Chapter 4

The role of energy sector in the development of the Chinese economy

Tomasz Motowidlak*
https://orcid.org/0000-0001-9948-4591

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Energy consumption is an essential parameter of any economy's functioning. Research shows that there is a close relationship between energy demand and economic growth. This relationship is confirmed by, among others data on the average 3-year growth of world real GDP[1] and the demand for crude oil and primary energy in total in the world economy over the years 1972–2011 (figure 4.1.). Therefore, energy demand can be considered as one of the important determinants of economic growth. In particular, the level of electricity consumption, which the International Energy Agency (IEA) treats as "the fuel of the future", should be seen as such a determinant.[2]

Along with energy prices and the energy intensity of GDP, energy demand is also a significant determinant of the competitive position of the economy. Lower energy costs and lower energy intensity of GDP are instrumental in strengthening this position.

In the 21st century, in addition to economic growth, climate change has become a significant factor influencing the pace of energy consumption.[3] Large temperature

* University of Lodz, Department of International Business and Trade.

1 Based on a fixed USD value of 2005.

2 In 2018, global demand for energy increased by 2.3%, and for electricity almost twice as much, i.e. by 4%. Its consumption exceeded 23,000 TWh, which accounted for 1/5 of global energy consumption, for: *World energy outlook 2018* [2018], https://www.iea.org (accessed: 11.09.2019).

3 M. Skłodowska [2019], *The appetite for electricity is growing. We can't keep up with production*, https://www.money.pl (accessed: 30.03.2019).

fluctuations and the resulting heat and cold waves engulfing various parts of the world imply an increase in energy demand for heating and air conditioning. The main reason for these changes are greenhouse gas emissions and industrial pollution associated with energy production and consumption processes, which are a source of ever-increasing external costs that further burden the economy.

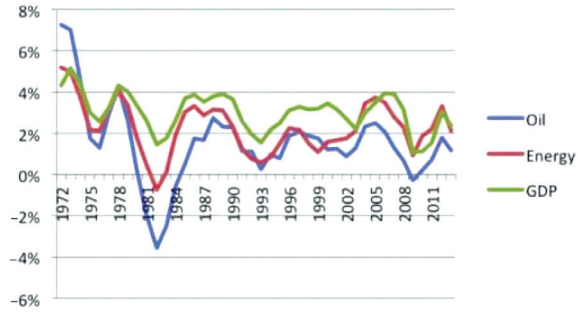

Figure 4.1. Word growth in oil, energy and GDP
Source: *Main links between energy and the economy* [2014], https://ziemianarozdrozu.pl (accessed: 20.09.2019)

Under these circumstances, energy policy of a given country, including the desired directions of energy sector transformation, has a large impact on the development pace and competitiveness of the economy. For many countries, the main goal of this transformation is to reduce CO_2 emissions, which is intended to be achieved by reducing the use of fossil fuels and replacing them with renewable energy sources (RES). The high costs of such a change in the structure of energy production are, in the short and medium term, a major challenge for the economies of these countries.

4.1. Primary energy consumption as a determinant of China's economic growth

The scale of growth of the Chinese economy is illustrated by the volume and dynamics of its gross inland consumption of primary energy (GIC). Even in 2000, this country consumed 1,130 Mtoe of energy, which accounted for 11.6% of global consumption, giving way only to the USA and Europe (table 4.1.). These relations changed radically in 2010. The share of China's economy in global GIC increased then to 20.3%, which meant that the country became the largest consumer of primary energy. During the years 2010–2018, this position was further strengthened. In this period, China's GIC increased by 24,8%, which means

that its dynamics was almost two times higher than the dynamics of global GIC growth. In 2018, China's economy consumed 3164 Mtoe of energy, thus increasing its share in global GIC to 22.6%.

Table 4.1. Gross inland consumption of primary energy in 2000–2018

Country/Region	2000		2010		2018		Dynamics 2018/2010
	Mtoe	%	Mtoe	%	Mtoe	%	
Europe	1.853	19.0	1.927	15.4	1.847	13.2	0.96
China	1.130	11.6	2.536	20.3	3.164	22.6	1.25
India	441	4.5	700	5.6	929	6.6	1.33
Japan&Korea	709	7.3	757	6.1	731	5.2	0.97
Russia	619	6.4	688	5.5	800	5.7	1.16
USA	2.269	23.3	2.218	17.7	2.258	16.2	1.02
Other	2.725	28.0	3.685	29.5	4.249	30.4	1.15
Total	9.746	100.0	12.511	100.0	13.978	100.0	1.12

Source: own elaboration based on *Global energy statistical yearbook 2019* [2019], https://yearbook.enerdata.net (accessed: 21.09.2019)

Gross inland consumption of primary energy of the USA and Europe was relatively stable over the period 2000–2018. As a result, the shares of this country and this continent in global GIC decreased in 2018 to 16.2% and 13.2% respectively. The corresponding shares of India, Russia, Japan and Korea, i.e. other leading global primary energy consumers, did not exceed 7%. However, attention should be paid to the relatively high level of energy intensity of the Chinese economy, which weakens the dynamics of its growth.[4] The lower energy intensity of US and European GDP is an important parameter for their economies, allowing them to partially offset China's advantage in terms of economic growth, which results from the higher growth rate of GIC.

High dynamics of economic growth and only small reserves of crude oil and gas mean that China imports more and more energy.[5] In 2008–2018, its imports increased from 117 Mtoe to 689 Mtoe, resulting in an increase in the energy dependence of the Middle Kingdom from 5.2% to 21.8% (figure 4.2.). In 2018, China's

4 In 2019, China used 3 kWh of primary energy to produce a GDP of 1 USD, while Germany, France and Japan – 1 kWh, the USA – 1.3 kWh, and Poland 2 kWh, for: *A Pole produces less for more – from where such energy consumption?* [2018], https://wysokienapiecie.pl (accessed: 08.08.2018).

5 Ł. Gacek [2012], *China's energy security*, Księgarnia Akademicka, Kraków, p. 23.

oil and gas import dependency ratios reached 70% and 43% respectively,[6] which was the result of importing 449 Mtoe and 104 Mtoe of these raw materials, respectively.[7] The value of the corresponding indicator for coal in 2018 was 7%, which translates to import volume of 136 Mtoe.[8]

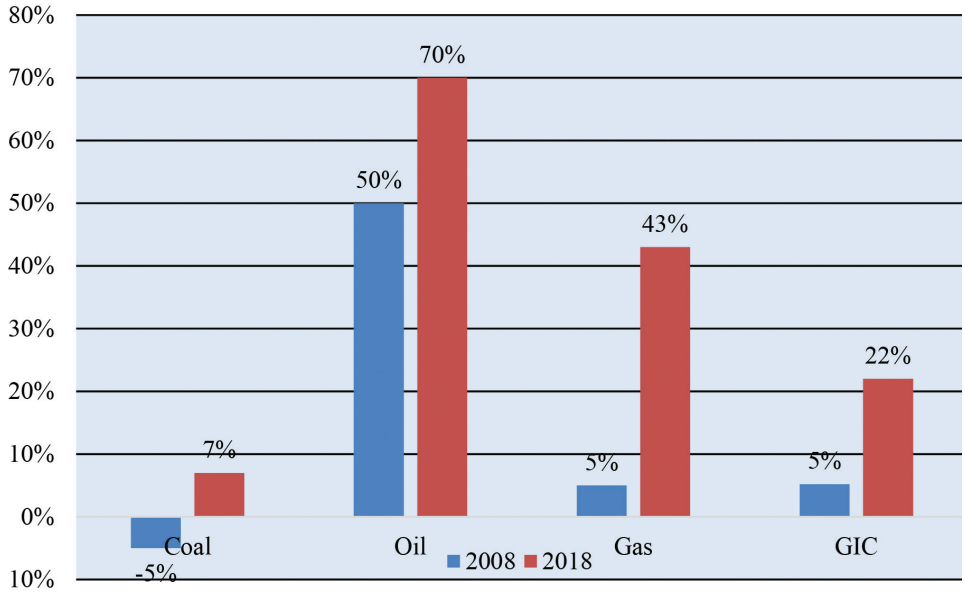

Figure 4.2. China's energy dependence 2008–2018
Source: own elaboration based on *BP Statistical Review of World Energy 2019* [2019], https://www.bp.com (accessed: 30.09.2019)

Growing imports make China a significant participant in its global market, which has a major impact on energy prices. The amount of crude oil imported in 2018 by the Middle Kingdom amounted to a 20.5% share in the global market for this raw material on the import side (table 4.2.). In this respect China's consumption was only second to Europe, whose corresponding share was 22.9%. China's share in global LNG gas imports was 17.2% and was only lower than the analogous parameter in Japan. After taking into account gas supplies carried out using onshore transmission infrastructure, the Middle Kingdom was the second (after

6 *China: Growing import volumes of LNG highlight China's rising energy import dependency* [2019], The Oxford Institute for Energy Studies, https://www.oxfordenergy.org (accessed: 24.06.2019), p. 2.
7 Back in 2008, China imported 193 Mtoe crude oil and 4 Mtoe gas, which met respectively 50% and 5% of domestic demand for these raw materials.
8 Even in 2008, China was a net exporter of coal, selling it in the amount of 80 Mtoe.

Europe) gas importer in the world.[9] These supplies, largely from Turkmenistan, accounted for 6% of global pipeline supplies in 2018.[10] Despite significant coal reserves, China has become its major importer. In 2018, its share in the global import of this raw material was 17.1%.

Table. 4.2. Oil, gas and coal net imports

Country/Region	Oil (%)	Gas LNG (%)	Gas by pipeline (%)	Coal (%)
Europe	22.9	16.7	59.5	17.5
China	20.5	17.2	6.0	17.1
India	10.1	7.2	0.0	16.5
Japan	6.7	26.2	0.0	14.0
Korea	5.7	13.9	0.0	10.8
USA	17.1	0.0	9.6	0.3
Other	17.0	18.8	25.0	23.7
Total	100.0	100.0	100.0	100.0

Source: own elaboration based on: *BP Statistical Review of World Energy 2019* [2019], https://www.bp.com (accessed: 30.09.2019)

4.2. Electricity consumption as a determinant of the development of China's economy

Outlined by the dynamics of GIC, the picture of China's economic growth is enriched by indicators related to electricity consumption. Electricity is the most valuable form of secondary energy and its production and transmission constitutes an economic bloodstream of every country which, next to the transport system, determines the efficient functioning of the economy. It is used to power many devices used, among others, in industry, communication, agriculture and many other

9 *Will the Chinese harm the diversification of gas supplies to Poland?* [2019], https://www.energetyka24.com (accessed: 27.02.2019).

10 According to the IEA sustainable scenario, China's demand for natural gas is expected to grow steadily by about 5% per year to reach over 600 billion m^3 in 2040. This country will thus become the second, after the US, gas market in the world, for: *The role of gas in today's energy transitions* [2019], IEA, https://webstore.iea.org (accessed: 15.06.2019).

branches. Electricity is also necessary for the development and implementation of new technological solutions in the economy, which allows it to improve its competitiveness.[11]

It should be emphasised that the very production and transmission of electricity is associated with the use of advanced technologies. It is thanks to the energy industry that different areas of modern technology are developing: electronics, IT, terrestrial and satellite communications. The computer and telephone networks are expanding. Therefore, the consumption of electricity not only indicates the economic growth of a given country, but also constitutes an important indicator of its economic development.

In 2000, China consumed 1368 TWh of electricity, which constituted almost 9% of its global consumption (table 4.3.). Chinese economy was significantly behind in this respect when compared to the developed economies of the USA, Europe, Japan and Korea, whose share in this consumption constituted 26.1%, 23.6% and 14.8% respectively. The dynamic development of China's economy meant that already in 2010 it consumed a comparable amount of electricity. In 2017, electricity consumption in the Middle Kingdom reached 6,594 TWh, which accounted for almost 26% of its global consumption.[12] China has thus become the largest electricity consumer in the world.

Table 4.3. Electricity consumption 2000–2017 and its forecast until 2030

Country/Region	2000		2010		2017		2030	
	TWh	%	TWh	%	TWh	%	TWh	%
Europe	3.621	23.6	4.083	19.1	4.137	16.2	4.417	13.3
China	1.368	8.9	4.190	19.6	6.594	25.8	9.530	28.6
India	553	3.6	980	4.6	1.604	6.3	3.099	9.3
Japan&Korea	2.266	14.8	3.020	14.1	3.372	13.2	4.406	13.2
Russia	709	4.6	851	4.0	915	3.6	–	–
USA	4.002	26.1	4.330	20.3	4.194	16.4	4.440	13.3
Other	2.820	18.4	3.920	18.3	4.737	18.5	7.386	22.2
Total	15.339	100.0	21.374	100.0	25.553	100.0	33.278	100.0

Source: own elaboration based on *Global energy statistical yearbook 2019* [2019], *op. cit.*, and World energy outlook 2018 [2018], https://www.iea.org (accessed: 11.09.2019)

11 China is making currently little contribution to the development of global technology. Currently, about 70% of new technologies come from Western countries or Japan.

12 In 2018, China's share in global electricity consumption increased to 26.9%.

IEA forecasts indicate that China will be strengthening its position in the next decade. The high dynamics of the Chinese economy's development will cause its consumption to account for 28.6% of global electricity, i.e. more than the European and US economies combined. The dynamic increase in electricity consumption by China will translate into a significant improvement in economic growth rates. According to Business Center Club forecasts, by 2050 this country will reach about 60% of GDP per capita of US.[13] Due to the huge population in 30 years, China will definitely become the first economy in the world, because although the average GDP per capita will remain lower than in the US or the EU,[14] the GDP of the entire country will correspond to the GDP level of the EU and USA combined.[15]

4.3. Side effects of China's economic growth

In the period 1985–2005, economic growth was the main priority of the Chinese economy, which meant that environmental protection and the harmful effects of electricity generation and industrial production on the environment were of secondary importance.[16] It was growth, which in terms of the environment and natural resources could be called robbery. It led to huge pollution of air, water and soils, threatening human health and life.[17] While in 1990 China emitted 2261 million tons of CO_2, which constituted "only" 11.2% of global emissions of this greenhouse gas (table 4.4.), in 2007 they overtook the USA and Europe in the classification of its largest emitters on the globe.

In 2010, China's share in global CO_2 emissions increased to 26.0%, and in 2018 to 28.8%, which was the result of the emission of 9467 million tonnes of CO_2, i.e. more than 4 times increase over the period 1990–2018. What's more, specialists – including Chinese – believe that maintaining current trends may mean that in 2030 the Middle Kingdom will emit more CO_2 than the whole world combined.[18] This scenario is quite realistic because the peak in CO_2 emissions announced by China is expected to occur around 2030. Realisation of this scenario means a significant burden to the global climate and a major contribution towards increasing the average global temperature by more than 2°C.

13 At this level, catching up with the most developed countries will fade away, as has happened in Japan, which currently generates 75% of GDP per capita in the USA.

14 It is estimated that in 2050 the population of China will be almost twice as high as the US and EU combined.

15 *In search of lost power. China from a poor country has become a global superpower* [2019], https://forsal.pl (accessed: 22.04.2019).

16 *China – a challenge for the world?* [2015], http://www.chronmyklimat.pl (accessed: 22.07.2019).

17 Ł. Gacek [2015], *Green energy in China*, Wydawnictwo Uniwersytetu Jagielońskiego, Kraków, p. 57.

18 B. Góralczyk [2019], *China's energy geostrategy*, https://www.cire.pl (accessed: 26.09.2019).

Table 4.4. CO_2-emissions of China 2000–2017 and their forecast until 2030

Country/ Region	1990		2000		2010		2018		Dynamics 2018/1990
	mln t	%	mln t	%	mln t	%	mln t	%	
Europe	4.424	21.8	4.263	18.7	4.178	14.0	3.839	11.7	0.87
Canada	430	2.1	529	2.3	548	1.8	596	1.8	1.39
China	2.261	11.1	3.144	13.8	7.763	26.0	9.467	28.8	4.19
India	522	2.6	908	4.0	1.575	5.3	2.277	6.9	4.36
Japan	1.049	5.2	1.134	5.0	1.100	3.7	1.123	3.4	1.07
USA	4.851	23.9	5.809	25.4	5.430	18.2	5.118	15.5	1.06
Other	6.776	33.4	7.050	30.9	9.257	31.0	10.496	31.9	1.55
Total	20.313	100.0	22.837	100.0	29.851	100.0	32.916	100.0	1.62

Source: own elaboration based on *Global energy statistical yearbook 2019* [2019], *op. cit.*, and *World energy outlook 2018* [2018], https://www.iea.org (accessed: 11.09.2019)

4.4. Fuel conditioning of electricity generation in China

The side effects of China's dynamic economic growth are largely a consequence of the hard coal-based electricity sector. This high-emission raw material dominated the structure of electricity generation in this country. In the first decade of the 21st century, the share of coal in this structure was about 80%. In the years 2000–2010, this share decreased by only 1 p.p.[19] (Table 4.5.). The use of coal for electricity generation in China is related to its significant resources in this country, which are estimated at around 14% of global resources and are second only to the USA and Russia, and which translate into relatively low costs.[20] CO_2 emissions related to the structure of electricity generation, are further compounded by the relatively high energy intensity of China's economy.

19 During this period, China also reduced by 3.1 p.p. the share of crude oil in the electricity generation structure. Instead by 1.8 p.p. increased the share of nuclear energy, by 0.9 p.p. of gas, by 0.7 p.p. by biomass and by 0.8 p.p. of hydropower in this structure.

20 China is the main producer of coal in the world, controlling almost half of its production.

Table 4.5. Fuel structure of electricity generation in China 2000–2017 and its forecast until 2030

Fuel	2000	2010	2017	2030
Coal (%)	78.9	77.9	67.4	49.2
Gas (%)	1.3	2.2	3.3	7.6
Oil (%)	3.4	0.4	0.2	0.1
Nuclear (%)	0.0	1.8	3.8	7.9
Bioenergy (%)	0.1	0.8	1.4	2.7
Hydro (%)	16.2	17.0	17.7	14.6
Wind (%)	0.0	0.0	4.3	9.4
PV (%)	0.0	0.0	1.9	8.3
Geothermal (%)	0.0	0.0	0.0	0.3
Total (%)	100.0	100.0	100.0	100.0

Source: own elaboration based on *World energy outlook 2018* [2018], https://www.iea.org (accessed: 11.09.2019)

Significant changes in the structure of China's electricity production occurred in the second decade of the 21st century. In 2017, a decrease of 10.5 p.p. of coal share in this structure was recorded. Correspondingly, there was a clear trend towards the use of low-carbon sources of electricity generation, among which RES became the most significant. The total share of RES (i.e. hydro, solar and wind energy) in the electricity generation structure was 25.3%. Although hydroelectric power (already previously used) had a decisive influence on this share, accounting for 17.7% of the electricity generation, this means an increase of 0.7 p.p. in the period 2010–2017.

The share of wind energy (4.3%) as well as photovoltaic energy (1.9%) and biomass (1.4%) have become significant. The importance of low-carbon sources in China's electricity generation structure has also increased due to greater use of nuclear and gas energy. In the period 2010–2017 the share of nuclear energy in this structure increased to 3.8%, i.e. by 2 p.p., and gas share to 3.3%, i.e. by 1.1 p.p.

IEA forecasts point to a further reduction of the role of coal in China's electricity generation in the next decade. In 2030, its share in the electricity generation structure will not exceed 50%. The share of RES in this structure will increase to 35.3%, to which hydropower will still contribute the most. However, its share will amount to 14.6%, which means it will be 3.1 p.p. lower than in 2017. The mentioned forecasts predict that the dynamics of RES growth will be much higher. The share of wind energy in the electricity generation structure will increase to 9.4%, and solar energy up to 8.3%. Geothermal energy will appear, with a 0.3% share in this structure.

4.5. New priorities in China's power industry

Limiting the role of coal and the development of RES in the energy sector are the result of a thorough change in the development model of China's economy. Economic expansion, resulting in an increase in electricity production, which has increased 10-fold over 10 years, mainly by burning coal, has become the cause of progressive environmental degradation. Already in 2004, problems related to environmental pollution costed China over USD 200 billion, which means that ecological damage absorbed about 10% of the country's GDP.[21] World Bank analyses have shown that in 2003 health costs in China resulting from air and water pollution amounted to RMB 362 billion, or 2.68% of GDP. Air pollution caused premature death of 358,000 people in 600 Chinese cities every year. In 2010, the dynamics of costs generated by pollution amounted to 13.7% and was by 3.3 p.p. higher than GDP growth dynamics. At the same time, this year the amount of RMB 558.9 needed for the utilization of pollution was as much as 94% higher than the amount spent for this purpose in 2004.[22]

The problems of environmental pollution have prompted the Chinese authorities to move away from the current model of economic expansion towards a sustainable economy based on internal consumption. It can be assumed that strategic decisions regarding this change were made during the Third Plenum of the Central Committee of the Communist Party of China in November 2013. The adopted documents referred directly to the transition to a "green" and even "carbon-free" economy in which energy is of paramount importance and is an integral component of a coherent and far-reaching state development strategy. The importance of the energy policy in this strategy is evidenced by the establishment of the National Energy Administration in 2008, which in January 2010 was transformed into the supra-ministerial National Energy Commission headed by the prime minister. In 2007, the first National Action Plan for Climate Change was adopted, and the second was approved in 2012.[23] It is in them, and in the assumptions of the twelfth 5-year plan for 2011–2015, where the goals of moving away from coal based energy and of the gradual transition to alternative sources were defined for the first time.

21 These data do not include additional costs for damage to health or death.

22 Ł. Gacek [2015], *op. cit.*, p. 83.

23 K. Pająk, J. Mazurkiewicz, P. Lis [2015], *China's Road to a Low Carbon Economy*, in: J. Marszałek-Kanwa, K. Pająk (eds.), *Energy Policy of Asia-Pacific States*, Wydawnictwo Adam Marszałek, Toruń, p. 184.

4.6. Development of technologies and innovative solutions in China's power industry

In addition to changing the fuel structure of electricity generation to reduce its emissions, a strategy for improving energy efficiency[24] and smart and sustainable development activities have become a key element of China's energy policy. The economic growth of the Middle Kingdom is to be based on effective investments in research and development of technologies and innovative solutions,[25] in particular in electricity, which is crucial for its economy and authorities.

The actions taken thus far are focused on the development of innovative technologies for electricity generation and energy-saving, environmentally friendly technologies. This is facilitated by capital expansion in Europe, concentrating on taking over technologies and organizational solutions in the energy sector. The long-term effect is to increase China's energy security while providing new impulses for the development of Chinese industry. The effects of scale should also be taken into account because the Chinese economy is comparable to the European, American and partly Asian economies taken together, so even a small change in this country will have global consequences.

Investments in RES became an important element in the development of China's economy.[26] Energy is and will permanently be a key factor in this development. In connection with this, the changes taking place in China's energy-related operations significantly affect energy security and the quality of social life.[27] RES are not only more and more profitable and (despite less support) are starting to compete on the market with traditional technologies, but they are driving progress and innovation. Their further development, in connection with works on improvement of energy storage devices and systems (carried out in China on large scale)[28] may remove one of the main obstacles to the promotion of RES, i.e. their instability.

Already in 2010, China became the world's largest investor in RES sector, allocating USD 45 billion to its development, while the second, Germany – USD 41.2 billion and the third, USA – USD 34 billion. It is estimated that even then the Middle Kingdom was responsible for about half of the global production of both photovoltaic

24 China has made tremendous progress in energy efficiency. Without the effects of its improvement introduced since 2000, the country would consume 12% more energy in 2017, which would entail an additional 1.2 Gt CO2 emissions, corresponding to half of US emissions, for: *Energy efficiency 2018* [2018], IEA, https : //www.iea.org (accessed: 24.07.2019), p. 145.

25 In 2020, China intends to spend 2.5% of GDP on innovation.

26 *Prospects for distributed energy systems in China* [2017], IEA, https://www.iea.org (accessed: 19.09.2019), p. 44.

27 R. Nowakowski [2019], *Sustainable energy transformation in Poland, or how can conventional sources support the rapid development of renewable energy?*, "Polish Energy Brief", vol. 2.

28 Intensive work on integrating energy storage with energy networks is underway in almost all developed countries, especially in Germany, China and the USA.

cells and wind turbines. In 2018 alone, 44 GW of photovoltaic power and 20 GW of wind power were installed in China.[29]

According to Bloomberg New Energy Finance, China's total investments in clean energy technologies amounted to USD 132.6 billion in 2017 (these expenditures increased by 24% compared to the previous year) and accounted for approx. 40% of global expenditure for this purpose[30] (figure 4.3.). China dominates both in terms of investment volume and global production.[31] Its share in global production of photovoltaic cells increased in 2017 to about 60%, while USA's and Canada's share was only about 6%.[32] US investment outlays for clean energy technologies in 2017 amounted to USD 56.9 billion (an increase of 1%), i.e. less than half of the value of Chinese investments. Germany (USD 14.6 billion, an increase of 26%) and Great Britain (USD 10.3 billion, an increase of 56%) allocated significantly less to the development of these technologies.

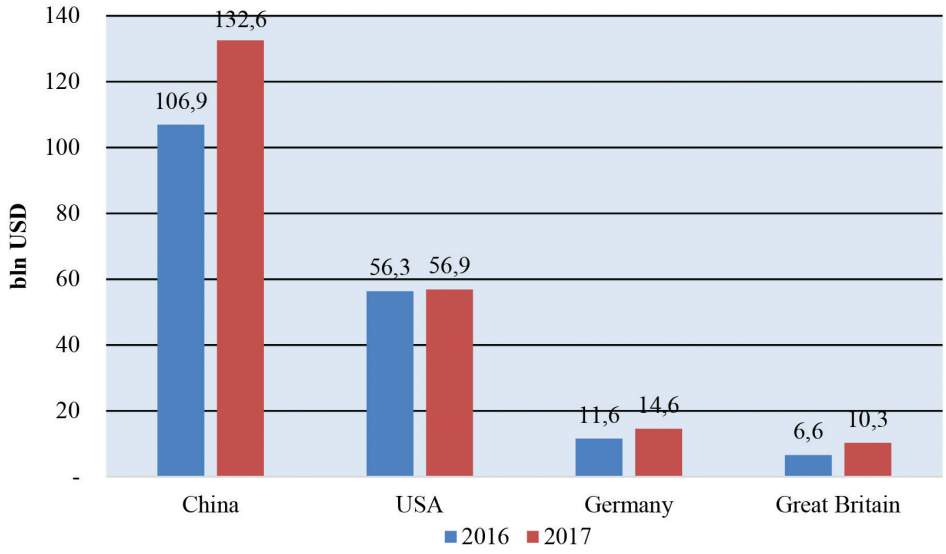

Figure 4.3. Investments in clean energy technologies
Source: own elaboration based on *Clean energy investment trends* [2018], Bloomberg New Energy Finance, https://data.bloomberglp.com (accessed: 16.01.2018)

29 *China power system transformation. Assessing the benefit of optimised operations and advanced flexibility options* [2019], International Energy Agency, https://webstore.iea.org (accessed: 14.10.2019), p. 7.

30 *Clean Energy investment trends* [2018], Bloomberg New Energy Finance, https://data.bloomberglp.com (accessed: 16.04.2019), p. 12.

31 In 2016, five of the six largest solar cell manufacturers came from China, for: *China's global renewable expansion* [2017], Institute for Energy Economics and Financial Analysis, http://ieefa.org (accessed: 21.10.2019), p. 2.

32 M. Wasiński [2018], *Prospects for the development of renewable energy sources in the USA*, https://www.cire.pl (accessed: 21.07.2019).

IEA predicts that by 2030 Chinese nuclear power will be 150 GW. The Middle Kingdom will thus overtake USA in terms of its capacity, becoming the largest nuclear energy producer in the world.[33] Nuclear power is to be an instrument reducing air pollution in the country. In 2018, approximately 60 nuclear blocks were built, of which over a third in China. The IEA indicates that by 2040 the share of installed capacity in nuclear energy in China's energy mix will be 4% compared to 2% in 2016.[34]

The development of nuclear power in China contrasts with its decline in the US and Europe, mainly in Germany and France. In the US, the closure of eight obsolete nuclear blocks has been announced, support plans have been discarted, and the lifetime of other installations has been shortened. Germany's energy policy assumes the shutdown of all nuclear power plants by 2022, while the decline in nuclear generation is noted by France, which is the leader in the region in terms of generating electricity from the atom.

According to the IEA opinion, the closure of nuclear power plants in Europe and North America threatens global plans to reduce CO_2 emissions, unless new installations of this type are created or the use of RES increases. Nuclear power is currently the largest low-emission source of electricity generation on these continents, and the capacity installed in it is almost three times greater than the total power of wind turbines and solar cells.[35]

4.7. China's capital expansion as a form of acquiring modern energy technologies

China's capital expansion towards Europe that was launched after 2010 is to serve the search for new solutions and modern technologies and management methods in the power industry.[36] Mergers and acquisitions have become the main object of interest for investors from the Middle Kingdom replacing the previously preferred greenfield investments. It should be remembered that among these investors there are the largest companies and state-market conglomerates of China, belonging to the world's richest fuel and energy concerns. They include CNPC (China

33 In 2018, 33 reactors were operated in China with a total capacity of 28.97 GW.

34 *IEA: China can be a leader in the construction of nuclear power plants* [2018], https://www.cire.pl (accessed: 23.06.2019).

35 *IEA: the closure of nuclear power plants threatens global plans to reduce CO_2 emissions* [2017], https://www.cire.pl (accessed: 23.09.2019).

36 In earlier years, this expansion focused on the areas of Africa and Latin America and its main goal was the search for raw materials.

National Petroleum Corporation), CNOOC (China National Oil Offshore Corporation), Sinopec, as well as solar cell manufacturers (e.g. Yingli, Suntech) and wind turbines (Sinovel, Goldwind).

Shares in network companies and energy producers of European countries acquired in recent years by Chinese entities, are to serve the modernization of China's power system. These entities have already become co-owners of transmission system operators (TSO) in Belgium, Greece, Portugal and Italy as well as power plants in Portugal and Great Britain.[37]

China's growing capital expansion has been a cause of concern in Germany since the takeover of Kuka – the leader of German robotics – in 2016.[38] This is why the initial agreement of February 2018 on the conditions for the sale of half of the 40% shares of the 50Hertz TSO belonging to the Australian IFM fund to the Chinese state company SGCC[39] (State Grid Corporation of China) caused a great deal of concern.[40] SGCC's goal was to transfer technologies related to the management of networks in which 53% of electricity comes from unconventional sources. By frustrating this transfer, German government has sent a strong political signal that it was interested in protecting critical energy infrastructure. This signal was all the more significant because it was sent at a time of high penetration by Chinese investors searching for takeover opportunities in companies pushing technical progress and in industries of strategic importance to Germany and other European countries.[41]

Conclusions

The high growth dynamics and the achieved stage of development of the Chinese economy require an appropriate energy strategy. One of the main determinants of maintaining this dynamics, which determines the possibility of implementing large investments and installing further air conditioners, washing machines and refrigerators in Chinese apartments, is to meet the growing demand for electricity, which forces the construction of new power plants. At first, this demand was met

37 K. Popławski [2019], *Chinese in German energy networks?*, https://www.osw.waw.pl (accessed: 21.02.2019).

38 The German government opposed this takeover. However, German regulations do not protect against taking over technology companies, but also companies of strategic importance.

39 SGCC owns most of China's power grid.

40 Energy is one of the 10 strategic areas in which China wants to become a leader by 2025 and will compete for this position, among others with Germany.

41 *In Germany, the purchase by the Chinese of shares in the TSO of energy was thwarted* [2018], https://www.cire.pl (accessed: 27.09.2019).

by coal, side effect of the combustion of which, both by the energy sector and by Chinese industry, was pollution and lack of emission and waste control.

At one point, it turned out that China can produce cheaply and increase the competitiveness of its economy, but this was at the expense of significant deterioration of the environment and, as a consequence, the standard of living of the citizens. Therefore, for China, the introduction of low-carbon forms of energy production has become a real necessity to save the lives of citizens. Hence, the shift towards the development of RES, but also nuclear energy.

Energy demand is one of the important measures of the position and dynamics of China's economy in the world. Satisfying it by the increasing use of low-carbon (generally innovative) technologies creates jobs and promotes the implementation of innovative solutions. In addition to government consumption expenditure, as presented in Chapter 5, the use of innovative technologies and solutions in the energy sector is one of the important determinants of China's GDP. Some of these solutions are obtained as a result of mergers and acquisitions of energy companies, mainly in Europe (Chapter 4 has been devoted to the role of mergers and acquisitions in the Chinese economy). An important incentive for the innovative development of China's economy are the rich resources of rare metals, without which the creation of modern energy technologies is not possible. The Middle Kingdom controls 90% of the rare metal mining sector and 72% of the processing sector.