
Chromium	CSP, geothermal	Negligible	Negligible	? (large)	Zimbabwe
Platinum group	Hydrogen	Negligible	Negligible	? (small)	South Africa, Zimbabwe

China's geological reserves for all other minerals in the table are either modest, accounting for around 15% of the global total, or less than 10%.

Although China's geological reserves are relatively modest for most of the critical minerals discussed, it has established a disproportionately strong position in terms of the annual output of its mines and processing plants. China is a global leader in several minerals in these parts of the supply chain, particularly rare earths. Although China only hosts 34% of the world's identified geological reserves of rare earths, it accounts for approximately 70% of annual mine output and 90% of processing and refining to produce rare earth metals. Most companies that mine rare earths in other countries send their ores to China for processing (with the exception of Lynas, which has built a processing plant in Malaysia for rare earth ores from its Mount Weld mine in Australia. Elsewhere, there is a small refinery in Estonia and a rare earth recycling plant in France)[120].

China's dominance in rare earth mining and processing was attained through a combination of early entry into the industry, government investment throughout the supply chain including R&D, export controls, low labour costs, and decades of weak environmental and safety regulation and illegal mining and processing.

Aside from rare earths, China has a significant share of global annual mined production for only four minerals: silicon, graphite, molybdenum and zinc. The country's share of global processed silicon is roughly proportional to its mine production. In contrast, China is responsible for 100% of the world's output of spherical graphite, which is used in battery anodes. China's share of the world's zinc supply is also much bigger than its share of global mine production[120].

For seven minerals, China's geological reserves and mine production account for only a modest or small share of the world total. However, the country has become a dominant or major player in processing and refining these minerals, with production ranging from 95% for manganese to 35% for nickel. The government's Go Out policy, which began in 1999 and encouraged state-owned enterprises (SOEs) in various industries to invest overseas, has contributed to their strong position in processing and refining. The aim of the policy was to develop SOEs into major international players and, in the case of the natural resource industries, to secure access to raw materials in support of the country's economic growth[120].

Examples of China significant overseas mining interests encompass copper and cobalt in the Democratic Republic of the Congo and Zambia, lithium in Australia and Latin America, nickel in Indonesia, manganese in Gabon, zinc in Australia, platinum in South Africa, and chromium in Zimbabwe. These minerals are often processed and refined in China, taking advantage of low labor and energy costs. Notably, platinum group metals like platinum and palladium, for which South Africa holds 90% of global geological reserves, are an exception. Despite China's small reserves and mine production, it compensates by importing large quantities, particularly platinum, contributing to a global deficit. China now holds approximately 85% of the world's platinum stocks, a significant increase from less than 5% four years ago[120].

The deteriorating relations with China and the increasing demand for minerals critical to the low-carbon transition have prompted industrialized countries to take measures to reduce their dependence on China for these minerals. These measures include imposing import restrictions, incentivizing domestic investment and production, stockpiling, and building partnerships with other countries. Research and development to identify alternatives to currently used minerals, enhance their efficiency of use, and expand recycling is a top priority.

The United States is currently the most active country in addressing supply chain vulnerabilities, particularly in critical minerals and rare earths. In February 2021, President Biden signed an Executive Order on Supply Chains, followed by a bipartisan bill that blocks US defense contractors from purchasing Chinese rare earths[120].

Substantial investments, exceeding US$100 million by the Department of Defense, and a Rare Earth Demonstration Facility worth US$156 million issued by the Department of Energy, highlight efforts to bolster the resilience of the rare earth supply chain. The Inflation Reduction Act of 2022 incorporates policy instruments such as a 10% tax credit and up to US$40 million in loan guarantees for critical materials projects. President Biden directed up to US$500 million in economic incentives, emphasizing battery materials under the Defense Production Act, with set targets and restrictions on foreign entities[120].

In 2023, the EU published a draft Critical Raw Materials Act that sets targets for 2030. These targets specify benchmarks of 10%, 40%, and 15% for the amount of mineral extraction, processing, and recycling – respectively - that should be based in the EU[120]. The law also sets a threshold of 65% for the maximum amount of annual consumption at any stage of extraction or processing that can be sourced from a single third country. It calls for the coordination of strategic raw material stocks among member nations, the monitoring of critical raw material supply chains, and the auditing and stress testing of key raw material supply chains for major companies[120].

Recognising the need for international cooperation, in June 2022 the US initiated the Minerals Security Partnership to strengthen critical minerals supply chains essential to the clean energy transition and fostering cooperation with countries such as Australia, Canada, Finland, France, Japan, the Republic of Korea, Norway, Sweden, the United Kingdom, the United States, and the European Union, as well as mineral-rich countries such as Argentina, Brazil, the Democratic Republic of the Congo, Mongolia, Mozambique, Namibia, Tanzania, and Zambia were also present[120].

To reduce dependence on China, two noteworthy trends involve developing alternatives like sodium-ion batteries and rare-earth-free permanent magnets and supporting domestic production of renewable energy equipment and electric vehicles in the US and Europe, aiming to boost metal ore processing and refining capacity[120].

Taken together, these actions represent a possible shift in global strategies aimed at countering China's control over the extraction and refinement of essential minerals. However, the impact is likely to be limited until 2030 due to the length of time required to establish new mines and processing facilities and to implement new technological advances, particularly due to environmental and social concerns. Beyond 2030, these policies - and any additional ones - are likely to begin to significantly weaken China's position, provided that they are sustained[120].

3.3 The renewable systems components industry

China has become a prominent player in technology manufacturing due to its long-term industrial strategy, which has resulted in significant investment in clean energy supply chains. These achievements are also the result of consistent policy signals for domestic clean technology deployment in successive Five-Year Plans.

China's 14th Five-Year Plan, launched in 2021, prosecuted the support of the clean technology manufacturing industry, contributing to the overarching goal of achieving a peak in CO2 emissions before 2030. Indeed, China has now become the world's largest manufacturer of clean energy technologies and their components, thanks to over a decade of policy support, and it is expected to maintain and even expand this position in the coming years[122].

Investment in clean energy supply chains has helped to reduce the costs of clean energy technologies not only in China but also globally. Additionally, China has become the leading exporter of several clean energy technologies[122].

According to IEA[122], in 2022, three countries accounted for nearly 90% of installed capacity for manufacturing solar PV modules, with China alone accounting for 80%. It is worth noting that some individual plants in China are country-sized with respect to their rated production capacity. The LONGi plant in Taizhou, China, is currently the largest operating plant in the world; it has the capacity to supply half of the solar PV modules added to the European Union in 2022, which totalled 38 GW. Vietnam and India are the next two largest countries in terms of installed manufacturing capacity, accounting for 5% and 3% of all capacity, respectively. However, the largest plants in these countries

[122] IEA. (2023). The State of Clean Technology Manufacturing.

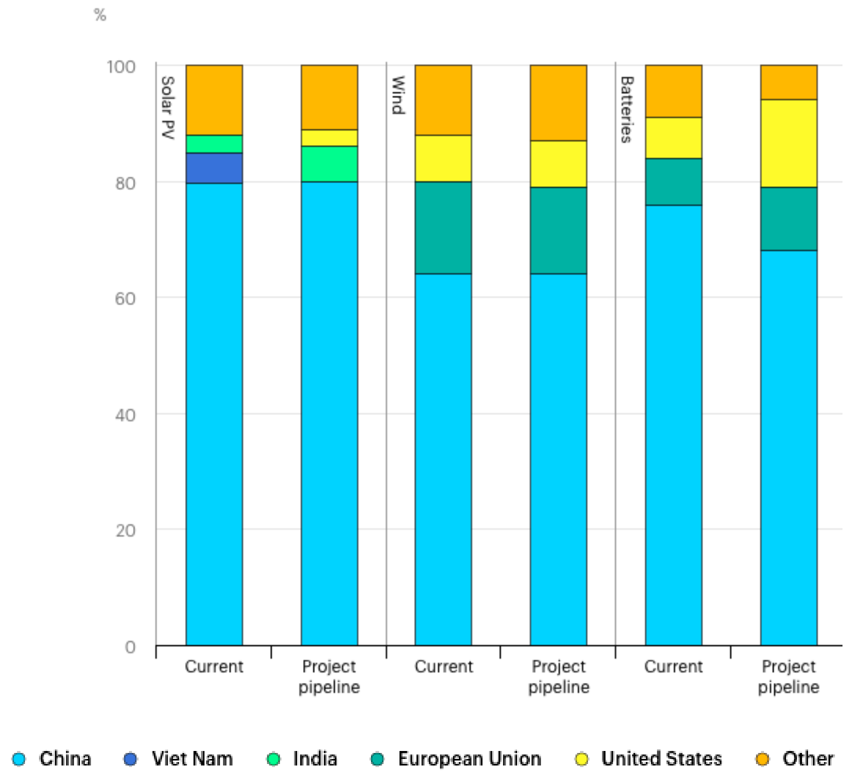
are much smaller than those in China, with an annual production capacity of around 7-8 GW[122]. If all announced projects are completed, the concentration among the top three producers will remain at the current level of 90%. India, currently the third largest producer, and the United States will surpass Viet Nam, which is currently the second largest producer by installed capacity. China's share will remain at around 80%[122].

Moreover, according to IEA data, in 2022 China, the European Union, and the United States accounted for more than 90% of the global installed battery manufacturing capacity, with China alone accounting for 75%. Korea also has a significant share of installed manufacturing capacity, representing 5% of the global total[122]. If all planned battery manufacturing projects are completed, the supply concentration will remain relatively stable, with China, the United States, and the European Union accounting for approximately 95% of the total.

Furthermore, IEA stated that in 2022 the manufacturing of onshore wind nacelles was also highly concentrated. Indeed, China had over 60% of the global manufacturing capacity, followed by the European Union (just below 15%) and the United States (10%). If all the planned projects for additional capacity were to be completed, the shares would not change significantly by 2030. The regional concentration also varies for different equipment, such as towers, blades, and offshore-specific components. It is estimated that for onshore equipment overall, the announced projects would lead to China accounting for 55-65% of global manufacturing capacity by 2030, and up to 70-80% for offshore equipment[122].

Source: IEA

Current and projected geographical concentration for manufacturing operations for key clean energy technologies, 2022-2030



Moreover, China is expected to capture around 65% of the global clean technology manufacturing capacity output in 2030, which amounts to $500 billion worth. This includes both existing and announced projects. If China's domestic deployment of key clean technologies does not exceed the levels projected in the APS, more than two-thirds of this output will be surplus to domestic requirements and will need to find export markets[122].

According to an analysis[123] carried out by the Center for Strategic and International Studies, China, which currently is the largest producer of climate technologies, is expected to continue leading the planned expansion of manufacturing key

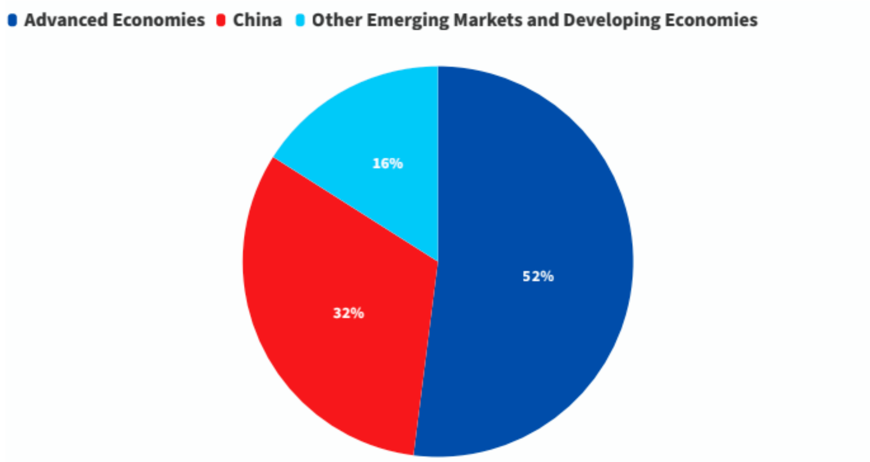
[123]Mazzocco, I. (2023). Balancing Act: Managing European Dependencies on China for Climate Technologies. *Center for Strategic & International Studies.*

technologies such as batteries, solar PV, and wind turbines, despite continued efforts by other countries to build alternative supply chains.

China dominates the production of clean energy technologies, with two-thirds of lithium-ion batteries and 80 percent of solar photovoltaic module capacity being manufactured in the country. Additionally, Chinese firms mine or refine a large share of the key minerals used for these technologies, including rare earths, lithium, and graphite. This is due in part to the high domestic demand for these products: indeed, China has the largest wind installations by generation capacity, and in 2022, about 60% of all electric vehicles sold globally were sold in China.

Clean Energy spending in selected regions in 2022

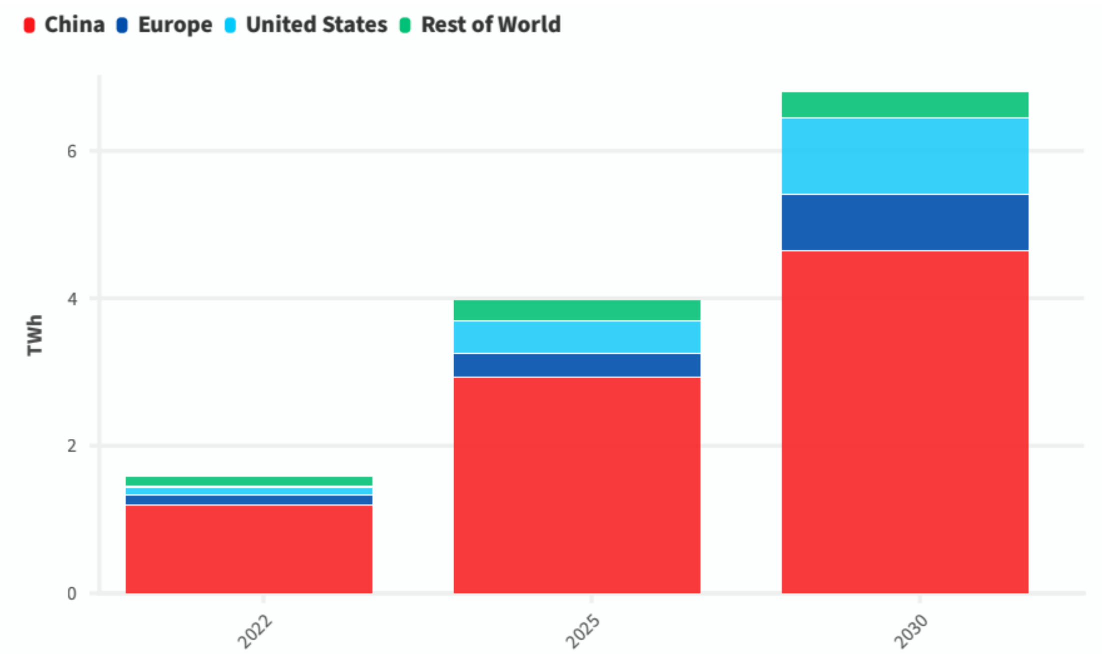
Source: CSIS based on IEA *World Energy Investment 2023* data



In 2022, approximately one-third of global clean energy spending occurred within China. Concerns have been raised in various capitals over the implications of Beijing's climate technology leadership, as Chinese companies or firms producing in China are increasingly supplying these technologies to the rest of the world[123].

Lithium-Ion Battery Manufacturing Capacity (2022-2030)

Source: CSIS based on IEA World Energy Investment 2023 data



As abovementioned, China did not become a climate technology giant overnight. The current supply chain layout is the result of long-standing global market trends, explicit government policies to promote manufacturing and strategic industries, international cooperation and integrated supply chains, and entrepreneurship. Additionally, government policies aimed at attracting domestic and foreign investment in targeted industries have created highly competitive environments. China's manufacturing advantage is not solely due to subsidies, although they have played a significant role. Therefore, reproducing alternative supply chains can be difficult, and matching subsidies or tariffs alone has generally been inadequate in creating similar conditions elsewhere[123]. The importance of globalised value chains in the development of these technologies should also serve as a reminder of the challenges of pursuing policies explicitly designed to create redundancies in supply chains. In many cases, this process raises costs. For instance, according to some studies, solar PV manufacturers in Europe faced a 20-25% disadvantage in 2022 compared to the lowest global cost levels due to high energy, capital, material, utility, and labor costs, even if they achieved economies of scale[123]. Based on the current objectives of the REPowerEU plan, it is estimated that producing all solar panels within the European Union would cost an additional $36 billion.

Multinational companies depend on China for inputs and components, especially in the refining of critical materials[123].

However, what is often overlooked is China's growing importance in the innovation systems of numerous international corporations. According to interviews with companies and business associations, many depend on the Chinese market not only for product commercialization but also for research and development[123]. Scientific collaboration is also a key factor in innovation, and Chinese universities are increasingly engaging in productive exchanges with research institutions and scholars worldwide, including those in Europe. In certain instances, European companies, such as Volkswagen, have invested in or formed joint ventures with promising Chinese companies. This adds complexity to identifying a firm's nationality[123]. These trends highlight the challenge faced by European governments and the European Commission as they plan for the future. Considering China's significant role in climate technology supply chains and the increasing global presence of Chinese companies, it is crucial to comprehensively examine the role of these companies as they expand and invest in Europe and other regions. To mitigate risks associated with climate technologies, it is important to identify and address these risks in a derisking policy. This requires clear identification of the risks that need to be addressed[123].

Furthermore, the CSIS analysis raises concerns about China's significant influence in the climate technology sector, as stated in the European Economic Security Strategy of June 2023. These concerns encompass security issues related to dependence on a single source and economic concerns about manufacturing competitiveness[123].

The discussion highlights the potential risks of relying on a single source for critical minerals and manufactured goods, particularly if the producing country is an economic competitor or systemic rival like China. This exposes European importers to price surges, shortages, and potential export bans[123]. Concerns have been raised about China's expanded export license requirements for key materials such as gallium, germanium, and graphite, which could lead to the weaponization of critical materials for clean energy technologies.

Nevertheless, although the likelihood of weaponising climate technologies is considered low, countries may be hindered from enacting punitive policies due to high dependencies on key goods. The article highlights economic risks, including threats to domestic employment, with a focus on Europe's concerns over deindustrialisation and lack of competitiveness, which are exacerbated by high energy costs[123].

The importance of retaining economic benefits from decarbonisation investments is emphasised to ensure continued taxpayer support. To address shocks to legacy industries and job losses resulting from economic adjustments, policymakers are advised. It is crucial to distinguish between security and economic concerns when determining policy actions, particularly in managing exposure to Chinese supply chains[123].

The text outlines three trends in the Chinese industrial landscape: scaling up existing capacity, reinvestment in research and development, and supply chain diversification through internationalization[123]. The expansion of Chinese firms in solar, electric vehicle, and battery production outside of China, particularly in Europe, is also discussed. The globalization of Chinese manufacturing[124] is viewed as having the potential to bring global benefits. This is due to the alignment with high environmental and labor standards in the EU, as well as contributing to local economies. Additionally, there are opportunities for developing countries to attract Chinese investment in climate technology manufacturing[123].

3.4 Relevance of International Relations: USA

The United States and China are competing in the global energy transition, striving for economic advantages and industrial dominance in clean energy technologies. Both nations have made significant investments in renewables, nuclear, carbon capture, and hydrogen; in terms of manufacturing and innovation, China is currently at the forefront of global capacity expansion in key sectors such as solar PV, batteries, onshore wind turbines and electrolysers, while the US has a much smaller share in these sectors[125]. Moreover, China dominates the global supply chains for minerals that are essential for the energy transition, especially in the processing segment. Although the extraction of various energy transition minerals is solid in several countries - including Australia, Chile and Indonesia - China's share of global processing amounts to two-thirds for lithium and

[124] Mazzocco I. (2023). Chinese Manufacturing in Clean Tech.*University of California Institute on Global Conflict and Cooperation*.
[125] Nakano J. (2023). Us–China Relations and the Global Energy Transition. *The Oxford Institute for Energy Studies.*

one-third for nickel[125]. China currently dominates global rare earths mining with around 60% of the market share, but its dominance in processing is even greater, accounting for almost 90% of global processing. This presents vulnerabilities for the US, which relies on imports to meet over 50% of its consumption for 47 minerals, including 100% for 17 of them on a net-import basis. China is the major source of imports for 26 of the 50 minerals classified as critical by the US Geological Survey[125].

In terms of innovation, China is emerging as a global leader, as evidenced by its patent filing trends. Chinese entities hold patents for core solar PV technologies, and their patent applications in emerging technologies like hydrogen have shown considerable growth. In the last decade, China's patent applications grew at approximately 15.2% annually, in contrast with a decrease in US patent filings in the same period[125].

To address the competitiveness gap, the US has enacted major legislation such as the Infrastructure Investment and Jobs Act (2021) and the Inflation Reduction Act (2022), which provide significant funding for clean energy supply chains, hydrogen programmes, research and development, and tax credits to encourage domestic production of clean energy components and critical minerals. Furthermore, the IRA Clean Vehicle Credit aims to broaden the supply chains of electric vehicles (EVs) in the US by imposing sourcing requirements for crucial minerals and battery components[125].

Bilateral relations between the United States and China in clean energy development demonstrate both collaboration and competition. In sectors such as carbon capture, utilization, and storage (CCUS), collaboration is ongoing. The United States is bringing its expertise to China, which is home to around 100 CCUS demonstration projects. U.S. companies such as Chevron and ExxonMobil are working with Chinese counterparts on the evaluation and advancement of large-scale CCUS projects in order to further their technological expertise through testing and demonstration opportunities in China[125].

The automotive industry provides another example of collaboration, notably in the electric vehicle market. China, which is the largest global market for EVs, is also the primary source of competitively priced EV batteries, including those used by American automakers. For instance, Tesla's EV factory in Shanghai, which sources EV batteries from China's Contemporary Amperex Technology Co., Limited (CATL), has become its largest export hub, providing cars to markets beyond North America. In 2022, the

Shanghai factory delivered more than 710,000 vehicles, representing over half of Tesla's global deliveries that year. Additionally, CATL has shown interest in joining the US EV value chains[125].

Bilateral trade in liquefied natural gas remains robust, with China emerging as the world's leading LNG importer in 2021. It is worth noting that Chinese buyers have signed several long-term LNG contracts with US sellers since 2021. However, the competition for energy transition is becoming zero-sum due to growing concerns about China. Specifically, the supply chains for critical minerals have become a focal point, with the US aiming to diversify sources and stakeholders to ensure the security of the global energy transition[125].

The prioritisation of expanding global supply chains and diversifying stakeholders to secure the global energy transition is a key focus for US policymakers. It is viewed as crucial to shift away from domestic supply chains that rely on China, especially given the establishment of the state-owned China Rare Earth Group and the introduction of an export-control law that impacts rare-earth supplies. China is regarded as a source of various challenges for the US, with its models of industrialisation and state capitalism disrupting the level playing field for private enterprise that is integral to US economic leadership[125].

As the US faces a competitor guided by industrial policies, it is reassessing the role of government in its economy. The Biden administration recognises the importance of an industrial strategy, acknowledging the development of clean energy technology as a significant growth opportunity. There is increasing support in Washington, even among conservatives, for government involvement in revitalising US industrial competitiveness.

Bilateral cooperation on clean energy faces challenges due to restrictions that prevent China from benefiting from subsidies under the Infrastructure Investment and Jobs Act and the Inflation Reduction Act. The IRA Clean Vehicle Tax Credit program, which limits benefits if components or critical minerals are sourced from a “foreign entity of concern”, including China, exemplifies this. This stance, influenced by concerns about China's dominance in EV battery components, could potentially slow US domestic EV deployment[125].

According to the paper[125], China's emergence as a leader in the clean energy sector is seen as being driven by economic opportunity and a commitment to decarbonisation.

However, recent pushback against Chinese participation in US green industrialisation may lead to China prioritising maintaining a competitive edge over the US in future investments. Since the IRA's passage, China stated that it is considering adding advanced solar wafer production methods to its export control list and nationalising advanced mineral equipment[125].

Distrust and fear between the two nations could affect major initiatives, but they could also cloud judgement. Rather than focusing on a zero-sum competition, a more meaningful question is whether the US and China can utilise their economic opportunities and industrial strengths in the ongoing energy transition. The answer holds significant consequences for both populations and global decarbonisation efforts[125].

3.5 Relevance of International Relations: BRICS

Since January 2024, the BRICS group of emerging market economies (Brazil, Russia, India, China, and South Africa) has expanded to include five new member countries: Egypt, Ethiopia, Iran, Saudi Arabia, and the United Arab Emirates. The group now represents 28.1% of global output in terms of GDP. However, this is still significantly less than the 43.2% of global GDP accounted for by the G7 economies, but the group is on a fast-growing trajectory[126].

Upon examining the "new" BRICS in relation to energy and energy transition, it is evident that the expanded group now accounts for over 43% of global oil production, which has doubled its capacity and enhanced its geostrategic reach into the Middle East through the admission of Saudi Arabia, Iran, and the UAE. Furthermore, the expanded group now represents 25% of global exports, while the original four BRIC members control and account for 72.5% of global reserves of rare earth minerals. China alone produced 85% of all globally refined rare earths in 2020[126].

The expansion of the BRICS group, and the presence of three major energy players in the Middle East (Iran, Saudi Arabia, and UAE) fulfils a long-term goal of China's foreign policy. In 2016, the Chinese government published an "Arab Policy Paper" outlining its vision for cooperation with the Arab world. The paper presents a

[126] Geopolitical Monitor. (2024). Will BRICS Expansion Finally End Western Economic and Geopolitical Dominance?

"1+2+3" cooperation framework that primarily focuses on energy cooperation, backed by improved infrastructure and trade, and identifies new areas of cooperation, including space, nuclear energy and renewable energy[127].

The Middle East is critical to China's energy security, supplying more than half of its oil imports, according to the Observatory of Economic Complexity's 2021 figures. In the same year, Iraq received the highest amount of Belt and Road Initiative (BRI) projects worldwide, with approximately US$10.5 billion in Chinese loans and investments deployed into oil and gas projects. However, China has added fintech, e-commerce and smart city solutions to the scope of its BRI-related projects in the region under the Digital Silk Road[127].

Moreover, securing long-term oil exports to China is a strategic imperative for Saudi Arabia and the UAE, as China is respectively their largest and second-largest oil market in 2021. According to OPEC, China is expected to remain a long-term growth market for oil despite the global transition to renewable energy sources. To secure Chinese demand for their oil and outcompete their rivals, Saudi Arabia and the UAE are investing billions of dollars in Chinese oil refineries and petrochemical industries. They are also negotiating long-term contracts to supply Chinese companies with oil. In addition to energy, Saudi Arabia and the UAE consider China to be an appealing partner in their efforts to achieve economic diversification. Saudi Arabia has emphasized the compatibility of Saudi Vision 2030 with China's Belt and Road Initiative; moreover, the country has formed partnerships and joint ventures with Chinese institutions and state-owned enterprises to access Chinese technology and expertise[127].

The BRICS+ group is expected to have a significant impact on global oil production, meeting two-thirds of the world's crude oil demand. These nations have a history of helping to balance global oil supply and demand, which in turn stabilizes crude oil prices. Russia and Saudi Arabia, both members of BRICS, are expected to play important roles in this evolving landscape. Following the introduction of Western sanctions against Russia following its invasion of Ukraine, Russia has begun to offer discounted oil to buyers. This has proved to be beneficial for India, the world's third largest importer of oil, which is actively seeking to diversify its sources of crude oil

[127] Alhasan H. (2023). With BRICS expansion, China and Middle Eastern powers draw closer. *International Institute for Strategic Studies.*

supply to meet its growing demand. As a result, India has significantly increased its oil imports from Russia, which have surged from 1% prior to the conflict to 34%, totalling 1.64 million barrels per day as of March this year[128].

For what concerns gas, the BRICS+ group is set to account for 37% of global liquids and 33% of gas production in natural gas production. This highlights the focus on energy production by the new members and positions BRICS+ as a global leader. This is even more significant when compared to the G7's liquids production, which only accounts for 27% of the global total, despite the rise in US production[128].

According to Lars Nitter Havro, senior analyst at Rystad Energy, the BRICS+ alliance is significantly changing the global energy landscape, challenging established paradigms, and committing to ambitious sustainability goals. As the economies of these emerging superpowers grow and energy demand continues to evolve, securing a stable and secure energy supply will be critical. However, these nations have an opportunity to shift towards advanced sustainable energy infrastructure instead of relying on outdated frameworks[128].

These countries face a challenge in reducing emissions due to their heavy dependence on fossil fuels. Led by China, they are key players in the clean technology supply chain, particularly in batteries and solar panels, crucial for the energy transition.

The pace of energy transformation can be measured by electric vehicle adoption. As abovementioned, China currently leads the world in pure battery EV (BEV) sales, surpassing the G7 countries. This growth in EV adoption is due to advancements in battery technology, infrastructure development, and supportive government policies[128].

China's impressive growth in solar capacity is aimed at reaching 1 TW by 2026. This is a significant step towards cleaner energy sources and reducing the carbon footprint of the transportation sector. The integrated approach highlights China's commitment to transforming its energy landscape and reducing reliance on fossil fuels. This trend is also observed in other BRICS+ nations. According to Rystad estimates, electric vehicles (EVs) are projected to make up more than 60% of all new car sales in the expanded bloc by 2035[128].

[128] Rystad Energy. (2023). BRICS expansion to widen the renewable energy gap with the G7, ushering in new global market dynamics.

3.6 Relevance of International Relations: Russia

China's relations with Russia are of considerable importance in terms of both oil and gas supplies.

Given that Russia, one of the world's biggest energy producers, and China, one of the biggest and most populous economies in the world, share thousands of kilometers of land border, it seems that collaboration between the two nations is inevitable. In the past, Soviet planners had been considering an eastern oil pipeline from west Siberia to the Pacific since 1977; they had also begun to explore the possibility of a gas pipeline from east Siberia to China in the early 1990s; and since the early 2000s, they had been considering a gas pipeline from east Siberia to China[129].

However, Russian energy trade has always been strongly focused on Europe, and during the 1960s and 1970s, this became one of the main global energy trade routes, and energy trade with China as a mere addendum to European trade[129].

China, meanwhile, relied mostly on the post-Soviet countries of Central Asia as its main supplier of imported energy.

Similarly, China sought to establish a presence along the entire value chain, including both upstream and midstream components, and succeeded in doing so in Central Asia. Russia, meanwhile, sought to maintain a distance from Chinese companies despite engaging in trade with China. Russia has been deeply concerned that Chinese companies might expand into its vital industries. Even in the early 2000s, when China was able to provide Russia with the funds it needed, Russian stakeholders opted to borrow capital rather than give Chinese companies the possibility to buy shares in significant Russian energy companies[129].

A sequence of loans that Rosneft and Transneft obtained from different Chinese firms between 2004 and 2017 served as the best evidence of this approach. These loans were utilized by Transneft to build the ESPO pipeline and by Rosneft as an arsenal for mergers and acquisitions to purchase Yukos[130] assets and TNK-BP[131].

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[129] Vakulenko S. (2023). Marriage Of Inconvenience—How The War In Ukraine Is Tying Russia To The Chinese Market. *The Oxford Institute for Energy Studies*, 137, 52-55.

[130] OJSC "Yukos Oil Company" was a Russian oil and gas company.

[131] TNK-BP (Tyumenskaya Neftyanaya Kompaniya, Tyumen Oil Company) was a major vertically integrated Russian oil company. In 2013 it was acquired by Russian oil company Rosneft.

Sinopec and CNPC acquired solely minority stakes in two less significant upstream Rosneft subsidiaries.

Furthermore, as a buyer, China had a monopsonist relationship with the Central Asian countries, which did not provide a rivalry for superpower status, making China feel more secure[129].

Nonetheless, the conflict between Russia and Ukraine in February 2022 resulted in a nearly total cessation of trade relations between Russia and Europe, and significantly altered the dynamics between Russia and China.

In fact, although at significant transportation expenses, Russia has been able to shift the majority of its crude oil shipments from European markets primarily to China and India. As a result, India and China purchase more than 80% of Russia's crude oil. China receives 35% of this volume through pipeline, with the remaining volume coming from deliveries from Kozmino in the Far East and ports in the Atlantic basin[129].

Due to this growth, Russia is now both countries' major import supplier, meeting 15% of China's demand and 50% of India's, with Saudi Arabia being a close second[129].

2023 has seen less than one-fifth of the previous amounts of Russian pipeline shipments to Europe. The market for LNG is still holding steady, and it likely will remain so until the new LNG and Qatari plants go online and provide a competitive alternative. At that point, Russia is likely to lose this market too: therefore, Russia has no realistic option except to move into the Chinese market given these prospects[132].

On top of that, China accounts for a large portion of Russia's imports, which range from consumer electronics and cars to drilling equipment and weapons components.

Therefore, although worries about China's collaboration have long existed and haven't faded, currently Russia has limited choices.

Russia would like to begin exporting the now-stranded Yamal gas eastward as soon as possible, and is reportedly beginning to invest in the Power of Siberia 2 pipeline prior to the formal purchase agreement with China. However, while announcements suggested that the deal would have been signed by the end of 2023, China, in the meantime, has merely said that it will be expanding the capacity of its pipeline imports

[132] Vakulenko S. (2023). Can China Compensate Russia's Losses on the European Gas Market? *Carnegie Politika.*

in relation to the construction of the fourth pipeline strand from Turkmenistan[129]. Therefore, the project is currently at a standstill.

This may push Russian gas further down the queue, but it does not necessarily mean that China has made its decision. There will still be a need for the extra 50 bcm of gas from Russia. China can currently afford to wait and use the upcoming LNG supply wave, which will likely start in 2025 or 2026, to put Russia and Turkmenistan against one another in order to get the best price[129].

In addition to fortifying and accelerating numerous already-occurring developments in the Russian-Chinese relationship, Putin's war on Ukraine in February 2022 also resulted in new dynamics that decisively tipped the balance of power in China's favor[129].

The energy trade between the two countries is becoming a significant geopolitical factor, similar to the long-standing US-Saudi relationship. This shift is creating new dynamics in the energy, political, and financial realms.

Conclusions

In conclusion, China's role in the international market, particularly in oil, gas, critical minerals, and rare earths, is characterised by a complex interplay of challenges and opportunities. China is the largest consumer and importer of oil and gas, which has global implications in light of the energy transition. Despite efforts to diversify sources, concerns about maritime security persist, which requires ongoing strategic evaluations.

China's dominance in the supply chains of critical minerals and rare earths has prompted responses from the United States and the European Union to mitigate dependence. Measures taken include investments, legislation, and international partnerships. However, their impact may be constrained until 2030 due to the time required for new facilities and alternative technologies. The energy transition poses challenges in securing stable mineral supplies, with China's dominance and export controls impacting the global landscape. Efforts to reduce dependence on China are likely to reshape the global supply chain.

As China's power grows, its strategies to mitigate vulnerabilities involve expanding its naval capabilities, global presence, and diplomatically securing critical materials. China's future energy security and global market role depend on successfully navigating challenges and participating in international cooperation.

For what concerns the renewable systems components industry, China has positioned itself as the world's largest manufacturer of clean energy technology. The 14th Five-Year Plan reinforces this commitment, contributing to global cost reduction. China's dominance in the manufacturing of solar PV, batteries, and wind components is substantial and is expected to persist until 2030. There are concerns about China's influence in climate technologies, which urge European governments to conduct a comprehensive examination and risk mitigation.

The competition between the US and China in the global energy transition is apparent in international relations, with China leading in key sectors of the energy transition. The BRICS+ group expansion has increased China's global oil production share, aligning with its Middle East energy cooperation goals.

While the shift towards sustainable energy infrastructure is acknowledged, reducing emissions remains a challenge due to dependence on fossil fuels. Moreover, geopolitical shifts have impacted trade dynamics, leading to the evolution of China's relations with Russia in oil and gas, impacting trade and potentially reshaping Russian gas exports.

Overall, this last paragraph provides a comprehensive understanding of China's intricate role in the global energy market, offering insights into the challenges and opportunities shaping the future of energy geopolitics.

Conclusions

This research highlights the dualism, the paradox of China: the biggest global emitter, but also the biggest renewables manufacturer.

China's energy transition, like the economic growth of recent decades, produces gigantic numbers. Although it is no longer the most populous country in the world, the scale at which the transformations occur is commensurate with its 1.4 billion inhabitants; tens of thousands of wind turbines and millions of solar panels are produced and installed every year. An industrial sector that measures itself with these numbers can achieve economies of scale that effectively alter the relationship between renewable energy and energy from fossil sources. However, the interventionist nature of the Chinese economy, coupled with the stringent control exerted over it by the state and the Communist Party (which has recently tightened even further), has both positive and negative effects. On the one hand, it allows for the exploitation of natural resources and the development of entire industrial sectors with little regard for environmental and labour concerns. On the other hand, it can hinder the economy in ways that a free market approach could potentially rectify, as evidenced by the recent collapse of the real estate sector, the full financial ramifications of which are yet to be seen.

China's commitment to energy transition is significant and verifiable, but it is also somewhat obscured from global awareness by a certain third-worldist rhetoric, which, polemising against the West and blaming the latter for emissions at an historical level, puts little light on the fact that progress is being made, as if saying so diminishes their ability to represent the global south. It is a geopolitical objective, more than an industrial one.

Through its initiatives, China is revealing just what is possible and achievable in a transition to a zero carbon economy.

China also reveals that the energy transition can have a dark side.

Indeed, the production of technologies such as solar panels, batteries, and windmills requires the mining of large quantities of non-renewable materials, which can have a significant impact on local ecosystems and populations. Decarbonisation is in motion, but our clean future is going to be more materially intensive than ever.

Therefore, it is crucial to address conflicts and establish new forms of international peace to create a climate-safe future, ensuring that the energy transition does not undermine human rights or lead to the weaponisation of supply chains at a time of international instability and climate disruption.

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