Impact of the Clean Development Mechanism on the expansion of renewable energies in China

Comparative analysis

Case study for the course Economic Development

Faculty of Economics

Chulalongkorn University

Table of contents

List of Figures

Introduction

Through the emission of greenhouse gases human activities caused global warming, which raised global surface temperatures to 1.1°C above the levels from 1850 to 1900 during the period from 2011 to 2020. These changes affect weather and climate extremes that lead to losses to nature and people (IPCC, 2023). The United Nations acknowledged climate change with the United Nations Framework Convention on Climate Change (UNFCCC) and defined the consolidation of greenhouse gas concentration at a level that prevents harmful adverse impacts to the climate system as their ultimate objective.

In order to achieve this objective emissions have to be reduced across various sectors. In 2022, at 43.8%, electricity and heat producers contributed the most to global greenhouse gas emissions (IEA, 2024b). With 31.1% China contributes the most to global greenhouse gases, with electricity and heat producers accounting for 57.2% of its total emissions (IEA, 2024a). Through this electricity and heat producers in China are the largest emitter of global greenhouse gases, accounting for 40.6% of the emissions in this sector. Renewable energies offer an alternative to fossil fuels to reduce greenhouse gas emissions in the electricity and heat production. Unlike fossil fuels, which can be depleted and contribute to environmental harm, renewable energies are derived from natural processes that are replenished. With 24.4% the renewable energy capacity of China exceeds all other countries (IRENA, 2024). The case study will focus on the energy sector and China as both are the largest global emitters of greenhouse gases.

Figure 1 Sustainable development goals

Source: United Nations Development Programme

Even though the sustainable development goals might have been influenced by competing interests of economic, social and environmental actors and the different dimensions are difficult to compare, these dimensions represent a transnational accepted definition of sustainable development and shall be used to discuss the impact of renewable energies on sustainable development.

Renewable energies drive sustainable development as defined in the Sustainable Development Agenda of the United Nations on various dimensions. Besides the obvious contribution to the seventh and the thirteenths goal, renewable energy might contribute to some of the other sustainable development goals.

Tian et al. (2024) discuss some other positive impacts of renewable energy on the sustainable development goals and the literature provides some evidence that these positive impacts can be applied to the Chinese case. As renewable energy can provide access to electricity to impoverished individuals, these might contribute to the first goal (Kwansinski et al., 2012). Cheng et al. (2021) discuss several cases in which the expansion of renewable energies has contributed to poverty alleviation in China. As agriculture becomes more profitable when combined with renewable energy, renewable energy might contribute to the second goal (Chel & Kaushik, 2011). Hu (2024) presents some evidence of such paired production in China. With the third goal, renewable energy might contribute to the reduction of air pollution and through this decrease the associated health consequences (Torres-Duque et al., 2008). Zhang et al. (2023) confirm decreasing air pollution because of renewable energy in China. As renewable energy plants can be installed without further deforestation and can repurpose degraded land, these might contribute to the fifteenth goal (Fthenakis & Kim, 2009). Lin and Wang (2023) argue for exploitation of wind and solar energy sources in degraded land in China.

Even though the described effects of renewable energy on sustainable development cover not all of the sustainable development goals, Tien et al. (2024) derive similar connections for the other goals. Through this renewable energies combine the mitigation of greenhouse gases with sustainable development. With the Kyoto Protocol a mechanism was established by the United Nations that was supposed to serve the same purpose. The Clean Development Mechanism (CDM) was supposed to reduce greenhouse gas emission while promoting sustainable development.

Even though the literature on whether the CDM initiated sustainable development in China is diffuse, there is sufficient evidence that renewable energy expansion initiated by the CDM contributed to sustainable development in China. For instance, Du and Takeuchi (2019) illustrate how renewable energy expansion initiated by the CDM contributes to the first goal, while Wan et al. (2024) discuss the contribution to the third goal.

Therefore a positive effect of the CDM on sustainable development in the energy sector in China can be assumed. This case study aims to answer the question of the extent to **which the CDM contributed to the expansion of renewable energy in China.** For this purpose, a descriptive analysis will be conducted, followed by a comparative analysis. Through the **descriptive analysis patterns within the impact of the CDM on renewable energy expansion will become apparent.** The comparative analysis enables benchmarking and performance evaluation and provides the basis for the following discussion of possible strengths and weaknesses of the promotion of renewable energies through the CDM in China.

Before the analysis is performed, the databases are presented and our methodological approach is explained.

The analysis will compare the share of the overall renewable energy capacity in China related to the CDM with the mean share of the other countries that implemented renewable energy capacity through the CDM in order to obtain an indicator for the performance of the CDM in the renewable energy sector in China. In order to assess whether deviations can be attributed to regional differences, we will compare the share with the mean share in Africa, America, Asia, Europe and Oceania.

The analysis will be followed by the discussion of possible explanations for the performance of the CDM in the renewable energy sector in China. The discussion will focus on the relevant literature.

In conclusion, the main findings are summarized and weighed against each other. Policy implications are derived on this basis.

Methodology

The descriptive section of the analysis is based on the Database for Project Activities and Programme of Activities of the UNFCCC. The database includes a wide selection of variables about the properties of projects in the phases of the registration process. The analysis utilized the variables project (sub-)type, project status, country (sub-)region and the installed capacity of electrical or thermal energy. The data is as of October 10, 2024.

The comparative section of the analysis is based on the Renewable Energy Statistics of the International Renewable Energy Agency (IRENA). The database illustrates the maximum net generating capacity of power plants and other installations that use renewable energy sources. The analysis utilized the variable total renewable energy capacity. For most countries the data is as of December 31, 2023.

Even though the data are not collected at the same time, as the most recent registration of a project under the CDM occurred on February 12, 2021 the databases are comparable.

As the database of the UNFCCC includes data on both registered as well as rejected projects, the registered projects were extracted from the database. From the registered projects, those that have capacity installed were identified. Based on this the renewable energy capacity related to the CDM in China as well as in the World, in Africa, in America, in Asia, in Europe and in Oceania was deducted.

The countries that installed capacity through the CDM were identified and categorized in the regions Africa, America, Asia, Europe and Oceania. Based on the database of the IRENA the total renewable energy capacity of the countries that installed capacity through the CDM in these regions was determined.

The total renewable energy capacity in countries that installed capacity through the CDM was compared with the capacity installed through the CDM in these countries on the regional level. Through this the respective share for China and the regions and subregions was obtained. The contribution of China to the capacity installed through the CDM was excluded from the share for the World and for Asia in order to determine the mean share of the other countries that implemented renewable energy capacity through the CDM.

Results

China has emerged as a dominant player in the Clean Development Mechanism (CDM), a market-based mechanism under the Kyoto Protocol that allows industrialized countries to invest in emission-reduction projects in developing countries. This dominance is evident in both the share of renewable energy capacity within participating countries and the share of renewable energy projects related to the CDM.

Figure 2 Total renewable energy capacity in host countries of renewable energy projects

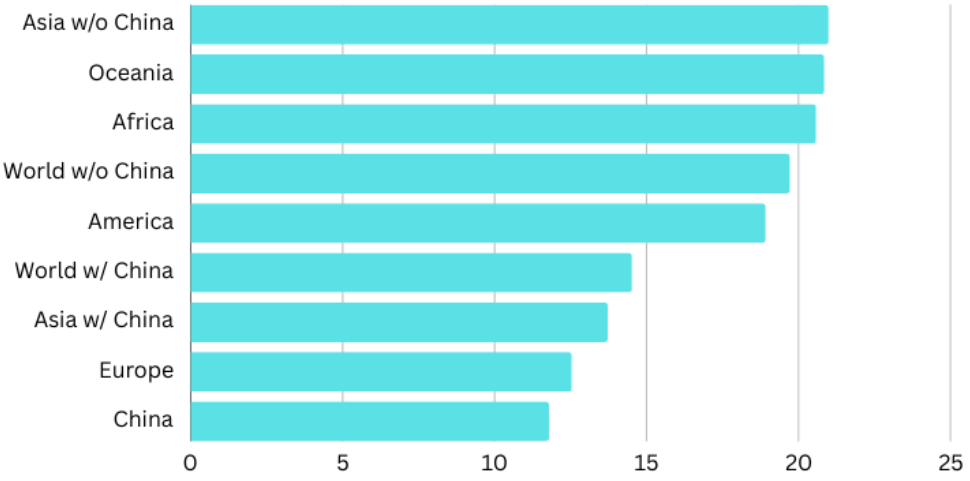
Source: Renewable Energy Statistics (IRENA, 2024)

Figure 3 Renewable energy capacity related to renewable energy projects

Source: Database for Project Activities and Programmes of Activities (UNFCCC, 2024)

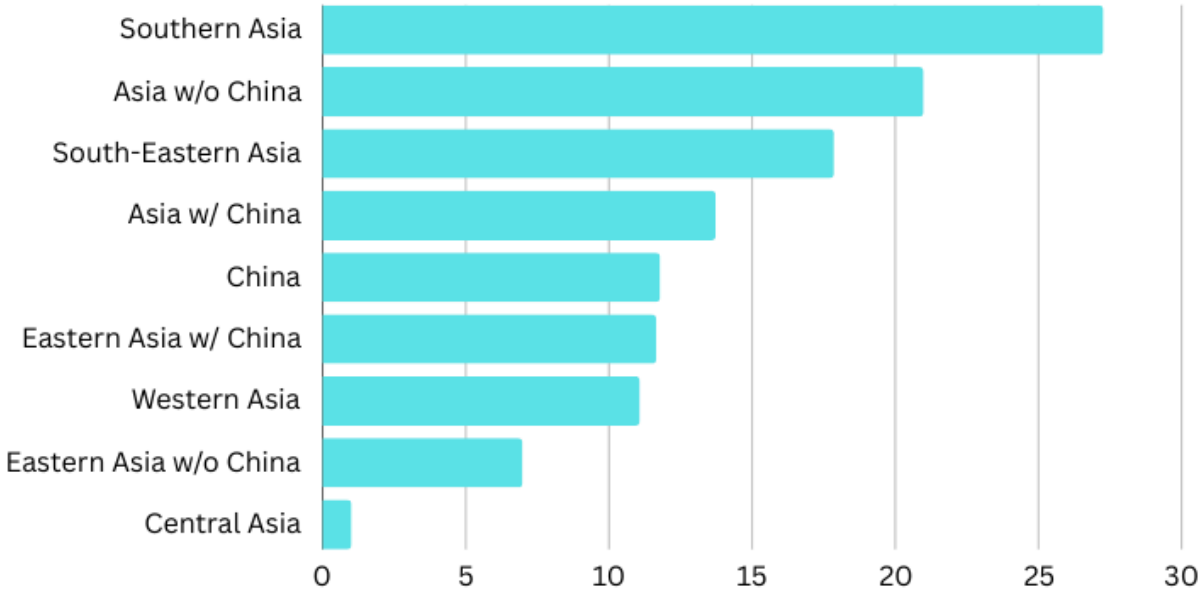
We also managed to see the competitiveness of China's CDM relative to its region and subregion, and we can see that China's CDM project is still very large.

Figure 4 Total renewable energy capacity related to renewable energy projects by region



Source: Database for Project Activities and Programmes of Activities (UNFCCC, 2024), Renewable Energy Statistics (IRENA, 2024)

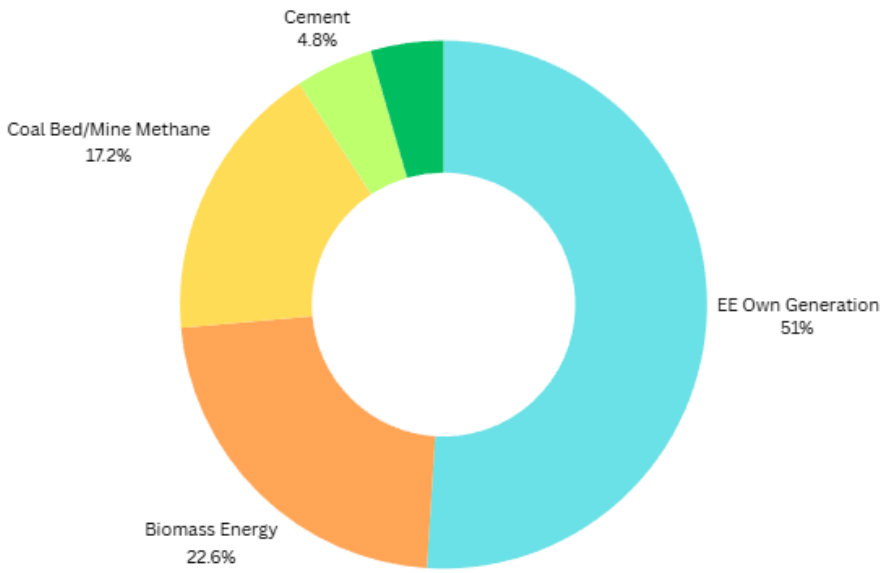
Figure 5 Total renewable energy capacity related to renewable energy projects by subregion



Source: Database for Project Activities and Programmes of Activities (UNFCCC, 2024), Renewable Energy Statistics (IRENA, 2024)

Is this huge investment from other countries to China really impactful to China's renewable energy transition? To know that, first we should know where the most money goes.

Figure 10 Leading Sectors of CDM Projects in China



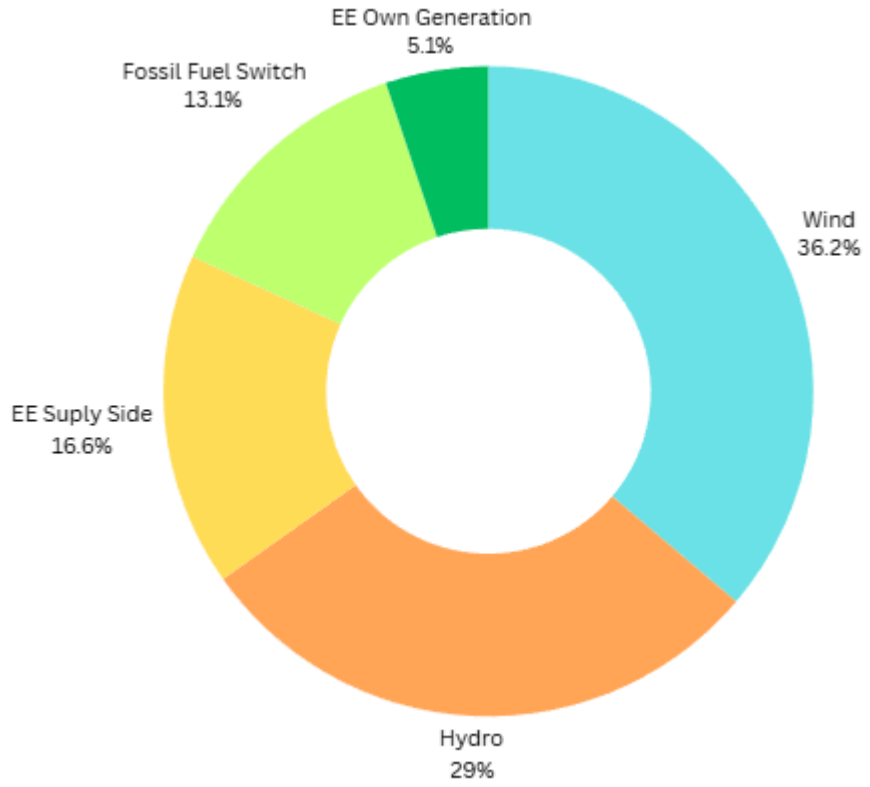
Source: Database for Project Activities and Programmes of Activities (UNFCCC, 2024)

From this graph which is generated from the UNFCCC dataset, we know that most of the investment will go to renewable energy generation which surely will have a significant impact on energy transformation in the long run. After that, most of the fund went to Biomass

energy and Coal Methane which are known to have a lot of emissions and investing in those sectors will help to reduce the emissions.

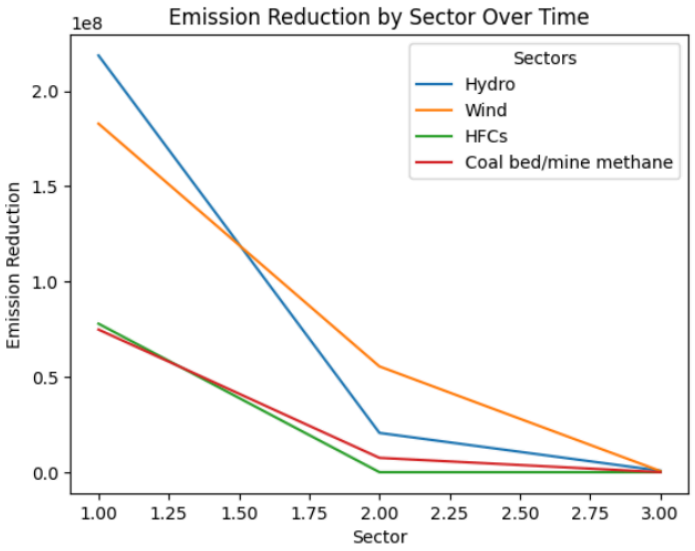
While China's dominance in the CDM has contributed to significant emission reductions especially in renewable energy, it is important to consider the potential risks and challenges associated with overreliance on a single sector. A more diversified approach, involving a wider range of sectors in renewable energy investment, could enhance the resilience and effectiveness of the CDM. And from this generated result, it is shown that the investment to renewable energy not only focused on one specific renewable energy type, but diversed on various sources.

Figure 11 Leading sectors with the most Installed Capacity

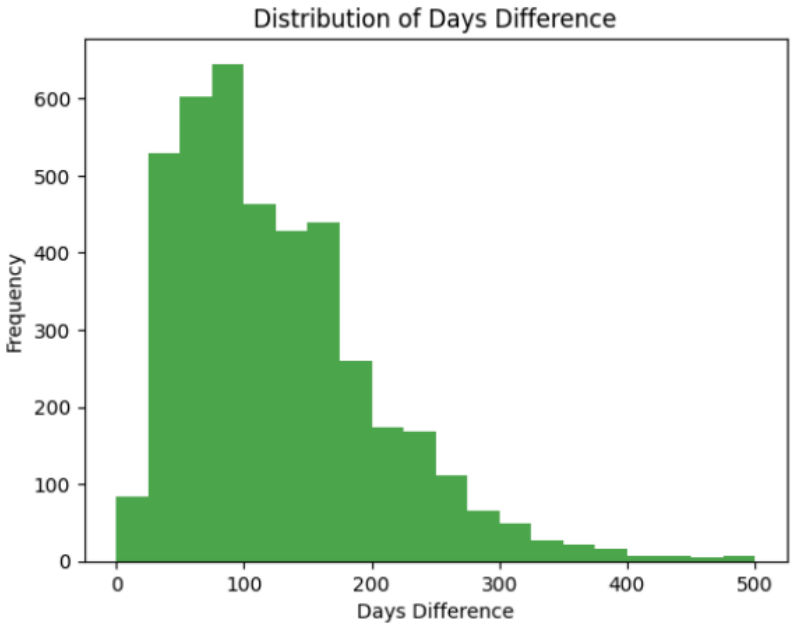


Source: Database for Project Activities and Programmes of Activities (UNFCCC, 2024)

We also managed to see how sustainable (or continuous) this emission reduction is by time. From a 3 year time span, the generated result shows the top 4 sectors which have the highest emission reduction over time. Even though there is still impact in the third year, the emission reduced slows down in the third year.



The country's strong economic growth, supportive regulatory framework, and increasing demand for clean energy have created a favorable investment climate especially in the CDM project. However, it is crucial to conduct thorough due diligence and assess the specific risks associated with each project.



The average days for China is 66 days and it is shown that China still needs work in terms of its registration process.

China's efficient registration and actualization process for CDM projects further enhances its attractiveness as an investment destination. The country's streamlined procedures and transparent regulatory environment contribute to a smooth project approval and implementation process.

In conclusion, China's dominance in the CDM has played a crucial role in driving the global energy transition. By investing in renewable energy projects in China, both developed and developing countries can benefit from reduced emissions and sustainable development. However, a balanced approach, involving a diverse range of countries, is essential to ensure the long-term success of the CDM.

Discussion

The results are diffuse as China overperforms in absolute terms while underperforming in relative terms. The literature provides evidence for both phenomena.

The literature discusses some explanations for the dominance of China within the CDM in the renewable energy sector. The likelihood of renewable energy projects under the CDM is higher for countries with faster economic growth, which might be because of the increasing demand for electricity (Rahman et al., 2016). China has exhibited a high growth rate of gross domestic product (World Bank, 2024) as well as of energy demand (IEA, 2024a) since the adoption of the Kyoto Protocol. Other determinants that influence the likelihood of renewable energy projects under the CDM are the mitigation potential and the project capacity (Rahman et al., 2016). Given that China is the largest emitter of greenhouse gases (Crippe et al., 2023) the mitigation potential is sophisticated. The extent of renewable energy projects under the CDM (UNFCCC, 2024) indicates a high project capacity of China. The impact of these determinants is reinforced by the positive correlation between larger gross domestic product, energy usage and institutional infrastructure. The characteristics of China suggest a supportive influence on renewable energy projects (Rahman et al., 2016).

While China accounts for the largest absolute number of CDM projects in the renewable energy sector, the contribution to the overall expansion of renewable energies in China remains rather small. The literature discusses some explanations for this. Schneider et al. (2010) argue that the dependence on carbon price and regional conditions differ across technologies. The impact of a carbon price to wind and hydro projects is rather small as these technologies are more dependent on regional conditions. As the renewable energy sector in China is dominated by wind and hydro (Lewis, 2010) this indicates a rather small importance of the global carbon price for the extension of renewable energy in China.

In order to get registered, a project must demonstrate that the greenhouse gas emissions reductions would not have occurred in the absence of the CDM. The observation that wind and hydro are close to the profitability threshold complicates the provision of evidence for the

additionality of a project (Schroeder, 2009). For instance, in December 2009, 50 Chinese wind projects under the CDM were rejected as the Executive Board accused the Chinese government of having lowered subsidies for wind power to make their emission reductions additional (Bloomberg, 2009).

Schroeder (2009) states that compared to other project types within the CDM, renewable energy projects are not the most profitable ones. Since renewable energy projects tend to issue a small amount of Certified Emission Reductions (CER) the transaction costs are more significant. This generates a comparative disadvantage compared to other types of CDM projects.

Kim and Park (2018) argue that the CDM has a significant positive impact on the development of renewable energy in countries with less developed financial markets, where debt and equity financing are limited as the CDM improves the access to financing in the renewable energy sector. As the credit market, the equity market and the overall financial market are well-developed in China, the CDM is not an important determinant of renewable energy deployment in China as capital can be raised from domestic markets. The green financial market of China exceeds that of any other developing country (Du et al., 2023). These findings contradict with the conclusion of Rahman et al. (2016). Even though Rahmen et al. (2016) also assume that the capital for CDM projects in poorer developing countries is scarce, resulting in a greater proportion of foreign investment, the association was not found robust for renewable energy projects. The authors attribute this to the need of renewable energy projects for more sophisticated infrastructure and energy policy.

The Chinese dual approach of attracting foreign investment and technology transfer while building a local renewable energy industry at the same time influences the dependence of the renewable energy sector on the CDM in China. Measures such as reduced corporate income taxes, substantial value-added tax reductions, feed-in tariffs and subsidies for project operators to offset their cost make renewable energy projects financially viable even without the revenues through the CDM (Rahman et al., 2015). These measures also reduce the additionality of a project.

While these factors have added to the low contribution of the CDM to the renewable energy sector in China, the ambitious expansion targets of the Chinese government might contribute most to explaining the low contribution (Qi et al., 2014). Even though the contributions of the CDM to the renewable energy sector in China have been substantial, the expansion of

renewable energy on an unprecedented scale necessitated the expansion to be financed through various sources.

Conclusion

The CDM will be followed by the Sustainable Development Mechanism (SDM) as proposed by the Paris Agreement. The parties of the Paris Agreement are still negotiating the methodologies and the SDM is still not operational.

Du et al. (2023) underline that caution should be applied in the comparison of the performance of the CDM in China with other developing countries as the impact might differ between the centrally planned economy of China and free market-based economies. However, the results give sufficient basis to discuss some policy recommendations.

The results indicate that China was able to access financing sources outside the CDM. In order to widen the extent through which renewable energy contributes to sustainable development, adjustments should focus on smaller projects and poorer countries. In order to reduce transaction costs, Mele et al. (2021) propose the differentiation and simplification of implementation rules. The reduction of bureaucratic inefficiencies in the project approval and verification process (Lewis, 2010) and streamlining administrative procedures (Schneider et al., 2010) might contribute to the participation of poorer countries. Schneider et al. (2010) underline the need for institutional capacity building while Kim and Park (2018) emphasize a design that enables countries with poor domestic financial markets to participate.

In order to expand the effect of renewable energy on sustainable development Schneider et al. (2010) propose multiplication factors to increase or decrease issued reductions with regards to their contribution to sustainable development. Mele et al. (2021) underline the need to address additionality concerns. Renewable energy subsectors that are close to the profitability threshold could be allocated less reductions (Schneider et al., 2010).

References

Bloomberg. (2009). UN Stops Certifying Wind Projects in China. *Bloomberg*. https://www.bloomberg.com/news/articles/2009-12-02/un-stops-certifying-wind-projects-in-china

Chel, A., & Kaushik, G. (2011). Renewable energy for sustainable agriculture. *Agronomy Sustainable Development*, *31*. https://doi.org/10.1051/agro/2010029

Cheng, X., Chen, J., Jiang, S., Dai, Y., Zeng, J., Shuai, C., Liu, J., Li, W., Liu, Y., Kang, X., Wang, C., Zhou, M., Zhang, P., Song, Y., Zou, L., Zhou, H., Wang, C., Chu, Q., & Liu, G. (2021). Purshuing sustainable development goals: A review of renewable energy and poverty alleviation nexus. *Environmental Development*, *40*. https://doi.org/10.1016/j.envdev.2021.100679

Crippa, M., Guizzardi, D., Pagani, F., Banja, M., Muntean, M., Schaaf, E., Becker, W., Monforti-Ferrario, F., Quadrelli, R., Risquez Martin, A., Taghavi-Moharamli, P., Köykkä, J., Grassi, G., Rossi, S., Brandao De Melo, J., Oom, D., Branco, A., San-Miguel, J., & Vignati, E. (2023). GHG emissions of all world countries. *Publication Office of the European Union*. https://doi.org/10.2760/953332

Du, J., Shen, Z., Song, M., & Vardanyan, M. (2023). The role of green financing in facilitating renewable energy transition in China: Perspectives from energy governance, enevironmental regulation, and market reforms. *Energy Economics*, *120*. 10.1016/j.eneco.2023.106595

Du, Y., & Takeuchi, K. (2019). Can climate mitigation help the poor? Measuring impacts of the CDM in rural China. *Journal of Environmental Economics and Management*, *95*. https://doi.org/10.1016/j.jeem.2019.03.007

Fthenakis, V., & Kim, H. C. (2009). Land use and electricity generation: A life-cycle analysis. *Renewable and Sustainable Energy Reviews*, *13*. https://doi.org/10.1016/j.rser.2008.09.017

Hu, Z. (2024). Toward solar extractivism? A political ecology understanding of the solar energy and agriculture boom in rural China. *Energy Research & Social Science*, *98*. https://doi.org/10.1016/j.erss.2023.102988

Intergovernmental Panel on Climate Change. (2023). Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. 10.59327/IPCC/AR6-9789291691647

International Energy Agency. (2024 [a]). *China*. Energy system of China. Retrieved November 06, 2024, from https://www.iea.org/countries/china/emissions

International Energy Agency. (2024 [b]). *World*. Global energy system. Retrieved November 06, 2024, from https://www.iea.org/world/emissions

International Renewable Energy Agency. (2024). Renewable capacity statistics 2024. 978-92-9260-587-2

Kim, J., & Park, K. (2018). Effect of the Clean Development Mechanism on the development of renewable energy: Less developed vs. well-developed financial markets. *Energy Economics*, *75*. 10.1016/j.eneco.2018.07.034

Kwansinski, A., Krishnamurthy, V., Song, J., & Sharma, R. (2012). Availability Evaluation of Micro-Grids for Resistant Power Supply During Natural Disasters. *IEEE Transactions on Smart Grid*, *3*. 10.1109/TSG.2012.2197832

Lewis, J. I. (2010). The eveloping role of carbon finance in promoting renewable energy development in China. *Energy Policy*, *38*. 10.1016/j.enpol.2010.01.020

Lin, V. K., & Wang, J. H. (2023). The Green Energy Transition and Peripheral City Development in China: Towards a Local Eco-developmental State. *Development and Change*, *54*. https://doi.org/10.1111/dech.12765

Mele, A., Paglialunga, E., & Sforna, G. (2021). Climae cooperation from Kyoto to Paris: What can be learnt from the CDM experience. *Socio-Economic Planning Sciences*, *75*. 10.1016/j.seps.2020.100942

Qi, T., Zhang, X., & Karplus, V. J. (2014). The Energy and CO2 Emissions Impact of Renewable Energy Development in China. *Energy Policy*, *68*. https://doi.org/10.1016/j.enpol.2013.12.035

Rahman, S. M., Dinar, A., & Larson, D. F. (2016). The incidence and extent of the CDM across developing countries. *Environment and Development Economics*, *21*. 10.1017/S1355770X15000388

Rahman, S. M., Larson, D. F., & Dinar, A. (2015). Cost of greenhouse gas emissions abatement under the Clean Development Mechanism. *Climate Change Economics*, *6*. 10.1142/S2010007815500050

Schneider, M., Schmidt, T. S., & Hoffmann, V. H. (2010). Performance of renewable energy technologies under the CDM. *Climate Policy*, *10.1*. 10.3763/cpol.2008.0580

Schroeder, M. (2009). Utilizing the clean development mechanism for the development of renewable energies in China. *Applied Energy*, *86*. 10.1016/j.apenergy.2008.04.019

Tian, J., Culley, S. A., Maier, H. R., & Zecchin, A. C. (2024). Is renewable energy sustainable? Potential relationships between renewable energy production and the Sustainable Development Goals. *Nature Partner Journals Climate Action*, *3*. https://doi.org/10.1038/s44168-024-00120-6

Torres-Duque, C., Maldonado, D., Perez Padilla, R., Ezzati, M., & Viegi, G. (2008). Biomass Fuels and Respiratory Diseases: A Review of the Evidence. *Proceedings of the American Thoracic Society*, *5*. 10.1513/pats.200707-100RP

United Nations Environment Programme. (2024). Emissions Gap Report 2024. https://doi.org/10.59117/20.500.11822/46404

United Nations Framework Convention on Climate Change. (2024). *Database for Project Activities and Programmes of Activities*. United Nations Framework Convention on Climate Change. https://cdm.unfccc.int/Projects/projsearch.html

Wan, P., Zhang, Z., & Chen, L. (2024). Environmental Co-benefits of Climate Mitigation: Evidence from Clean Development Mechanism Projects in China. *China Economic Review*, *85*. https://doi.org/10.1016/j.chieco.2024.102182

World Bank. (2024). *World Economic Indicators*. China. Retrieved 11 08, 2024, from https://data.worldbank.org/country/china

Zhang, G.-X., Yang, Y., Su, B., Nie, Y., & Duan, H.-B. (2023). Electricity Production, Power Generation Structure, and Air Pollution: A Monthly Data Analysis for 279 Cities in China (2015-2019). *Energy Economics*, *120*. https://doi.org/10.1016/j.eneco.2023.106597

Appendix

(Sub-)region	Total capacity (MW)	Installed capacity (MW)	Share (%)
World (w/ China)	2,225,066.00	323,514.85	14.54
World (w/o China)	771,365.00	152,136.06	19.72
Africa	48,696.00	10,020.00	20.58
Eastern Africa	9,948.00	2,234.74	22.46
Middle Africa	8,488.00	1,069.86	12.60
Northern Africa	13,510.00	2,087.51	15.45
Southern Africa	11,335.00	3,416.37	30.14
Western Africa	5,415.00	1,211.69	22.38
America	322,320.00	58,952.42	18.29
Caribbean	3,870.00	745.76	19.27
Central America	46,679.00	11,978.00	25.66
South America	271,771.00	46,227.87	17.01
Asia (w/ China)	1,843,260.00	253,137.01	13.73
Asia (w/o China)	389,559.00	81,758.21	20.99
China	1,453,701.00	171,378.80	11.79
Central Asia	8,431.00	85.00	1.01
Eastern Asia (w/ China)	1,496,961.00	174,398.20	11.65
Eastern Asia (w/o China)	43,260.00	3,019.40	6.98
Southern Asia	212,001,00	57,804.78	27.27
South-Eastern Asia	101,766.00	18,179.36	17.86
Western Asia	24,101.00	2,669.66	11.08
Europe	10,165.00	1.274,96	12.54
Southern Europe	10,165.00	1.274,96	12.54
Oceania	625.00	130.30	20.85
Melanesia	625.00	130.30	20.85