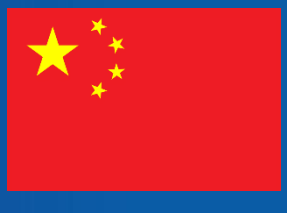
Implementation of bioenergy in China

Country Reports

IEA Bioenergy: 10 2021



This report was prepared from the 2021 IEA World Energy Balances and Renewables Information, combined with data and information provided by the IEA Bioenergy Executive Committee and Task members[1]. Reference is also made to FAOstat data as well as data from national statistics. All individual country reports were reviewed by the national delegates to the IEA Bioenergy Executive Committee, who have approved the content. General background on the approach and definitions can be found in the central introductory report for all country reports.

Edited by: Luc Pelkmans, Technical Coordinator IEA Bioenergy

Contributions: Dou Kejun (China National Renewable Energy Centre), Wang Zhongying, Ren Dongming (Energy Research Institute)

HIGHLIGHTS

- Renewables make up 10% of *total energy supply* in China in 2019. The renewable energy share in *final energy consumption* is 15%[2], of which around one third is from biomass and waste. 12% of renewable energy is from modern bioenergy (residential use of biomass excluded).
- Growth in renewable energy is mainly in electricity through hydropower, solar energy and wind power. The traditional use of biomass for residential heating is going down (and mostly replaced by oil and gas). Modern use of biomass for power and/or heat production and biogas is growing.
- China has important opportunities to further deploy bioenergy, particularly through the replacement of coal by solid biomass in existing assets, the increase of transport biofuels (which are still less than 1% of transport biofuels) as well as biogas to replace natural gas. There are ample opportunities for (renewable) energy from MSW as part of the development of waste management systems.
- China has considerable potential of biomass resources. Under the strategy of "carbon peak and carbon neutral", bioenergy should be actively exploited, and departments at all levels should form a consensus on priority utilization of bioenergy, to play a positive role in achieving the goal of addressing climate change.

[1] While data for 2020 are starting to become available at national level, it was decided to consider trends up to 2019 for good comparability and benchmarking between the different IEA Bioenergy member countries. Care should also be taken when using 2020 data for analysing trends as these data are distorted by the COVID19 Pandemic.

[2] The difference between the share of renewables in supply and consumption relates to unused heat from power plants (which is counted in energy supply, but not in final consumption).

COUNTRY PROFILE

Population and land use

China is a large country in Asia, with a total land area of 9,6 million km². It is the world's most populated country with over 1.4 billion inhabitants. Its population density is relatively high with 152 persons per km².

China's landscape is vast and diverse, ranging from deserts in the arid north to subtropical forests in the wetter south. Around a quarter of the land area is forest land (*of which 14% protected*). 55% is agricultural land, of which a quarter is arable land.

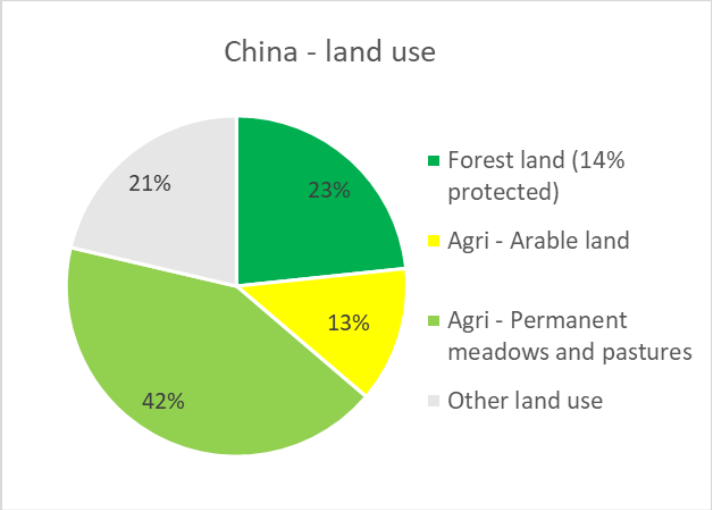


***Figure 1**: Land use in China (2018 figures - Source: FAOstat)*

Economic development and CO_2 emissions

Since China's accession to the World Trade Organization, its economy has entered a chapter of tremendous development fuelled by export and urbanization. During 2000-2019, its exports increased by nine times, and the urban area (the area of urban land that meets certain standards for construction and infrastructure) by 1.9 times and GDP by 4.2 times, both in real terms.

The soaring economy greatly increased China's real GDP per capita by 3.6 times, from US$ 2,151 in 2000 to US$ 9,986 in 2019. Large-scale industrial development, accelerated urbanization, and increasingly modernized lifestyles of a large population resulted in a significant expansion in energy consumption, which is the fundamental cause of the increase of CO_2 emissions in China.

On the plus side, China's CO_2 emissions per unit of energy consumption, energy consumption per unit of GDP, and CO_2 emission per unit of GDP have all reached their turning points and showed obvious downward trends. China's CO_2 emissions per unit of energy in 2019 decreased by 10% compared with 2000, and its energy consumption per unit of GDP and carbon intensity both dropped by 40% during the period, a result of China's relentless efforts in energy conservation, emission reduction, and clean energy development in recent years. China has achieved remarkable results in promoting green, sustainable, and low-carbon development.

However, during the same period, China's CO_2 emissions per capita increased by 1.6 times. Despite the downward trends of the previous three factors, China is yet to reach its peak in CO_2 emissions per capita. How to reach the turning point quickly and drive down CO_2 emissions per capita steadily will be the determining factor for China to fulfil its commitment to striving to peak CO_2 emissions by 2030 and achieve carbon neutrality by 2060.[3]

[3] http://english.scio.gov.cn/in-depth/2021-05/08/content_77475496.htm

Final energy consumption

Overall final energy consumption in China (*also including non-energy use of oil, natural gas, and coal in industry*) comes down to 1.44 tonnes of oil equivalent (toe) per capita, which is around two thirds of the average of IEA Bioenergy countries. More than half of final energy consumption in China is in industry - levels of energy use in industry (per capita) are comparable to several OECD countries. Transport energy consumption and residential energy use per capita is very low.

***Table 1**: Distribution of the final consumption of energy carriers by sector in China (2019 figures - Source: IEA (2021) World Energy Balances and Renewables Information)*

Final consumption energy carriers	Toe/capita (2019)	% of total	*Median* (toe/capita)*
Industry (energy use)	0.71	49%	*0.67*
Industry (non-energy use)	0.12	9%	*0.21*
Transport	0.23	15%	*0.69*
Residential	0.24	17%	*0.57*
Commercial & public services	0.06	4%	*0.34*
other	0.09	6%	
Total	1.44		*2.34*

** Median of the 25 member countries of IEA Bioenergy*[4]

NATIONAL POLICY FRAMEWORK IN CHINA

TARGETS AND STRATEGIES RELATED TO CLIMATE AND RENEWABLE ENERGY

Renewable Energy Law of the People's Republic of China January 1, 2006

The Renewable Energy Law of the People's Republic of China was issued in 2005 and was carried out formally on January 1, 2006. The Renewable Energy Law is a framework policy which lays out the general conditions for renewable energy to become a more important energy source in the People's Republic of China.[5]

Blue-Sky Action Plan[6] July 3, 2018

China's State Council released a three-year "Blue Sky Protection Plan (2018-2020)". The plan focuses on reducing the total emissions of major air pollutants and reducing greenhouse gas emissions.

[4] Comparative figures of the different IEA Bioenergy member countries are discussed in the central Countries' Report.

[5] https://www.iea.org/policies/3080-renewable-energy-law-of-the-peoples-republic-of-china

[6] http://english.www.gov.cn/policies/latest_releases/2018/07/03/content_281476207708632.htm

Action plan for reaching carbon dioxide peak before 2030[7] October 26, 2021

According to the plan, the consumption ratio of non-fossil energy will reach 20 percent of the total in 2025, with energy consumption and carbon dioxide emissions per unit of GDP down 13.5 and 18 percent compared with that of 2020. During the 15th Five-Year Plan (2026-2030) period, the nation will basically establish a policy system to support green, low-carbon and circular development. By 2030, the consumption ratio of non-fossil energy will account for 25 percent of the total and carbon dioxide emissions per unit of GDP will be reduced by more than 65 percent compared with 2005, the total installed capacity of wind and solar power will be above 1.2 billion kW.

Table 2: renewable energy and climate targets in China.

Sector	Share of renewables in gross final consumption	GHG reduction target
Overall target	non-fossil energy accounts for 25% by 2030	-65% by 2030 per unit of GDP compared to 2005 Peak CO_2 emissions by 2030 Carbon neutrality by 2060

A description of renewable energy and climate policies and measures in China is available at the IEA's Policies and Measures Database:
https://www.iea.org/policies?country=China%2CPeople%27s%20Republic%20Of%20China

Specific policies related to renewable electricity, renewable heat and transport biofuels will be highlighted in the chapters about the role of bioenergy in different sectors.

[7] http://english.www.gov.cn/policies/latestreleases/202110/26/content_WS6178023cc6d0df57f98e3d5c.html

THE CONTRIBUTION OF BIOENERGY IN NATIONAL ENERGY SUPPLY

TOTAL ENERGY SUPPLY

The total energy supply (TES) of China in 2019 amounted to 141.1 exajoule (EJ) with fossil fuels (coal, oil, gas) still contributing 87%. Coal (85.5 EJ) is the dominant fuel, representing over 60% of total energy supply. Oil products (27.6 EJ) represents another 20%, gas 7% (10.4 EJ) and nuclear energy 2.7% (3.8 EJ). Renewable energy sources represent 9.7% of total energy supply (13.7 EJ), consisting of about 12% modern bioenergy (1.8 EJ), 25% traditional bioenergy (3.4 EJ), 33% hydropower and 29% other renewable energy sources (solar, wind, geothermal).

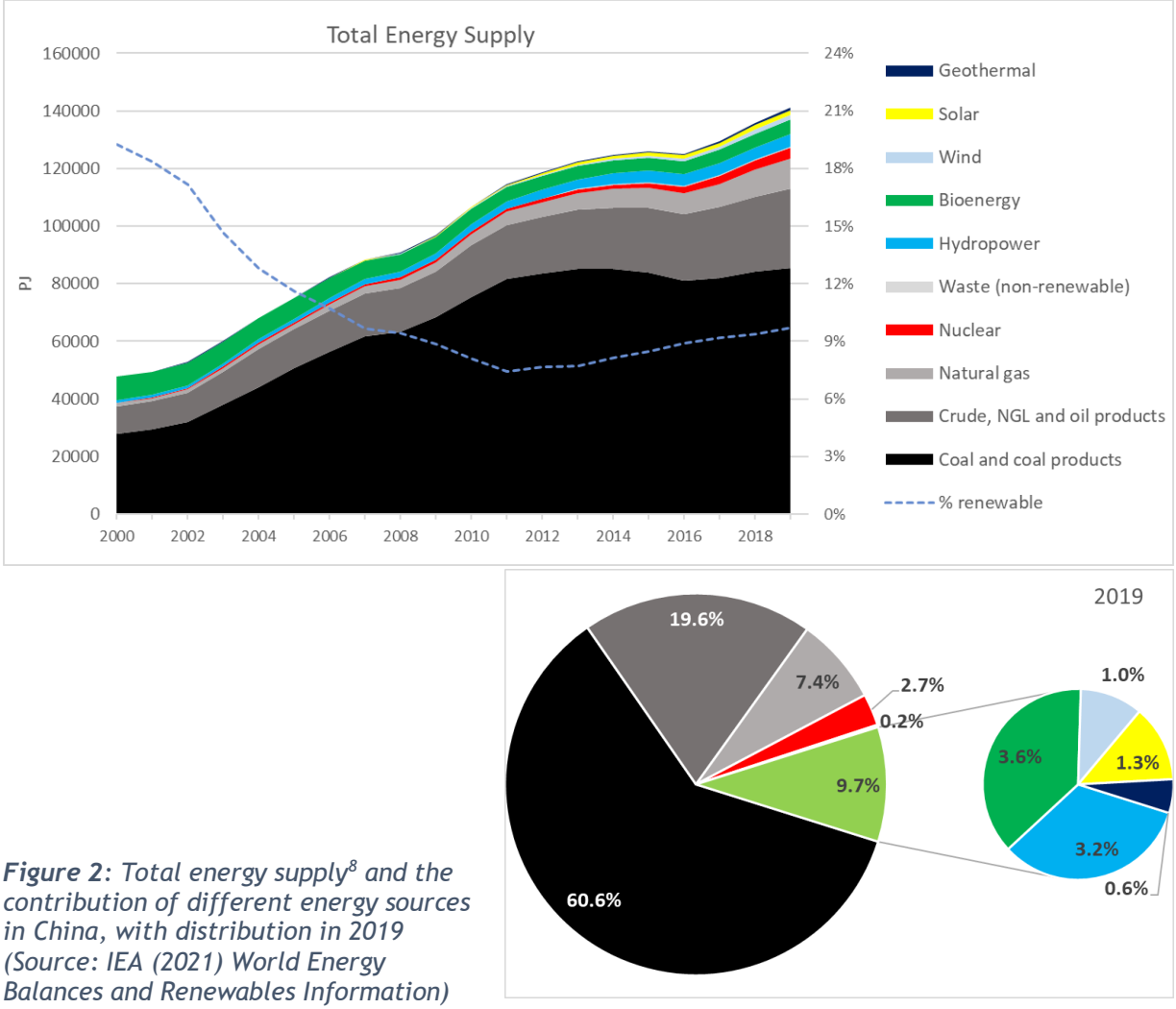


***Figure 2**: Total energy supply[8] and the contribution of different energy sources in China, with distribution in 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)*

Total energy supply in China continues to grow after a short temporisation in 2014-2016. Since 2012 coal stabilized and picked up slight growth levels again after 2017 (with a continuing increase for power production and a decrease for industrial heat). The main growth is now in oil and gas. Since 2010 oil has grown by 73% (from 15.9 to 27.6 EJ) and natural gas has grown more than threefold

[8] Total energy supply refers to the use of resources. In terms of the role in the energy system this distribution overestimates the role of resources producing electricity with a high share of unused waste heat (like nuclear plants).

(from 3.2 to 10.4 EJ). Renewable energy was relatively stable around 9 EJ in the 2000s (which means that the share of renewable energy went down due to the growing TES); after 2011 there was a consistent growth up to 13.7 PJ in 2019, which corresponds to an increased share from 7.4% to 9.7%. The main growth in this period was in hydropower, solar and wind energy.

The following figure shows that solid biofuels represent the major part (>90%) of bioenergy in China. The figure shows that traditional biomass uses for residential heating and cooking dominated [9], but modern biomass applications are steadily taking over. Modern use of solid biofuels includes the use of agricultural and forestry residues, mainly for electricity production. In addition, pellets are used for industrial heating and a small part of residential heating.

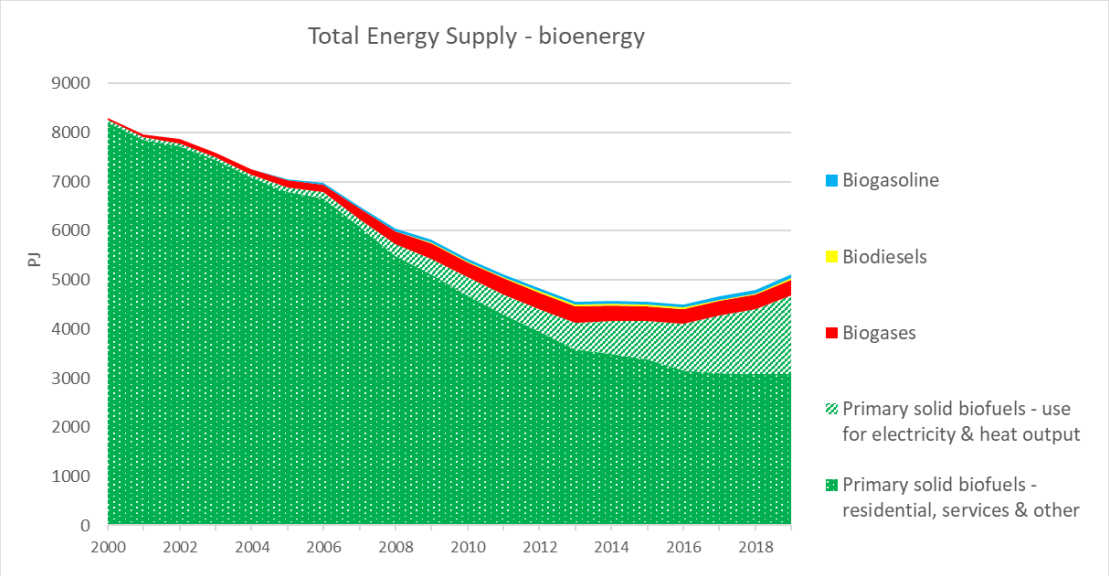


***Figure 3**: Development of total energy supply from bioenergy in China 2000 – 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)*

Evolution of the bioenergy carriers:

- In the past 20 years the share of biomass for residential heating (mostly traditional biomass) dropped from 70% to 30% and was replaced by oil and gas. Prior to 2006, traditional biomass was used mainly in rural areas and heating for urban residents was mainly coal-fired central heating. After 2012 the decline of solid biofuels in residential heating was compensated by an increase of solid biofuels in electricity and heat production. Since 2016 the overall use of solid biomass for energy increases again.
- Biogas has stabilised around 300 PJ, which is 16.6% of bioenergy. This is mainly used to supply gas to residents for cooking and electricity production.
- Transport biofuels (predominantly bioethanol) represent 7.2% of bioenergy in China.

Table 3 displays the 2019 total bioenergy supply values on a per capita basis. Compared to the other 24 member countries of IEA Bioenergy (expressed per capita), China ranks at the low end for all types of bioenergy, so has quite some growth potential.

[9] The data used for biomass in residential applications are estimations. National statistics in China mainly monitor bioenergy use in commercial applications.

Table 3: Total energy supply per capita in 2019 for different bioenergy carriers

	Supply per capita	*Median IEA Bioenergy members*
Bioenergy	3.6 GJ/cap	*10.6*
Solid biofuels	2.8 GJ/cap	*7.0*
MSW[10]	0.4 GJ/cap	*0.8*
Biogas	0.2 GJ/cap	*0.7*
Liquid biofuels	0.1 GJ/cap	*1.5*

Source: IEA (2021) World Energy Balances and Renewables Information

Table 4 indicates the amounts of the different bioenergy carriers compared to some relevant reference points, namely the amount of forest in the country (for solid biomass), the amount of generated MSW (for renewable MSW used for energy), the amount of natural gas consumed in the country (for biogas) and the amount of fossil oil products consumed (for liquid biofuels).

Table 4: Comparison of the supply of different bioenergy carriers in 2019 to specific reference points

	Compared to reference points			*Median**
Bioenergy	3.6 %		of total energy supply	*7.2 %*
Solid biofuels	21.8 GJ/ha_forest		compared to the domestic hectares of forest land (excl. protected)	*21.3 GJ/ha_forest*
MSW	2.98 GJ/ton_MSW		compared to the total generated MSW in the country	*1.4 GJ/ton_MSW*
Biogas	0.029 GJ/GJ_NG		compared to natural gas supply	*0.023 GJ/GJ_NG*
Liquid biofuels	0.004 GJ/GJ_oil		compared to oil products supply	*0.028 GJ/GJ_oil*

Source: energy data from IEA (2021) World Energy Balances and Renewables Information; forest figures from FAOStat; waste figures from World Bank
** Median of the 25 member countries of IEA Bioenergy*[11]

Specific comments in relation to the reference points:

- The use of solid biofuels compared to the domestic forest area is modest (~1.1 tons_dry mass of wood per hectare[12]) and there is room for increased mobilization. Mind that the use of straw (as solid biomass) also represents a big potential for bioenergy applications.
- Transport biofuels and biogas are still at low level, so these have high growth potential.

[10] Solid biofuels and MSW are reported together. Based on the operation of MSW power generation, the amount of MSW used for energy is estimated at 625 PJ (0.43 GJ/capita) is derived from MSW. This is subtracted from the solid biofuels reported in the IEA database.
There is no indication how much of the MSW is renewable.

[11] Comparative figures of the different IEA Bioenergy member countries are discussed in the central Countries' Report.

[12] Counted with a typical calorific value of wood (dry mass) of 19 GJ/ton$_{\text{dry mass}}$

ROLE OF BIOENERGY IN DIFFERENT SECTORS

OVERVIEW

The overall share of renewables in **final energy consumption** among electricity, transportation and heat sectors is almost 15%, with bioenergy making up 4.6% of the energy share (1.2% specifically for commercial bioenergy) (Table 5). Mind that these figures are higher than the shares in total energy supply (where unused waste heat, e.g., in fossil power production, is also included).

***Table 5**: Role of bioenergy and renewable energy in electricity, transport energy and fuel/heat consumption in 2019*

Sector	Share of bioenergy	Share of renewable energy	Overall consumption
Electricity[13]	1.5%	26.9% *(17.0% hydro)*	7451 TWh (25.6 EJ)
Transport energy (final consumption)	0.9%	2.0%	14.1 EJ
Overall fuel and heat consumption[14]	7.5%	11.4%	45.2 EJ
TOTAL FINAL ENERGY CONSUMPTION*	4.6% (1.2% commercial, 3.4% residential)	**14.6%**	**85.5 EJ**

Source: IEA (2021) World Energy Balances and Renewables Information

The following paragraphs will consider the evolutions in the different sectors.

ELECTRICITY

The Chinese power production is largely dominated by coal, representing two thirds of power production. Natural gas and nuclear energy represent respectively 3 and 5%. Hydropower is the dominant source of renewable electricity with 17% of total electricity production. In the past 10 years there was also a consistent growth of wind energy (now at 5%) and solar energy (now at 3%).

The role of electricity from biomass and MSW is very modest around 1.5%. Recent figures from national Chinese statistics indicate that in 2019, 61 TWh of that amount was produced from solid biomass and 50 TWh from MSW.

[13] Renewable electricity production compared to final consumption. Potential renewable shares of imported electricity are not included.

[14] This includes final consumption of fuels and heat in industry, the residential sector, commercial and public services and agriculture/forestry. Transport fuels are excluded. Energy used for transformation and for own use of energy producing industries is also excluded.
Electric heating (direct or through heat pumps) is not included in these figures as this is not separately reported.

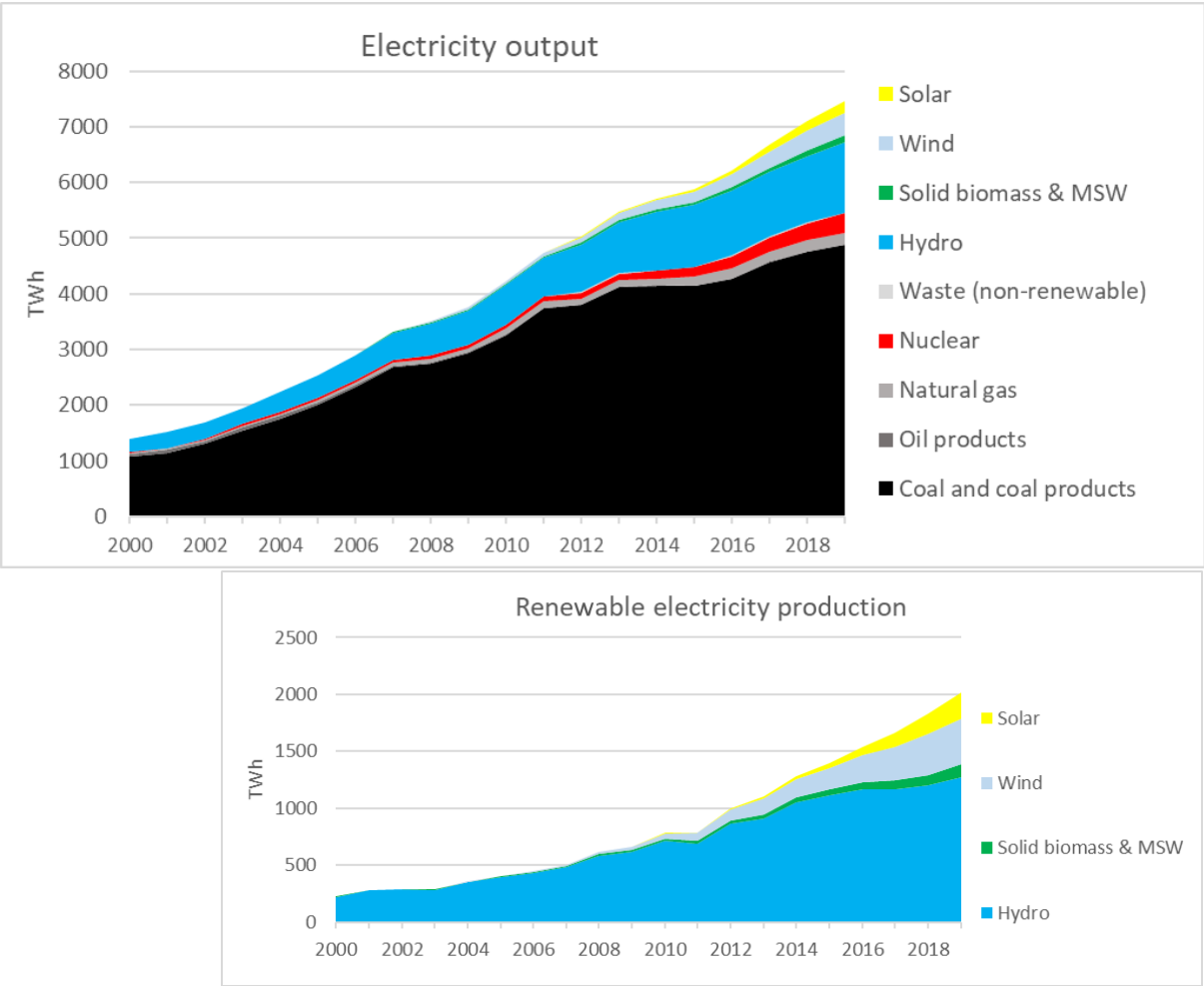


***Figure 4**: Evolution of the electricity mix in China 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)*

Policy framework

The main relevant policy instruments behind these evolutions, relevant for bioelectricity, are:

- Fixed feed-in tariff: Since 2010, the new agricultural and forestry biomass power generation projects have uniformly implemented the benchmark feed-in tariff of 0.75 yuan per kilowatt hour (including tax).
- Notice on improving price policy for bio-power from agricultural and forestry - July 18, 2010
- Views on promoting the healthy development of electricity from non-water renewable sources - January 20, 2020
- Improve the implementation plan of biopower project construction and operation - September 11, 2020

HEAT/FUEL

Figure 5 shows the role of different fuels/energy carriers for providing heat in different sectors (industry, residential sector, commercial and public services and other). Fuel use by energy producing industries for transformation and for own use is excluded. Mind that electric heating (direct or through heat pumps) is not included in these figures as this is not separately reported in IEA statistics.

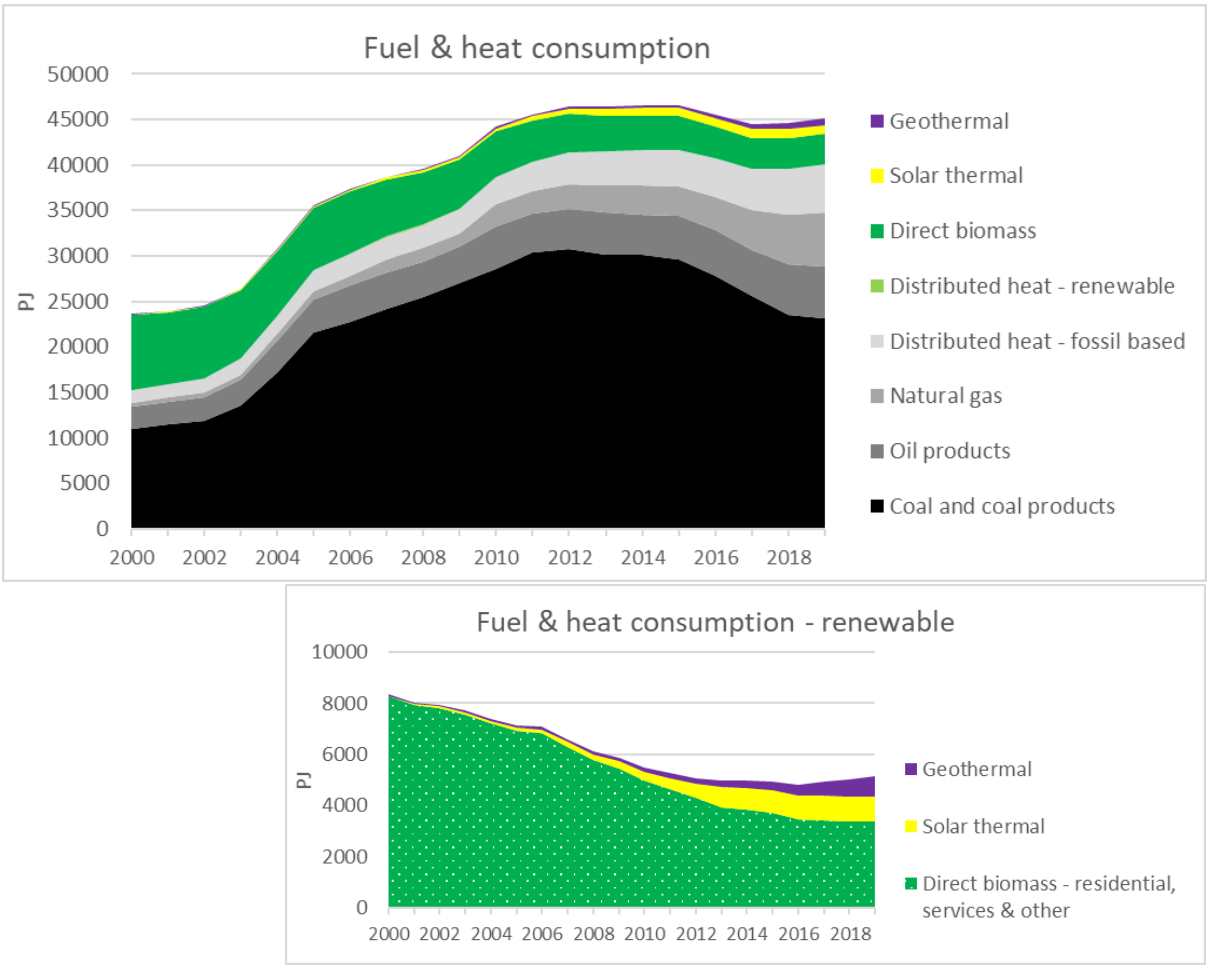


***Figure 5**: Evolution of fuel and heat consumption in China 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)*

The provision of heat is largely based on fossil fuels, mainly coal, oil products and natural gas. Direct use of coal still dominates, although there was a decline in the past years, which is mostly compensated by other fossil fuels and heat distribution. Direct use of biomass, which consists of 90% solid biomass and 10% biogas, represents around 7.5% (3.4 EJ) of heat provision. This is less than half of levels in the past. Most decline has been in the residential sector[15] where (traditional) biomass heating was replaced by oil and gas heating. On the other hand, there is also an increase of solar thermal and geothermal heat at residential level. Mind that the use of renewable energy for industry heat is marginal (<0.1%).

[15] The data used for biomass in residential applications are estimations. National statistics in China mainly monitor bioenergy use in commercial applications.

Heat output generated and sold by CHP plants and heat plants represents around 12% of fuel/heat provided and is steadily growing. This is also dominated by fossil fuels, particularly coal. The role of biomass for distributed heat is marginal (<0.2%).

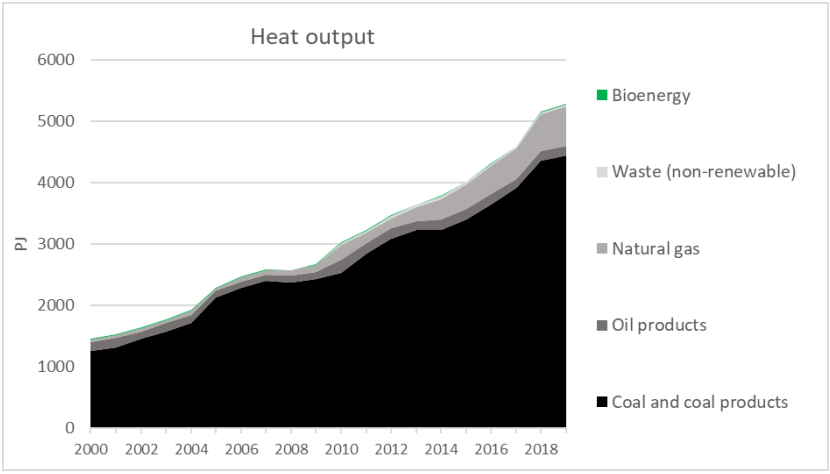


***Figure 6**: Evolution of fuels for heat output in China 2000 – 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)*

Policy framework

The main relevant policy instruments behind these evolutions, relevant for biomass-based heat, are:

- Guiding Opinions on Promoting the Development of Biomass-based Heating, December 2017
- North of China Winter Clean Heating Planning, December 2017
- 100 counties biomass CHP programme, January 2018

TRANSPORT

Figure 7 shows an overview of the energy used in transport in China, split up by different fuels/energy carriers. Transport energy continues to grow at an average pace of 6% per year. Diesel and gasoline are the dominant fuels. The consumption of diesel has stabilized around 5 EJ, but the consumption of gasoline is still increasing (now at 5.8 EJ). Natural gas is also used as transport fuel (~7%) and its share is growing. Between 2005 and 2012 there was an increase of biofuels, but this has stabilized for a certain period. In 2019 there was some growth both in biodiesel and bioethanol, together now representing around 0.9% of transport energy use in China.

Electricity *(of which 27% was renewable in 2019)* represents a share of 4.1% of total transport energy use; this share is steadily growing, partly through rail, partly through electric scooters and cars. The use of electricity in road vehicles is already substantial at 1.7% of Chinese transport energy use.

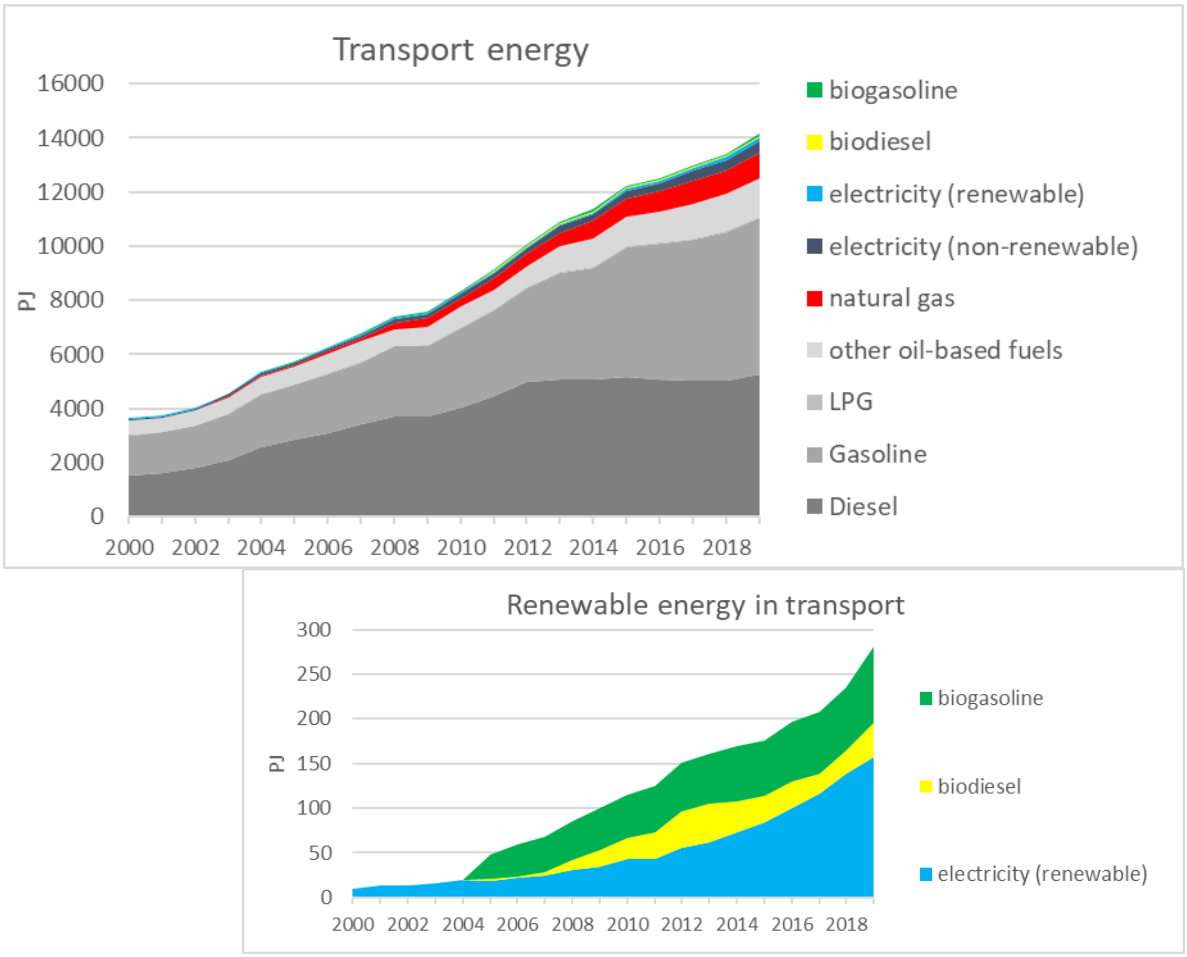


***Figure 7**: Evolution of transport fuels in China 2000 – 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)*

Policy framework

The main relevant policy instruments behind the evolutions in biofuels are:

- Expanded pilot programme for fuel ethanol - February 10, 2004
- Notification on strengthening the management of fuel ethanol projects, and promoting the healthy development of fuel ethanol industry - December 14, 2006
- Mid-long-term planning on the development of renewable energy - September 2007
- The 12th Five-Year Plan for bioenergy development (2011-2015) - July 24, 2012
- The 13th Five-Year Plan for bioenergy development (2016-2020) - October 28 ,2016
- Implementation plan on expanding biofuel ethanol production and promoting the use of fuel ethanol - September 13, 2017

RESEARCH FOCUS RELATED TO BIOENERGY

In terms of technical progress, from research to production practice, more attention has been paid to the development of flexible processing methods for various raw materials, construction of new product structures, and adoption of technical approaches to reduce process energy consumption, explore potential for net energy increase, as well as cost reduction. New approaches of cellulosic ethanol technology have been explored.

RECENT MAJOR BIOENERGY DEVELOPMENTS

The Chinese Academy of Agricultural Sciences (CAAS) and Beijing Shoulang Biotechnology Co., Ltd. jointly made breakthroughs in the core technology of clostridium ethanol protein, greatly improved the reaction speed (22 seconds synthesis) and created the world record of the highest protein yield of 85% in one-step biosynthesis under industrial conditions. October 30, 2021

LINKS TO SOURCES OF INFORMATION

An overview of the biomass energy policy in China - BE Sustainable Magazine (2015) http://www.besustainablemagazine.com/cms2/overview-of-biomass-energy-policy-in-china/

Global CO2 emissions and China's challenges (2021) http://english.scio.gov.cn/in-depth/2021-05/08/content_77475496.htm

b145a6631698460e8777d1ab4581ef1f.pdf (www.gov.cn)

Catalogue of Industries Encouraging Foreign Investment (2020 version - in Chinese): http://www.gov.cn/zhengce/zhengceku/2020-12/28/5574265/files/b145a6631698460e8777d1ab4581ef1f.pdf

Wei Liu, Congmin Liu, Parikshit Gogoi, Yulin Deng. Overview of Biomass Conversion to Electricity and Hydrogen and Recent Developments in Low-Temperature Electrochemical Approaches [J].Engineering, 2020,6(12):1351-1363. https://www.sciencedirect.com/science/article/pii/S2095809920303039

Bo Wu, et al. Current status and future prospective of bio-ethanol industry in China. Renewable and Sustainable Energy Reviews, Volume 145, July 2021, 111079 https://www.sciencedirect.com/science/article/abs/pii/S1364032121003671