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China's carbon emissions trend after the pandemic

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ABSTRACT

Is China on a path to peak its greenhouse gas emissions in the near future as it has pledged under the Paris Treaty? We compare carbon emissions and energy production trends in the first eight months of 2019 and the first eight months of 2023. The former period represents typical conditions before the COVID-19 pandemic, while the latter is the first period after China removed most COVID-19 related restrictions in December 2022. Carbon emissions increased by 10 % over this period or an average of 2.95 million tonnes per day, while emissions from the power sector, where decarbonization efforts might be expected to be first focused, increased by 21 %. Though renewable energy production has increased significantly, the production of fossil fuels continues to grow strongly. Coal production in the first eight months of 2023 grew at a compound rate of 6.1 % per annum since the corresponding period in 2019, and the share of coal in the total energy mix also increased for the first time since 2007, by 0.2 %, between 2021 and 2022. Therefore, there is little sign of "growing back greener". Going forward, the changing geopolitical environment may further impede China's emissions peaking.

1. Introduction

The recent series of extreme climate and weather events serves as a strong reminder that climate change remains one of the most pressing global issues. During the pandemic, the decrease in greenhouse gas emissions was seen by many as a chance for rapid progress toward a low-carbon economy. For instance, Chen et al. (2022) predicted that Chinese emissions would peak between 2021 and 2026 at a level between 11.7 and 13.1 Gt with more than 80 % probability, and Lui (2022) wrote that China is "set to significantly overachieve the targets it promised internationally for 2030, with emissions peaking by 2025." However, China's emissions, and especially those from the power sector, continue to grow strongly, raising concerns about China achieving its climate commitments. Furthermore, sluggish post-pandemic economic recovery and rising energy security concerns amidst a changing geopolitical landscape mean that China may struggle to reach these ambitious targets (Ahmed, 2023).

Currently, China is the world's second-largest economy and both the largest consumer of energy and emitter of carbon dioxide. Its energy consumption amounts to approximately 24 % of the global total. Thus, China's role in global efforts to combat climate change is critical. Since 2005, China has witnessed a significant surge in its primary energy demand by 47 %, and this trajectory is expected to continue with an additional increase of around 30 % between 2020 and 2040.[1] Fossil fuels remain dominant among China's primary energy sources, accounting for an overwhelming majority of energy use (83 %), while also being responsible for most of the country's carbon emissions.

Like many other countries, China is also facing the adverse impacts of climate change (Lu et al., 2022). For instance, Fig. 1 shows that on July 16th, 2023 Sanbao County recorded the country's highest temperature ever at a scorching 52.2 °C. Moreover, there has been a rise in the occurrence of extreme weather events such as floods, droughts, heatwaves, and sandstorms within the country. The economic cost of such events has significantly increased over the recent past (Dai et al., 2015). Pursuing the net-zero emissions goal is in China's self-interest.

This short communication aims to understand China's new carbon emissions and energy production trajectories following the pandemic by comparing the carbon emissions and energy production trends in the first eight months of 2019 to the first eight months of 2023. The former period represents typical conditions before the COVID-19 pandemic, while the latter is the first period after China removed most COVID-19-related restrictions in December 2022. Our research shows that carbon

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[1] https://climateactiontracker.org/countries/china/policies-action/ [Accessed July 2023]

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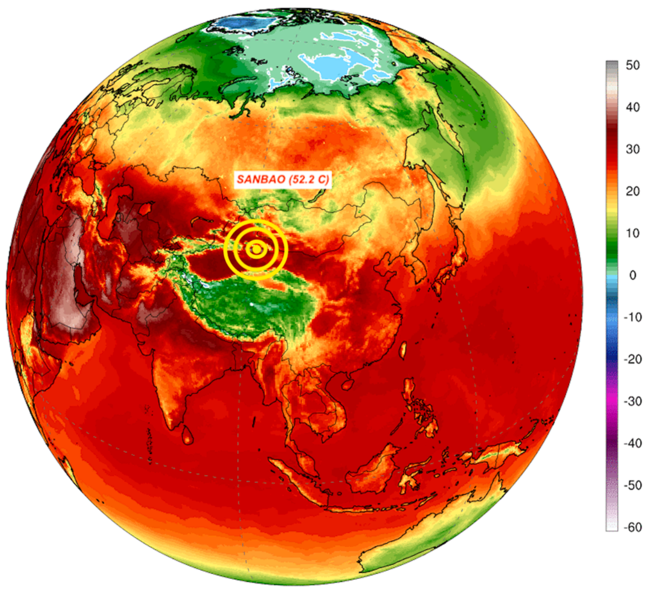

Fig. 1. GFS 2 m **Temperature (°C) July 16, 2023.** ClimareReanalizer.org, Climate Change Institute, University of Maine.

emissions have increased substantially over this period, and China is now following a more carbon intensive path than recent research suggested. It seems less likely that China will peak emissions before 2030. While research has addressed changes in Chinese carbon emissions during the pandemic (e.g. Li et al., 2023), the post-pandemic trend has not yet been investigated.

2. Analysis

We collected data on daily Chinese carbon emissions from Carbon Monitor (Liu et al., 2020). The box plots in Fig. 2 show the variation in daily emissions over the first eight months of each of the two years. The lowest daily emissions levels occur during the Chinese New Year period. There is very little variation in daily transport emissions. We test whether there is a statistically significant change in emissions between the two periods by estimating a separate regression equation with just a constant for each of 2019 and 2023 using seemingly unrelated regressions and then computing the difference in regression coefficients between the two equations and its standard error. We use Newey-West autocorrelation robust standard errors with 14 lags (See. Newey and West, 1987). Total emissions rose 2.95 million tonnes or 10 % (standard error = 0.38 million tonnes, $p = 0.0000$). Mean daily emissions from the power sector increased by 2.55 million tonnes or 21 % (0.34, 0.0000) between the two periods, while emissions from industry increased by 0.47 million tonnes or 4 % (0.22, 0.0028). On the other hand, there were no statistically significant changes in emissions from the two smallest sectors: transport (−0.03, 0.02, 0.1350) and residential (−0.04, 0.05, 0.3347). Monthly and annual Chinese data are from the National Bureau of Statistics of China.[2]

The shares of solar and wind in total power generation increased from 1.7 % and 4.9 %, respectively, in the first eight months of 2019, to 3.2 % and 9.0 % in the corresponding period in 2023. Fig. 3 shows that though electricity production from wind and solar grew very substantially over the four years, so did electricity generation from fossil fuels. Average monthly thermal power generation in the first eight months of the year increased 95 TWh or 23 % between 2019 and 2023, while generation from new renewables increased 50 TWh or 131 %. Nuclear generation increased by 29 %, while hydropower fell by 8 %. As a result, the share of thermal power in total generation only decreased from 71.9 % in 2019 to 70.5 % in 2023. So, it is not surprising that, with the majority of increased electricity output coming from fossil fuels, emissions of the sector increased substantially.

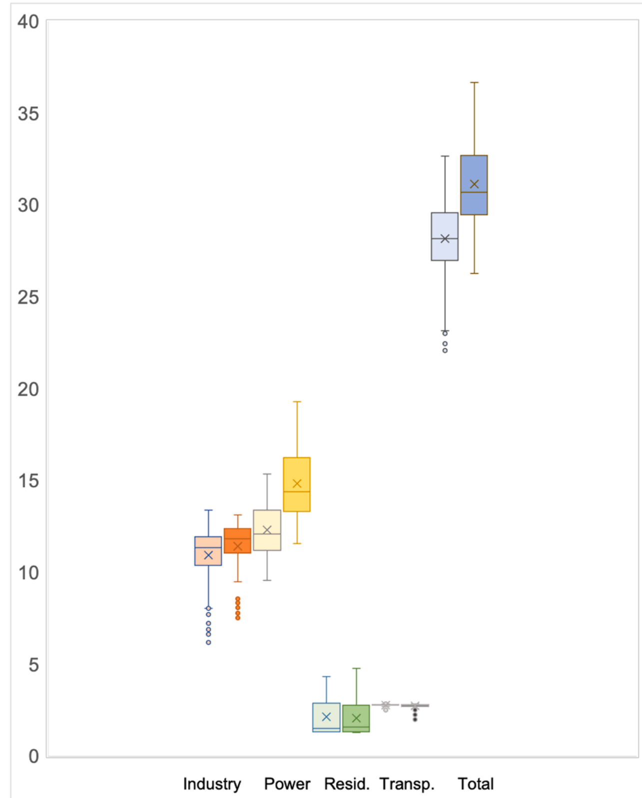

Fig. 2. Chinese Carbon Emissions in 2019 and 2023. Daily carbon dioxide emissions from fossil fuel and cement production. Each pair of box plots shows daily data for 2019 emissions on the left and 2023 on the right. Resid. = residential sector. Transp. = transportation sector. Source: Carbon Monitor.

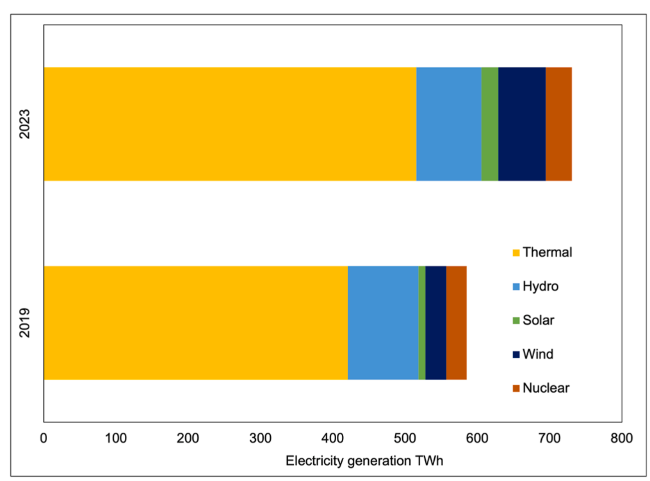

Fig. 3. Energy Sources of Chinese Electricity Production in 2019 and 2023. Figure shows monthly means for the first eight months of each year. Source: National Bureau of Statistics of China.

Production of energy in general has also continued to increase. Fig. 4 shows that coal production has grown fairly consistently over this period as shown by the fitted exponential trend. Comparing the first eight months of 2019 to the first eight months of 2018 coal production rose by

[2] https://data.stats.gov.cn/english/easyquery.htm?cn=A01 and https://data.stats.gov.cn/english/easyquery.htm?cn=C01 (Accessed, October 2023)

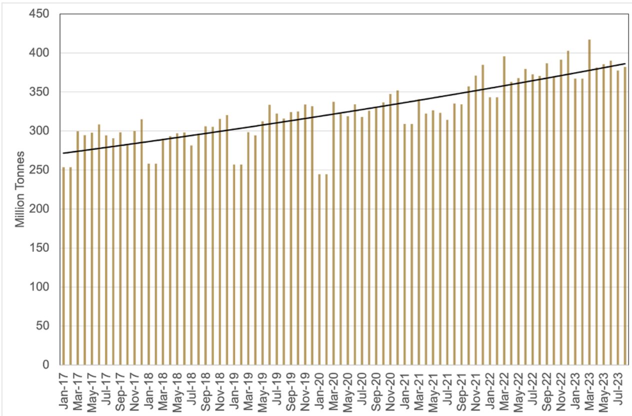

Fig. 4. Monthly Coal Production 2017–2023. Values for January and February are identical as only a total for both months is provided in the source. A fitted exponential trend is shown. Source: National Bureau of Statistics of China.

5.7 %, while coal production rose by 4.1 % between the first eight months of 2023 and the same period in 2022. Coal production in the first eight months of 2023 was 26.6 % higher than in the comparable period in 2019, a compound growth rate of 6.1 % per annum. For the first time since 2007, the share of coal in China's total energy consumption increased from 56 % in 2021 to 56.2 % in 2022.

3. Discussion

There may be catch up growth as well as economic stimulus as the economy comes out of pandemic period of slow growth, though, so far, news reports suggest a slow recovery. Previous research has found mixed results regarding the behavior of carbon emissions following recessions. Burke et al. (2015) found that globally over the five decades from 1961 to 2010 emissions tended to grow more slowly relative to GDP following recessions than after economic expansions became established. Similarly, Bersalli et al. (2023) found that 26 out of the 28 countries that have so far peaked carbon dioxide emissions did so just before or during a recession. However, emissions grew strongly in 2010 following the global financial crisis mainly because energy intensity rose (Jotzo et al., 2012).

Besides coal, China suffers from energy insecurity as it consumes much more oil than it produces. China also has the most to gain from reducing carbon emissions. Tol (2019, 188–189) estimates that around half the global benefits from mitigation accrue to China, and, as the largest emitter, a given percentage reduction in emissions in China translates to more avoided carbon than anywhere else. For these reasons, we might expect China to be a leader on climate action among developing countries. In the past, China has set seemingly ambitious climate mitigation goals, though these were not necessarily very strict compared to business as usual (Stern and Jotzo, 2010). Under the Paris Treaty, China has pledged to peak carbon emissions by 2030 and reach net zero emissions by 2060. However, following the energy crisis of 2022 and increased tensions between China and the West, China may have less incentive to continue to invest in the development and manufacture of renewable energy technologies (Goldthau and Tagliapietra, 2022). Furthermore, these increasing political tensions between the US and China are reducing the potential for co-operation on climate policy. For example, at COP 27 in Sharm As-Sheikh in November 2022, China did not join a pledge to curb methane emissions and refused to provide financial support as part of the Loss and Damage Fund. This stance and the data we have presented in this article cast some doubt on China following through on its previous pledges and certainly on peaking emissions in the next two years.

4. Conclusion

To examine whether China is on a path to peak carbon emissions by 2030 and carbon neutrality by 2060 under the Paris Agreement, we compare China's carbon emissions and energy production trajectories first eight months of 2019 and 2023, defined as pre- and post-pandemic periods, respectively. We find that China's total emissions rose by 2.95 million tonnes a day (a 10 % increase) with contributions from the power sector of 2.55 million tonnes (21 %) and from industry of 0.47 million tonnes (4 %). However, the emissions from the transport and residential sectors remained stable. Regarding energy production, the production of coal has grown at a compound annual rate of 6.1 % since 2019. Moreover, we note that the share of coal in China's total energy production increased for the first time since 2007, from 56 % in 2021 to 56.2 % in 2022.

Our new findings contrast with the research of Le Quere et al. (2021), who argued that "the pervasive disruptions from the COVID-19 pandemic have radically altered the trajectory of global CO_2 emissions" (197). Emissions fell sharply globally because of the curtailment of passenger transport during the pandemic (Jiang and Stern, 2023) but Le Quere et al. (2021) believed there was a window of opportunity to continue the slowing of emissions growth that they had seen since 2015. Similarly, Chen et al. (2022) predicted that Chinese emissions would peak between 2021 and 2026 at a level between 11.7–13.1 Gt with more than 80 % probability and Lui (2022) wrote that China is "set to significantly overachieve the targets it promised internationally for 2030, with emissions peaking by 2025." Nonetheless, our findings suggest that China may find it challenging to achieve these targets within that time frame. China needs to make renewed efforts to reduce emissions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

Ahmed, K., 2023. Perspective on China's commitment to carbon neutrality under the innovation-energy-emissions nexus. J. Clean. Prod. 390, 136202.
Bersalli, G., Tröndle, T., Lilliestam, J., 2023. Most industrialised countries have peaked carbon dioxide emissions during economic crises through strengthened structural change. Commun. Earth Environ. 4 (1), 44.
Burke, P.J., Shahiduzzaman, M., Stern, D.I., 2015. Carbon dioxide emissions in the short run: the rate and sources of economic growth matter. Glob. Environ. Chang. 33, 109–121.
Chen, J., Xu, C., Gao, M., Li, D., 2022. Carbon peak and its mitigation implications for China in the post-pandemic era. Sci. Rep. 12 (1), 3473.
Dai, J., Kesternich, M., Löschel, A., Ziegler, A., 2015. Extreme weather experiences and climate change beliefs in China: an econometric analysis. Ecol. Econ. 116, 310–321.
Goldthau, A., Tagliapietra, S., 2022. Energy crisis: five questions that must be answered in 2023. Nature 612 (7941), 627–630.
Jiang, X., Stern, D.I., 2023. Asymmetric business cycle changes in U.S. carbon emissions and oil market shocks. Clim. Change.
Jotzo, F., Burke, P.J., Wood, P.J., Macintosh, A., Stern, D.I., 2012. Decomposing the 2010 global carbon dioxide emissions rebound. Nat. Clim. Change 2 (4), 213–214.
Le Quéré, C., Peters, G.P., Friedlingstein, P., Andrew, R.M., Canadell, J.G., Davis, S.J., Jackson, R.B., Jones, M.W., 2021. Fossil CO2 emissions in the post-COVID-19 era. Nat. Clim. Change 11 (3), 197–199.
Li, H., Zheng, B., Ciais, P., Boersma, K.F., Riess, T.C.V., Martin, R.V., Broquet, G., van der A, R., Li, H., Hong, C., Lei, Y., 2023. Satellite reveals a steep decline in China's CO2 emissions in early 2022. Sci. Adv. 9 (29) eadg7429.
Liu, Z., Ciais, P., Deng, Z., Davis, S.J., Zheng, B., Wang, Y., Cui, D., Zhu, B., Dou, X., Ke, P., Sun, T., 2020. Carbon Monitor, a near-real-time daily dataset of global CO_2 emission from fossil fuel and cement production. Sci. Data 7 (1), 392.

Lu, L.C., Chiu, S.Y., Chiu, Y.H., Chang, T.H., 2022. Sustainability efficiency of climate change and global disasters based on greenhouse gas emissions from the parallel production sectors–a modified dynamic parallel three-stage network DEA model. J. Environ. Manage. 317, 115401.

Lui, S., 2022. Guest post: why China is set to significantly overachieve its 2030 climate goals. Carbon Brief, 19 May (2022). https://www.carbonbrief.org/guest-post-why-china-is-set-to-significantly-overachieve-its-2030-climate-goals/.

Newey, W.K., West, K.D., 1987. A simple, positive semi-definite, heteroskedasticity and autocorrelation. Econometrica 55 (3), 703–708.

Stern, D.I., Jotzo, F., 2010. How ambitious are China and India's emissions intensity targets? Energy Policy 38 (11), 6776–6783 (2010).

Tol, R.S.J., 2019. Climate Economics: Economic Analysis of Climate, Climate Change and Climate Policy, 2nd ed. Edward Elgar, Cheltenham.