BU Global Development Policy Center

GCI WORKING PAPER 043 • 06/2025

Empowering Africa

THE IMPACT OF CHINA'S POWER FINANCE ON ENERGY POVERTY

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ABSTRACT

Sustainable Development Goal 7 aims for "affordable, reliable, sustainable and modern energy for all" by 2030. However, with millions living in energy poverty, Africa is lagging in reaching this target. Bold, joint and accelerated actions from African nations and international development partners are needed. Since the early 2000s, China has actively participated in Africa's energy revolution. Employing subnational-level data, we find that between 2012 and 2020, China-financed power generation capacity in Africa was effective in combating energy poverty. Specifically, each additional 1,000 MW of operating capacity financed or co-financed by China leads to a 0.4 percentage point increase in the average likelihood of electrification. This positive and significant effect remains robust after controlling for several variables. However, this progress in electrifying the continent has been largely driven by fossil fuels. We highlight three pathways through which Chinese development finance institutions can engage with Africa's energy sector: refinancing and repurposing aging fossil fuel capacity, exploring the phasedown of existing coal plants and promoting renewable energy to enhance Africa's participation in global value chains in renewable manufacturing.

Keywords: development finance; energy poverty; energy infrastructure; nighttime light; China; Africa

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INTRODUCTION

Energy poverty is a pervasive and persistent development issue in Africa. Over half of the continent's population, approximately 600 million people, primarily in sub-Saharan regions, lack reliable access to electricity, representing more than 80 percent of the global electricity access gap. In response, the African Development Bank (AfDB) has identified addressing energy poverty as one of its five priorities, known as the High 5s. Africa's situation is often described as "rich in the dark": the continent is rich in natural resources, including renewable energy sources beyond oil, gas and mineral rents. Yet despite this wealth, the "resource curse" remains a reality for countries with insufficient generation capacity, aging power plants, weak institutions and a lack of affordable energy finance (Hafner et al. 2018; Ongo Nkoa et al. 2023). Additionally, the continent faces crippling energy deficits driven by urbanization and industrialization, coupled with limited fiscal space to support low-income users.

At the same time, there is a need to enhance access to electricity while ensuring that this expansion does not rely on fossil energy. In multiple African countries, energy poverty has well-documented implications for low quality of life, high premature mortality rates and household air pollution (Ogwumike and Ozughalu 2016; Njiru and Letema 2018; Ang'u et al. 2023). The use of unprocessed biomass for lighting, heating and cooking emits toxic gases that are hazardous to human health, contributing to premature deaths from respiratory, cardiovascular and various other diseases (WHO 2024). Specifically, household air pollution is estimated to have caused approximately 0.7 million deaths in Africa in 2019, while ambient air pollution accounted for an estimated 0.4 million deaths (Fisher et al. 2021). The largest source of ambient air pollution is not electricity generation but agricultural burning and road transportation (Naidja et al. 2018). However, as fossil fuels—primarily oil, gas and coal—remain the primary source of electricity generation, the continued industrialization will inevitably lead to worsening air quality and increased health risks.

Development finance can address two hurdles in expanding access to electricity: financing and technology. The costs of providing this support are significantly lower than those associated with managing the instability and insecurity that energy poverty may induce (Birol 2007). Access to electricity is fundamentally tied to enhanced economic growth and human development, making it a crucial element for the success of many development finance projects. Meanwhile, energy infrastructure projects generate a market for equipment manufacturing through local sourcing and technology transfer (Kim 2018). This, in turn, enhances the participation of recipient countries in global value chains (Amendolagine et al. 2024). Nonetheless, traditional development financiers have, by and large, withdrawn from the energy sector.[2] For years, underinvestment by development partners and the inability to attract private investment in the sector have left many African countries grappling with fragile and unreliable energy infrastructure (Foster and Briceno-Garmendia 2010, 25; Lin and Wang 2017). This lack of investment stems from neoliberal ideologies, which advocate for the privatization of infrastructure, utilities and public services (Rodrik 2002). Western donors generally do not favor the power sector, as they often direct assistance and resources toward social sectors or water infrastructure, which have a more immediate impact on health outcomes than other types of hard infrastructures.

As traditional donors tend to overlook energy finance, China becomes a critical development partner in financing Africa's energy sector. From a project delivery perspective, Chinese energy infrastructure projects are typically quicker to materialize and have fewer restrictions compared to those backed by the World Bank, exemplified by the Bui Dam in Ghana (Swedlund 2017, 128). From 2000 to 2023, it is estimated that China lent a total of $62.7 billion to the continent in the energy sector through its two development banks (GDP Center n.d.a). Between 2012 and 2021, it was Africa's largest energy

[2] Energy aid accounts for approximately 5 percent of the total foreign aid disbursed by Organisation for Economic Co-operation and Development (OECD) creditors from 2002 to 2015 (Kim 2018).

finance provider (primarily fossil energy and hydropower in terms of electric power generation), surpassing the World Bank Group, the AfDB and other bilateral financiers in investment amounts (Moses 2023). Given China's and Africa's recognition of climate cooperation and clean energy transition as a crucial pillar in the Forum on China-Africa Cooperation (FOCAC) , this deep involvement is unsurprising.

Limited evidence exists regarding the effectiveness of development finance within the energy sector. Most aid effectiveness literature focuses on the relationship between development finance and economic outcomes.[3] In many cases, partial answers are provided to answer the question, "Is aggregated aid beneficial?" Nevertheless, much development finance is allocated to specific sectors through projects such as energy, health and education rather than for overall development or budget support. In particular, the effectiveness of energy development finance is rarely studied. Maruta and Banerjee (2021) examine the effectiveness of energy aid on national energy efficiency, noting a positive impact, and Chapel (2022) reports similar findings. Furthermore, evidence suggests that certain development financiers may exaggerate their accomplishments.[4] Considering the substantial debt-servicing costs that African nations face, it is crucial to ensure that development finance in the energy sector is effective.

In this paper, we attempt to answer the following questions: What is the spatial and technological distribution of China's overseas development finance in the energy sector in Africa? Has China's power finance alleviated energy poverty at the subnational level? For the purpose of this study, China's power finance refers to overseas development finance in electric power generation provided by China's two major development finance institutions (DFIs)—the China Development Bank (CDB) and the Export-Import Bank of China (CHEXIM). This energy financing has been used for the construction, expansion, rehabilitation and/or maintenance of various energy projects.

This working paper contributes to the existing literature and empirical work in the following aspects. First, we demystify China's energy finance in Africa. This includes analyzing the geographical and technological distribution of China's energy finance in Africa in comparison to the other existing utility-scale energy units. While we are interested in electric power generation projects financed by Chinese DFIs, our descriptive analysis also encompasses other types of energy-related project footprints.

Second, we employ an innovative results-based approach to measure energy poverty in Africa. We use satellite-based nighttime light imagery as an innovative indicator of energy poverty, employing global datasets developed by Min et al. (2024). The high spatial resolution of the data enables consistent and comparable assessments, which are essential for identifying the locations and causes of energy access deficiencies.

Third, we examine the effectiveness of China's bilateral energy support in Africa. To the best of our knowledge, our study is the first comprehensive analysis documenting the effectiveness of Chinese power projects in Africa. Specifically, the findings assess whether China's power finance enhances electricity service provision by using comprehensive operational data rather than relying on assumptions based on project commitment or disbursement dates.

The remainder of the paper is organized as follows. Section 2 reviews the concept of energy poverty and a novel satellite-based measurement of energy poverty. Section 3 examines the current energy

[3] Development finance is viewed as a means to alleviate income poverty through various channels: poverty reduction (Collier and Dollar 2002; Mosley et al. 2004), human capital accumulation (Gyimah-Brempong and Asiedu 2008), health and well-being improvement (Kotsadam et al. 2018), aggregated economic growth (Moreira 2005), and releasing development bottlenecks to promote structural transformation (Lin and Wang 2017; Wang and Xu 2023).

[4] The U.S.-led initiative Power Africa reported 10.6 million connections in 2017. Nevertheless, 8.3 million, or 78 percent, were from the distribution of solar lanterns, i.e., basic access to a single light.

landscape in Africa and China's involvement in the continent's energy sector. Section 4 outlines the data used in the empirical study. Section 5 explains the empirical methodology employed, and Section 6 presents the empirical results. Finally, Section 7 concludes and provides policy recommendations.

MEASURING ENERGY POVERTY FROM OUTER SPACE

A global consensus is missing for a holistic definition of energy poverty. One broadly accepted definition is "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development" (UNDP 2000, 44). More broadly, energy poverty is perceived as primarily relying on traditional biomass for energy needs and the deprivation of access to modern energy services, like electricity (Birol 2007). Overall, without a clear definition, the concept of energy poverty remains ambiguous, making it difficult to compare across different scales. As a result, there is limited quantitative evidence concerning the progress made in tackling energy poverty locally across the continent. Nevertheless, as Pachauri and Spreng (2011) have noted, "understanding energy poverty is central to any efforts to alleviate it."

The literature has not yet found a uniform way to measure energy poverty. The most commonly used indicators in the literature are expenditure- and consensual-based, particularly in developed countries (Herrero 2017). Some empirical research adopts multidimensional measurement frameworks, such as the Multidimensional Energy Poverty Index (MEPI) proposed by Nussbaumer et al. (2012), for single-country analysis. The MEPI measurement relies heavily on the information provided by consensual-based household surveys, such as the Demographic and Health Surveys (DHS) datasets (Munyanyi and Awaworyi Churchill 2022). Those indicators are subjective, primarily based on households' perceptions of their ability to meet basic energy needs. This approach is not always reliable, as participants can understate the extent to which they experience energy poverty.

A comparable and reliable measurement is necessary to track progress at an international, national or subnational scale. In Africa and many other developing countries, the lack of available data on energy consumption and expenditures in national surveys has posed challenges in measuring energy poverty. Case-by-case analysis is often used to measure energy poverty in the context of the developing world, but its findings have limited applicability to broader situations, raising concerns about external validity and generalizability. However, for those case-by-case analyses relying heavily on household surveys, not all datasets are available in public domains. Many time-series datasets are only accessible through subscriptions (even for those at the national level) or grant no access at all to either policymakers or researchers. Given the data restrictions, energy poverty has been studied more frequently at the national and international levels than at the local level in developing countries.

The satellite-based High-Resolution Electricity Access (HREA) project provides an alternative way to measure energy poverty from outer space by offering three settlement-level measures of electricity access, reliability and usage derived from the complete archive of nightly satellite imagery. As noted by its developers, this dataset classifies "human settlements as electricity poor when they exhibit no statistical evidence of electricity consumption across a time series of nighttime satellite imagery" (Min et al. 2024, 5). This classification is applicable in various contexts and straightforward for empirical analysis. It relies solely on a comprehensive analysis of the complete historical record from Visible Infrared Imaging Radiometer Suite Day/Night Band (VIIRS-DNB) nighttime satellite imagery. Thus, the data generated by the project are unaffected by the differing coverage periods of commonly used sensors by design.

Unlike traditional measures, this new approach provides evidence based on outcomes. Each night, the radiance levels observed over human settlements are compared to those of a matched sample of similar uninhabited cells (i.e., based on geographical proximity, land cover and other geographical attributes) within the same country over the year. The spatial unit is the 1-kilometer (km) cell. Both human settlement cells and uninhabited cells are identified. The statistical analysis assumes that uninhabited cells are unelectrified. Given this counterfactual setting, all else being equal, human settlement cells should be brighter than nearby cells without human settlements.

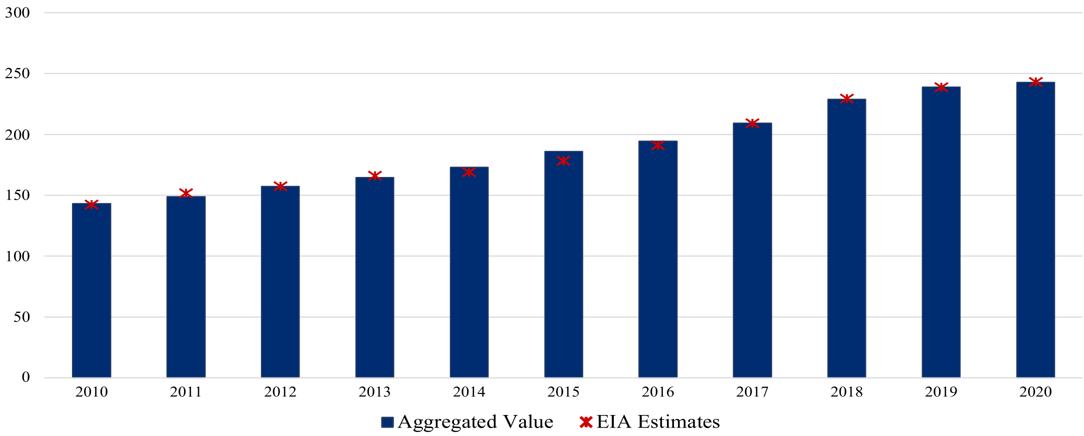
The probability of each human settlement cell being electrified is then computed. Specifically, the final dataset estimates the probability that a settlement cell is statistically brighter on any given night compared to a similar uninhabited area.[5] This day-to-day comparison increases the reliability of the data since the background noise can be demeaned. Overall, the dataset offers opportunities to conduct empirical research on what has effectively addressed energy poverty across space and over time, with a certain degree of generalizability. In addition to the access indicator, the dataset also provides two other indicators for the reliability of electricity services (measured by the proportion of nights a settlement is statistically brighter than matched uninhabited areas) and electricity usage (measured by a high level of brightness).

ENERGY SUPPLY IN AFRICA AND ENERGY FINANCE BY CHINA

We compile a panel dataset at the power plant unit level from the S&P Capital IQ Pro Global Power Plant Database (S&P GPP) to assess the current state of energy supply in Africa. The S&P GPP provides information for each power generation unit regarding operating capacity, fuel type, geospatial location and operating status. This panel dataset includes 5,327 power generation units across 1,952 power plants from 1980-2024, and it excludes generation units that were out of service or mothballed during the observed period. All generation units are in utility-scale power plants.

We further compare the aggregated values at the national and continental levels with the estimates reported by the US Energy Information Administration (EIA). Figure 1 shows that from 2010-2020, electric power generation capacity in Africa increased from 143 gigawatts (GW) to 243 GW, with a growth rate of 71 percent.

Figure 1: Electric Power Generation Capacity in Africa, GW



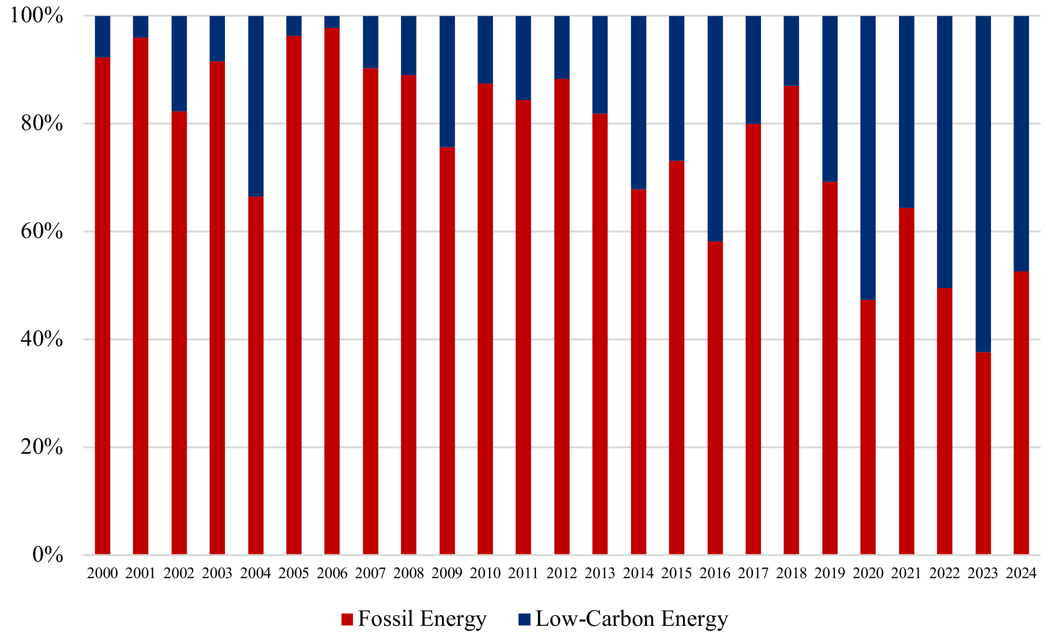
Source: Authors' elaboration based on S&P GPP and EIA.

[5] By design, the counterfactual radiance level for each settlement cell is the average expected baseline if the cell were unpopulated or unelectrified (see Min et al. 2024, 13–14 for their computation process). The regression model quantifies this by the predicted value from the regression model for each cell. The residuals for the human settlement cells are then obtained by subtracting the predicted values from the observed values, and the negative values are adjusted to zero. The average standardized nightly residuals over the year (i.e., the z-score referred to in the methodology) is calculated, and the respective cumulative distribution function (CDF) is obtained. This CDF is subtracted by half and multiplied by two to return a value between zero and one for each human settlement cell.

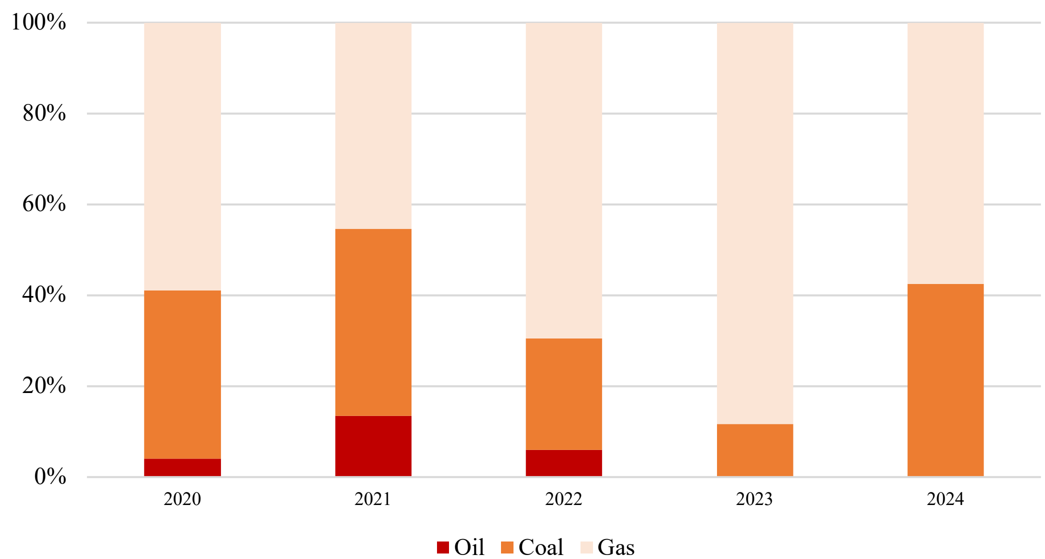
Africa has been steadily racing toward low-carbon energy sources, while fossil fuels still dominate electric power generation. Figure 2 presents annual additions to generation capacity. There is a clear surge in capacity from low-carbon energy sources as African countries leverage solar, wind, hydropower and other renewable sources for power generation. However, the continent's energy generation is still primarily powered by fossil fuels.

Figure 2: Share in Annual Capacity Additions in Africa, Fossil Energy vs. Low-Carbon Energy

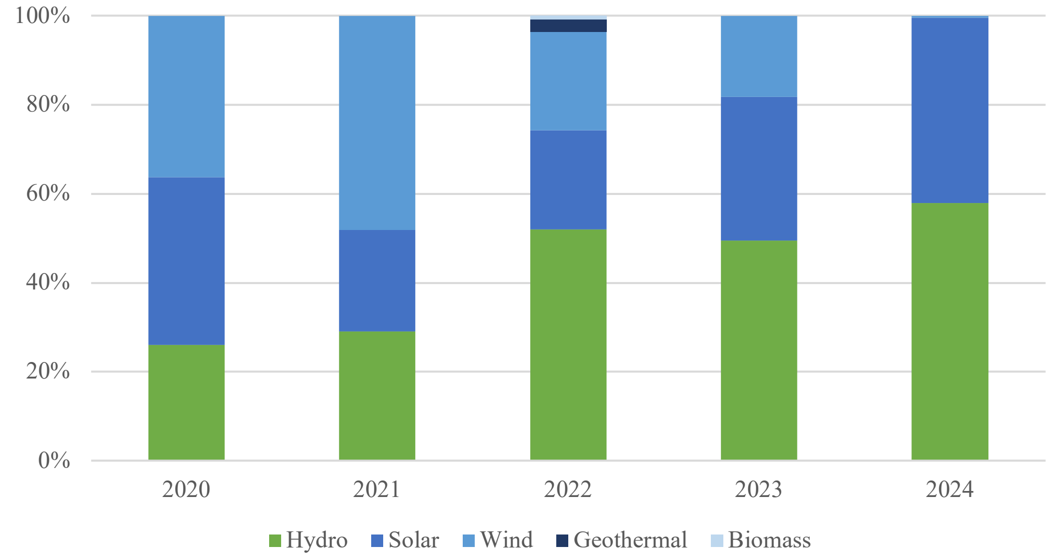
2A. All Fuel Types, 2000-2024



2B. Fossil Energy, 2020-2024



2C. Low-Carbon Energy, 2020-2024

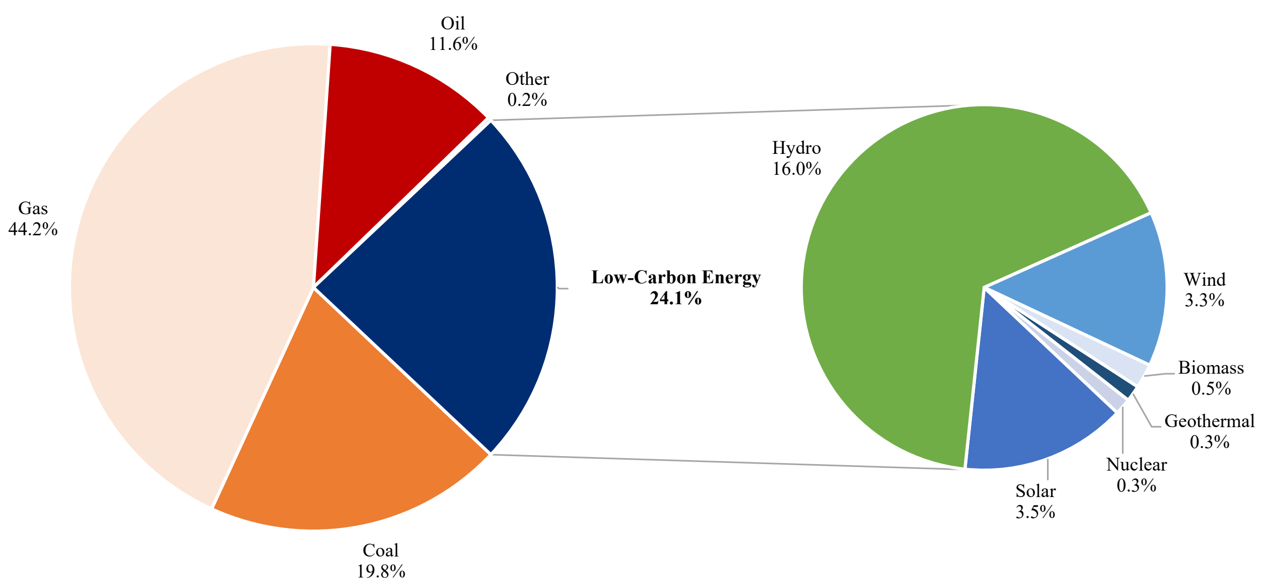


Source: Authors' elaboration based on S&P GPP.

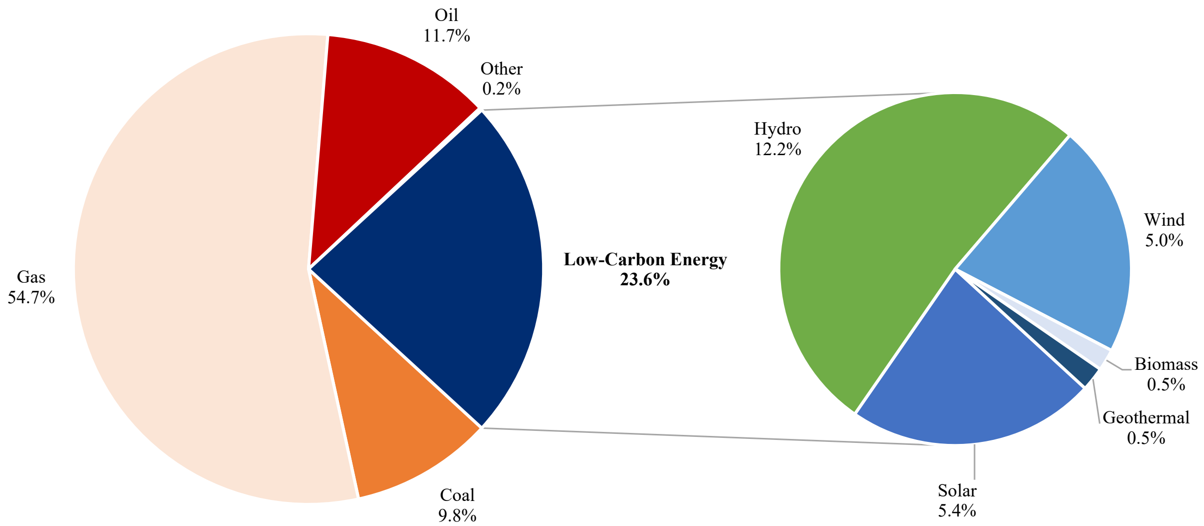
In the past 24 years, the continent's energy mix has gradually changed, with gas overtaking coal as Africa's biggest source of electric power generation. Additionally, the continent now generates electricity from a more diverse range of renewable energy sources than before 2000, with a significant growth in the share of wind and solar in nominal capacity (Figure 3).

Figure 3: The Composition of Nominal Capacity in Africa, Various Periods

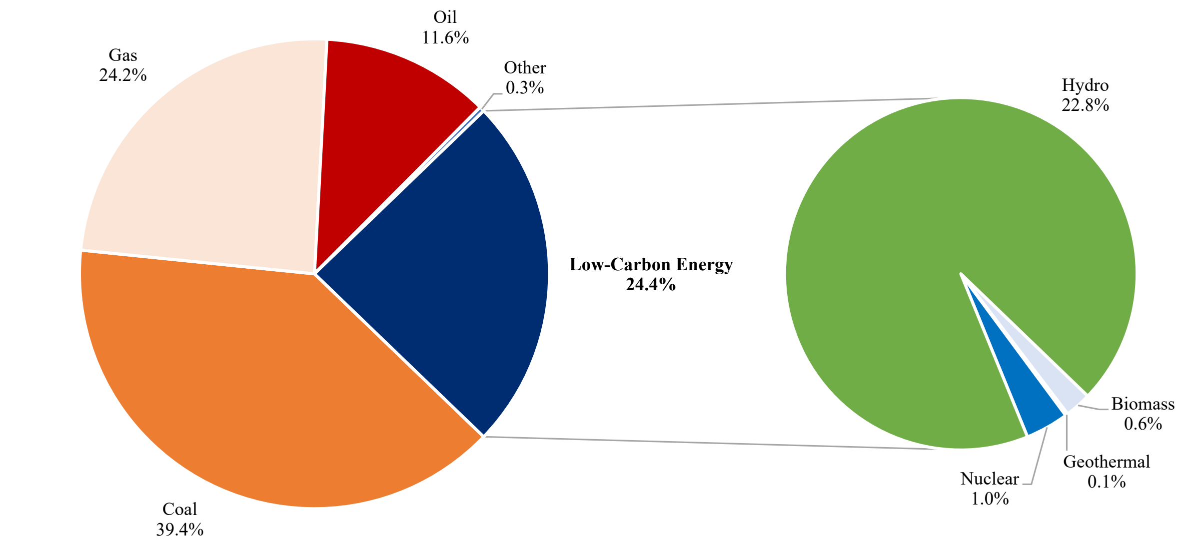
3A. Total Operating Capacity as of 2024



3B. Capacity Additions During 2000-2024



3C. Total Operating Capacity Before 2000



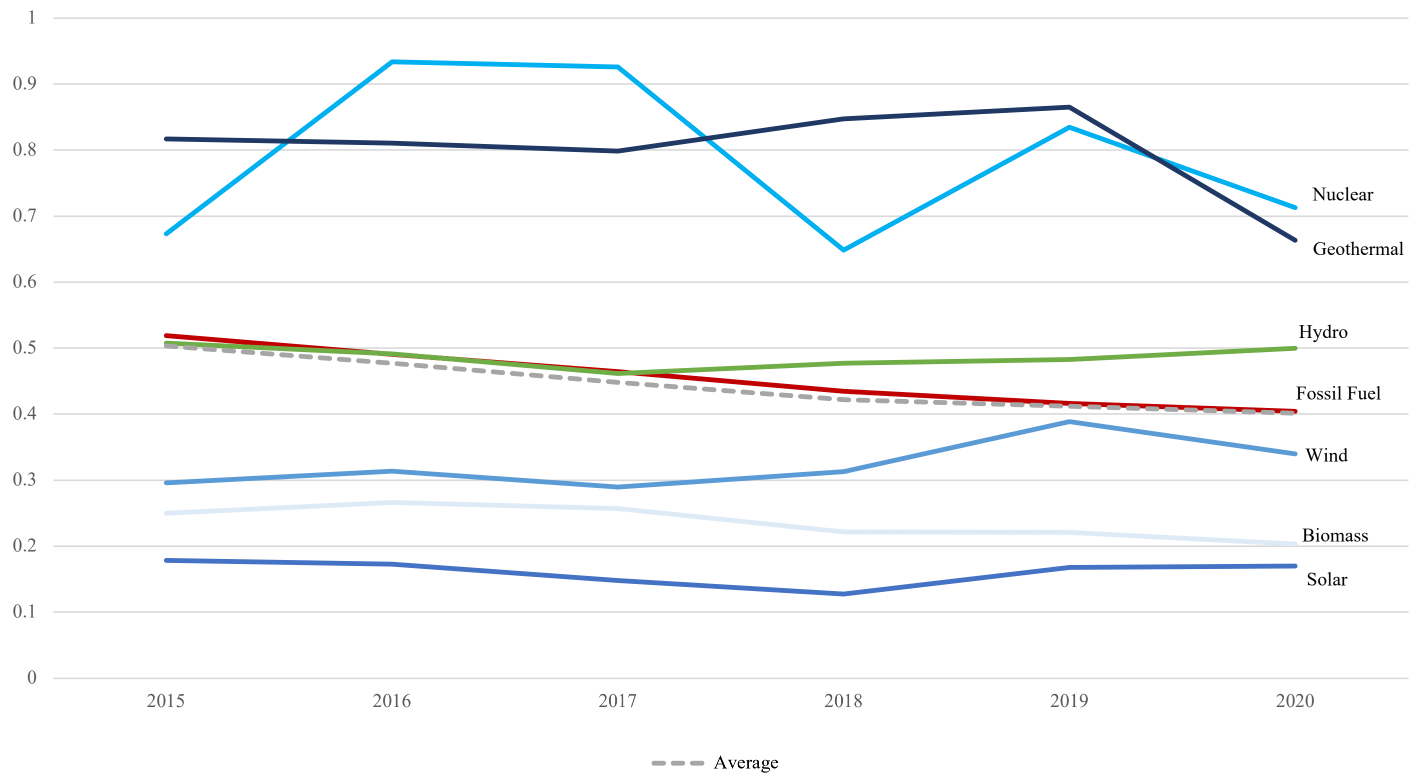
Source: Authors' elaboration based on S&P GPP.

Nevertheless, the lower efficacy of power generation from renewables means that greater capacity additions are required to meet demand. Due to technological and thermodynamic constraints, power plants using different generation technologies have varying efficacies. Two power plants with the same capacity can produce different amounts of electricity due to variations in generation technology. This difference in efficacy can be measured with the capacity factor (CF). Globally, renewables such as solar and wind tend to have a lower CF than fossil energy. Following Bolson et al. (2022), we calculate the CF for the continent as a whole using data on net electricity generation and nominal capacity installed reported by the EIA (Figure 4):

$$CF_f = \frac{Generation_{AFRC,f}}{Africa_{AFRC,f} \times 365 * 24} = \frac{Generation_{AFRC,f}}{Africa_{AFRC,f} \times 8760} \quad (1)$$

We do not use country-specific CFs in this study because there are suspicious values associated with the quality of EIA-reported data.

Figure 4: Average Capacity Factor from 2015 to 2020, by Fuel Type



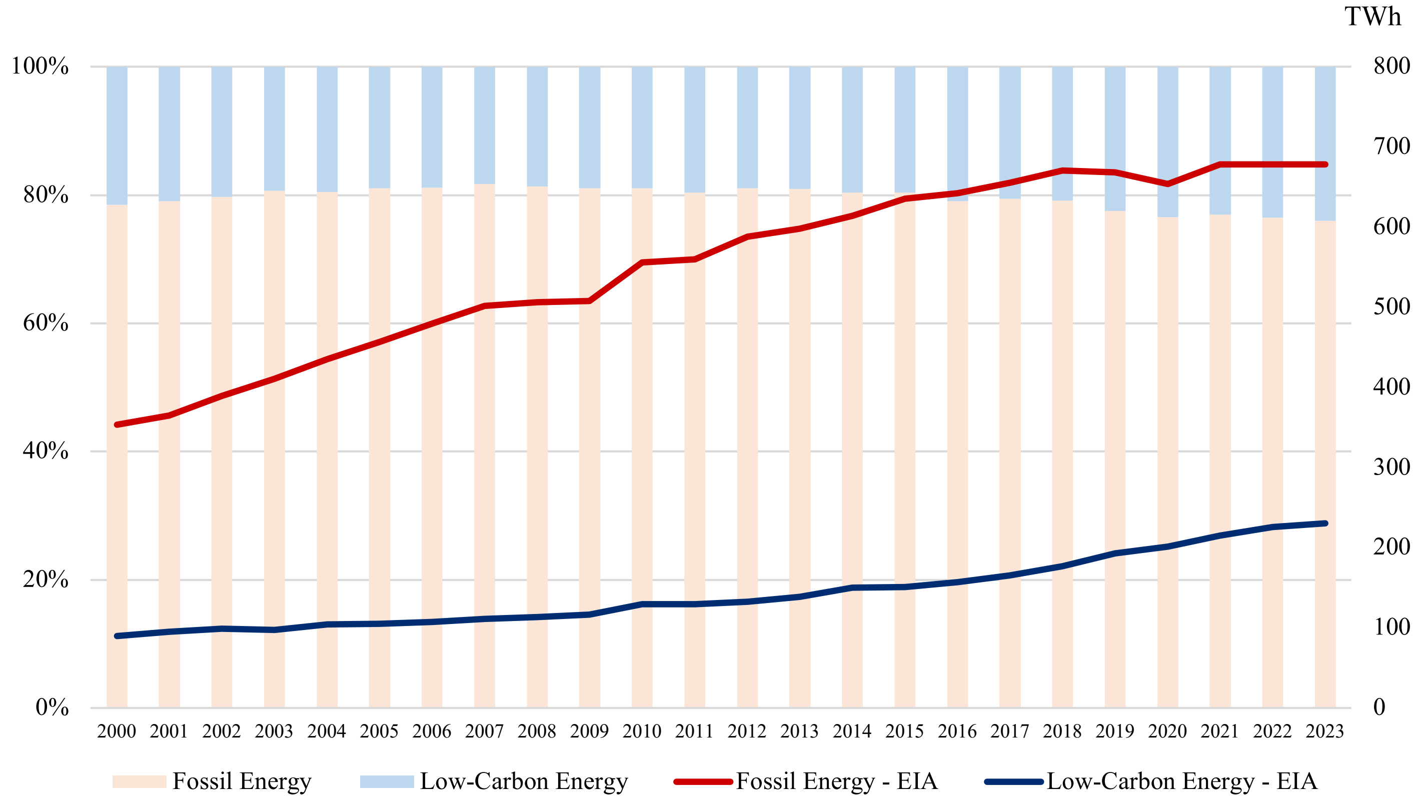
Source: Authors' elaboration based on EIA.

It is encouraging that low-carbon energy sources now make up a larger share of the continent's energy mix. Nevertheless, the installed and planned capacity is far from sufficient, and much of its low-carbon energy potential remains untapped. The International Renewable Energy Agency (2021, 38) estimates that the theoretical low-carbon energy generation potential in Africa is 2,431,765 terawatt-hours (TWh), composed of 1,449,742 TWh of solar, 978,066 TWh of wind, 2,374 TWh of biomass, 1,478 TWh of hydropower and 105 TWh of geothermal. While enthusiasm for low-carbon energy sources is growing across the continent, progress remains insufficient to achieve universal renewable electricity access. Peters et al. (2024) estimate that if all proposed and existing low-carbon plants are implemented and operate at full capacity, they will meet up to 51 percent of Africa's electricity needs by 2040 (1,225 TWh of 2,321 TWh) .[6] More development finance is essential for realizing renewable energy ambitions across the continent.

Replacing fossil energy in Africa will require extensive infrastructure and the installation of significant low-carbon energy capacity. Fossil fuels still account for about 80 percent of electricity generation and generation potential on the continent (Figure 5). Transitioning to low-carbon sources will be especially challenging for countries currently heavily reliant on fossil fuels. Moreover, cleaner alternatives may have lower generation potential than fossil fuels at the same nominal capacity, meaning more nominal capacity must be installed. Based on the average CF in 2020, replacing 1 GW of fossil energy capacity would require 2.4 GW of solar or 1.2 GW of wind. In addition to the intermittency of renewable power generation, most renewable resources, except for solar, are not evenly distributed

[6] This scenario considers universal access to electricity and is consistent with Agenda 2063.

Figure 5: Share in Generation Potential (Stacked Column, Left Axis, %) and Actual Generation (Line, Right Axis, TWh) in Africa, Fossil Energy vs. Low-Carbon Energy



Source: Authors' elaboration is based on S&P GPP and EIA.

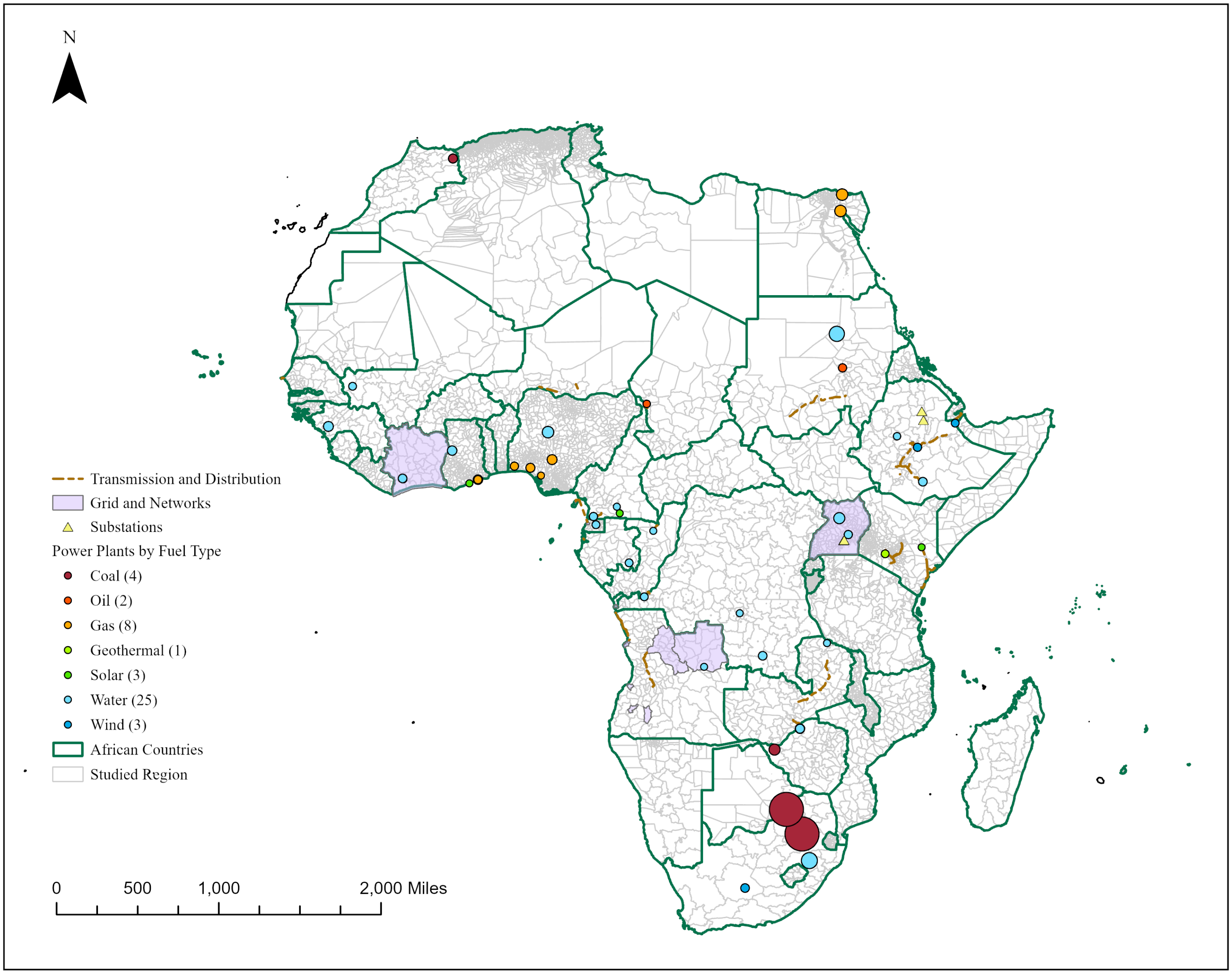
Note: We calculate each power generation unit's generation potential (in terawatt-hours, TWh) with the annual average CF for the respective fuel type. The share of fossil energy in total generation potential is close to the actual generation reported by the EIA.

geographically. Solar power's performance can be significantly reduced by panel soiling caused by Saharan dust, especially in regions near the Sahara Desert (Li et al. 2020).

Participation in Africa's energy revolution is crucial to China's growing role in global energy development finance. Figure 6 illustrates the spatial and technological distribution of the country's energy development finance in Africa. An update to the Chinese Loans to Africa (CLA) Database, managed by the Boston University Global Development Policy Center (GDP Center), estimates that between 2000-2023, Chinese loans primarily targeted Africa's energy sector, amounting to $63 billion out of a total of $182 billion. China's involvement in Africa's energy sector extends beyond power generation, recognizing that grid resilience and network infrastructure are essential for ensuring affordable and reliable access to electricity in modern society.

Despite being the continent's largest financier for large energy infrastructure projects, the Chinese government does not provide specific project-level details for its development finance initiatives. As a result, most researchers rely on databases compiled by various research institutes. In this study, we use China's Overseas Development Finance (CODF) Database (GDP Center 2023), developed by the GDP Center. In addition to tracking development finance projects, the GDP Center also maintains

Figure 6: Energy Development Finance by China in Africa



Source: Authors' elaboration, GADM version 4.1, and CODF Database 2023 .

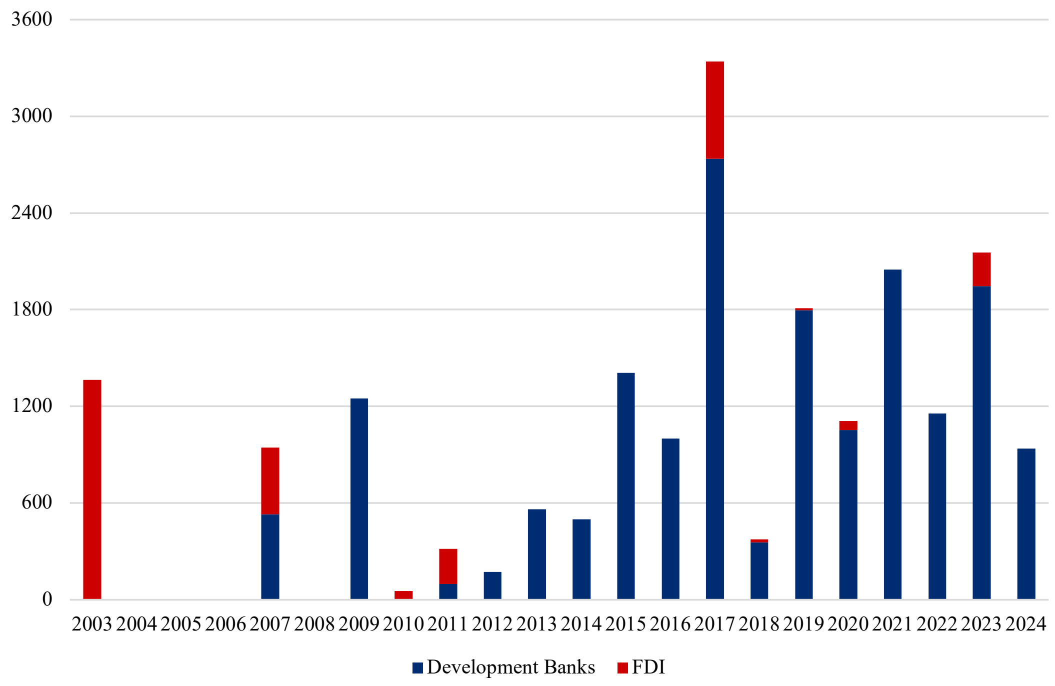
Note: The symbols' size reflects each plant's relative operating capacity. The projection is based on the World Geodetic System 1984. The numbers of projects are reported in parentheses.

China's Global Power (CGP) Database (GDP Center 2022), which monitors power plants financed by Chinese foreign direct investment (FDI) as well as financing from CDB and CHEXIM. The CODF Database stores information related to project financing for electric power generation, as well as transmission and distribution projects, whereas the CGP Database maintains records of power plant units. We obtain the project-level information from the CODF Database and match power generation unit attributes with the S&P GPP. This study only concerns utility-scale power generation units.

CDB and CHEXIM finance the majority of recorded projects in the CGP and CODF Databases. From 2003-2024, the two banks and FDI financed or co-financed 20.5 GW of additional capacity in Africa, representing around 12.4 percent of total added capacity on the continent during that period.

Together, the banks accounted for 85.5 percent of this capacity. Figure 7 shows the annual increase in operating capacity financed by the banks and FDI. In 2017, capacity additions financed with Chinese capital rose significantly.

Figure 7: Annual Capacity Additions in Africa Financed with Chinese Capital, megawatt (MW)



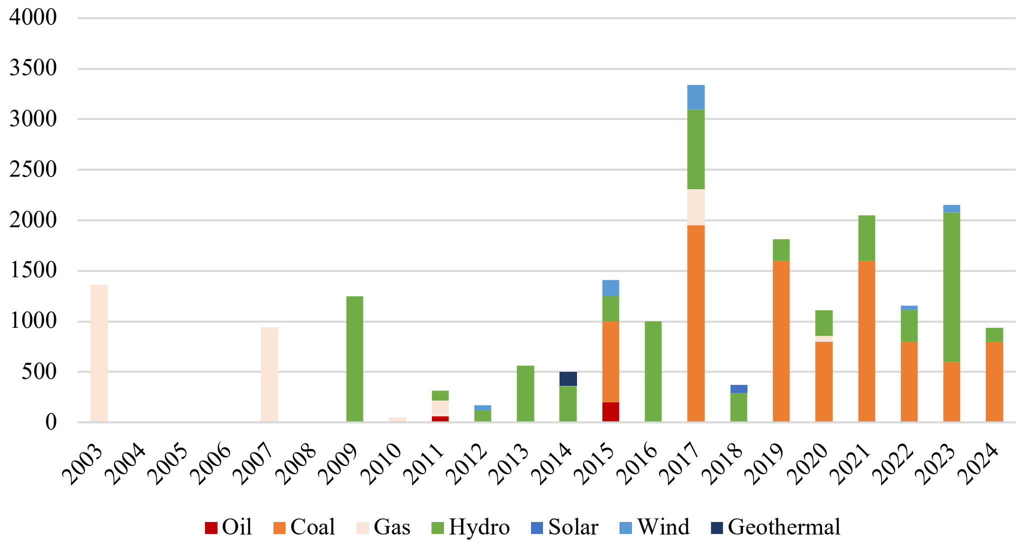
Source: Authors' elaboration based on the CODF Database, CGP Database and S&P GPP.

How much of China's financing has supported fossil energy compared to renewables? Figure 8 shows a clear trend: in recent years, more low-carbon energy power plants have received Chinese investment, dominated by hydropower. This coincided with China's commitment to shifting to a green Belt and Road Initiative (BRI) , as reflected in its September 2021 pledge to stop financing new coal-fired power plants abroad. However, fossil fuel plants still accounted for about 60 percent of total additional capacity from 2003-2024, amounting to approximately 12 GW. Chinese DFIs remain contractually bound to projects committed to before the pledge, many of which were already under construction at that time or were a few years into their expected decades-long lifetimes.

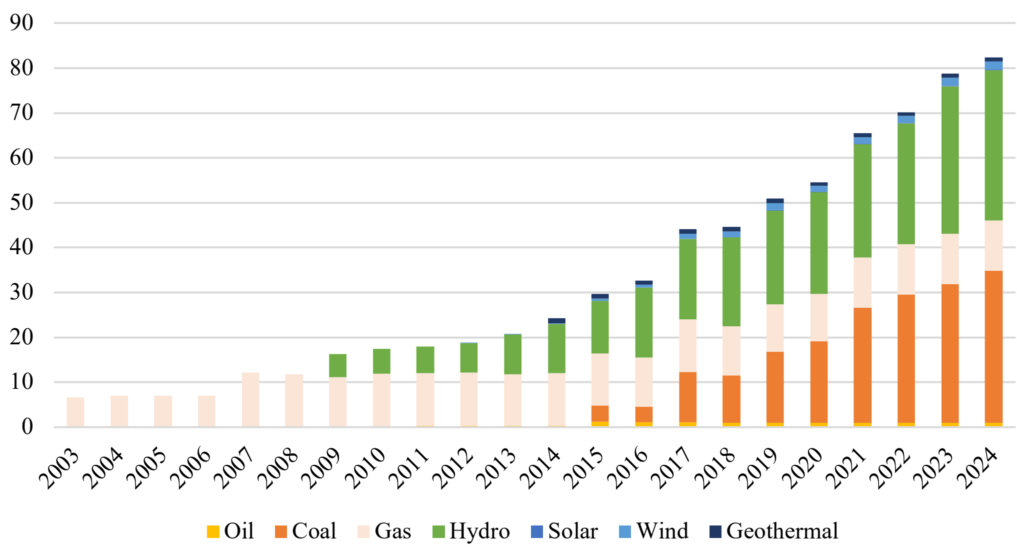
What options exist for the coal plants financed by Chinese DFIs? Some researchers suggest early phasedown (Manych et al. 2023), yet this is very likely to be costly, and there have been limited practices in developing countries. From a practical perspective, the early retirement of coal plants financed and co-financed by Chinese DFIs requires long-term planning for refinancing and substantial policy efforts. A just energy transition could benefit from active collaboration between Chinese DFIs and other development partners. However, most existing "just energy transition" and climate investment initiatives are backed by Western donors (GDP Center 2023). Such institutions for refinancing are not readily available for Chinese overseas coal power assets.

Figure 8: Annual Capacity Additions and Generation Potential Financed with Chinese Capital, by Fuel Type

8A. Annual Capacity Additions, MW



8B. Annual Generation Potential, TWh



Source: Authors' elaboration based on the CODF Database, CGP Database, S&P GPP and EIA.

DATA

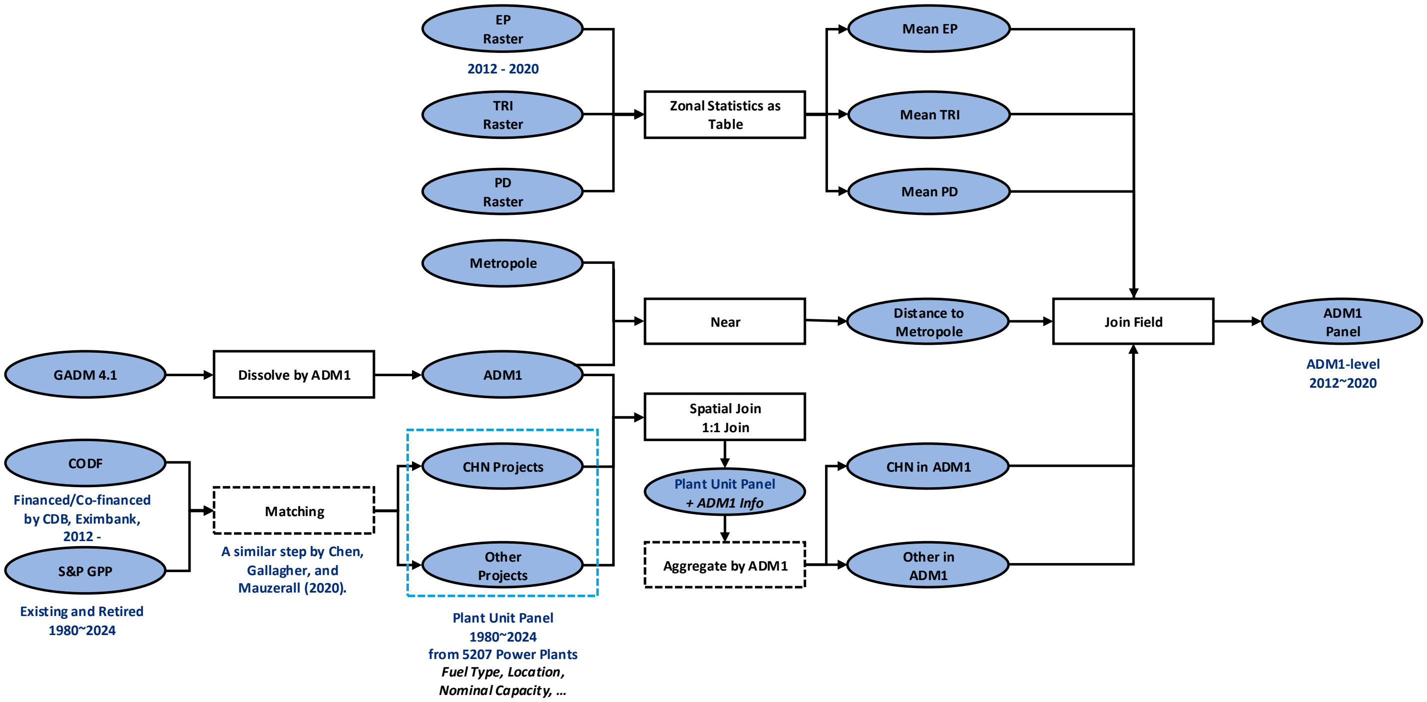
We use spatial informatics and follow a holistic approach to geoprocessing to create a panel dataset covering 2012-2020 across 850 subnational regions in Africa. The process begins with formalizing the shapefile[7] for these regions across 54 African countries. Next, we convert raster-based data on

[7] A vector-based data model that represents geographic features, i.e., the polygons depicting boundaries of subnational regions in this study.

energy poverty into numerical values for each region. The vector-based shapefile defines the zones, within which statistics can be computed from a value-raster (where all cells have numerical values) within each zone. Following this, we match the operating capacity of power plant units in each subnational region, regardless of fuel type and whether they were financed by the CODF Database. Other control variables are gathered and compiled using a similar methodology. All the map projections are set to the World Geodetic System 1984 by default.

The geospatial methodology is illustrated in Figure 9, and Table 1 details the definitions and sources of the variables used in our analysis.

Figure 9: Geoprocessing Steps, Simplified



Source: Authors' elaboration for illustration purposes.

Table 1: Definition of Variables and Sources

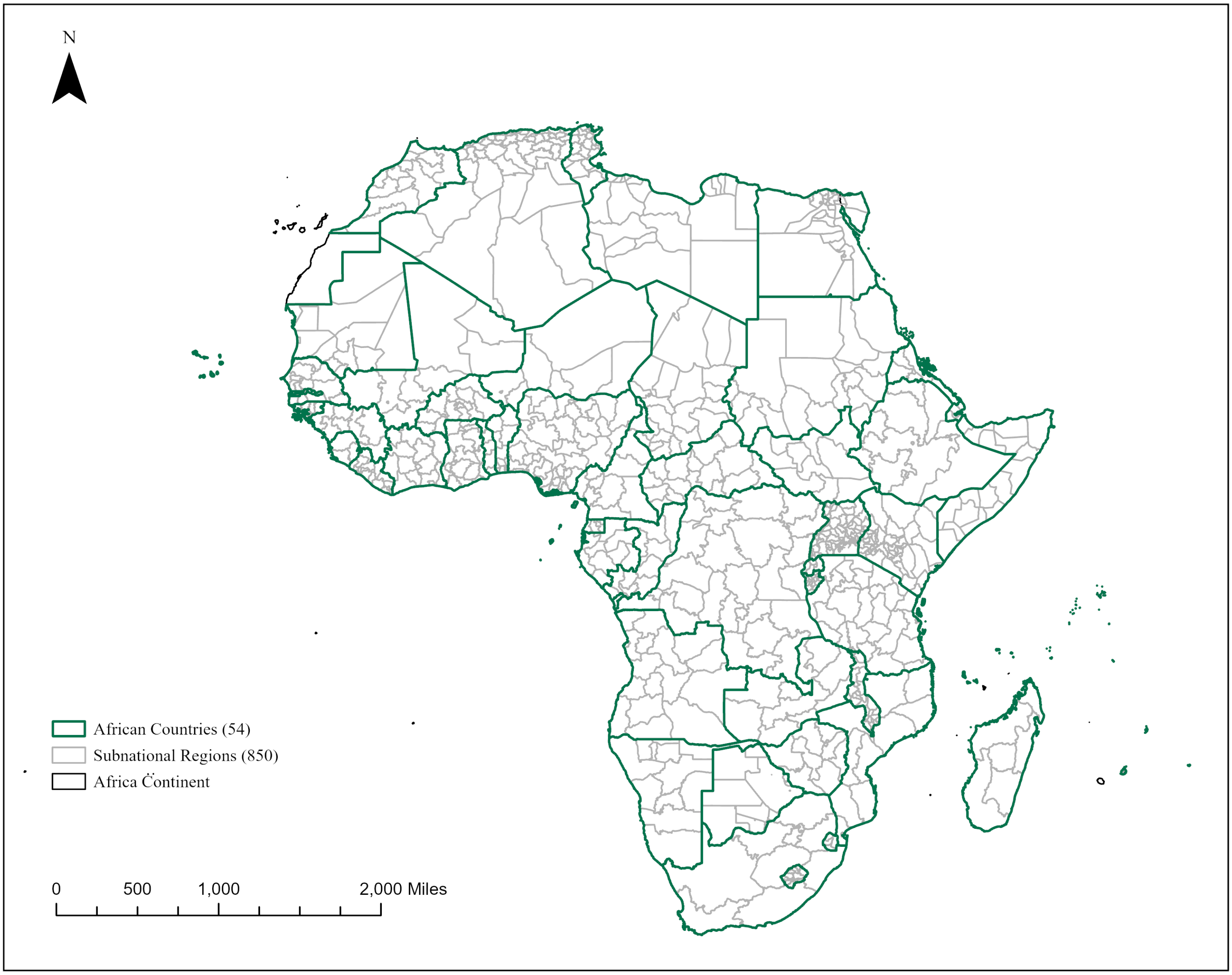
Variable Name	Definition	Source
EP	Average likelihood of electrification at the subnational level, Eq. (2)	Min et al. (2024)
CHN	China-financed/co-financed electric power plant units	CODF Database, S&P GPP
Other	Other electric power plant units	S&P GPP
PD	Population density	UNDP GeoHub (2024)
TRI	Terrain Ruggedness Index	Esri (2024)
Distance to Metropole	Distance to national metropoles	OECD/SWAC (2024)
ADM1	Subnational region	GADM 4.1
ADM0	Country	GADM 4.1

Source: Authors' elaboration.

Spatial Unit

The spatial unit in this study is the first-order administrative (ADM1) regions in 54 African countries, i.e., subnational regions. We prefer subnational regions as the spatial unit because power generation plants and grid infrastructure in Africa primarily operate at that level. Figure 10 indicates the spatial scope of the analysis. While we lack comprehensive spatial and temporal data on Africa's grid infrastructure, a visualization from the Africa Electricity Grids Explorer (World Bank 2023) indicates that many countries have inadequate grid infrastructure. The raw boundary data for administrative regions are obtained from the Database of Global Administrative Areas (GADM) vector dataset (version 4.1), released on July 16, 2022, the latest version at the time of this empirical analysis.

Figure 10: Spatial Scope of the Study: Subnational Regions in Sub-Saharan African Countries



Source: Authors' elaboration, GADM version 4.1.

Note: According to the United Nations Department for General Assembly and Conference Management, 54 countries belong to the African Group and are members of the United Nations. We followed the same definition. The projection is based on the World Geodetic System 1984.

Outcome Variable

We use the HREA data at the settlement level to calculate the average likelihood of electrification for each African subnational region. First, we match each 1-km human settlement cell to a single subnational region. Next, we estimate energy poverty (EP_{ist}) at the subnational level (i) by averaging the likelihood of electrification across all human settlement cells ($cell$) within each subnational region in each year (t), as shown in the following equation:

$$\boldsymbol{EP_{ist}} = \frac{\sum_{cell} \boldsymbol{likelihood\ of\ being\ electrified_{cell,i,t}}}{\boldsymbol{N_{cell,i,t}}} \quad (2)$$

Figure A1 illustrates this for the year 2020. Overall, efforts to combat energy poverty in Africa are gradually improving, though progress remains slow. Over the observed period, the average likelihood of electrification in African subnational regions rose from 34 to 37 percent (Table 2). However, this progress is insufficient, as many regions still lack access to reliable electricity. This finding aligns with estimates that around 600 million Africans—nearly half the continent's population—still lack reliable access to electricity. Significant disparities in energy poverty also persist both among and within countries. In particular, subnational regions in sub-Saharan Africa have a lower average likelihood of electrification than those in North Africa, with most regions still falling below 50 percent.

Table 2: Average Likelihood of Electrification in the Sampled Subnational Regions in Africa

Year	Observation	Mean	Std. Dev.	Min	Max
2012	838	34.29	30.10	0.84	100
2013	838	34.78	30.22	0.34	100
2014	838	34.66	30.21	0.53	100
2015	838	35.14	30.41	0.45	100
2016	838	36.01	30.37	0.73	100
2017	838	35.64	30.60	0.50	100
2018	849	36.66	31.00	0.74	100
2019	829	37.15	31.61	1.14	100
2020	849	37.24	31.17	1.04	100

Source: Authors' elaboration.

Independent Variable of Interest

The key explanatory variable of concern is the exact operating capacity of electric power plants in Africa that were financed or co-financed by China. We use the geocoded the CODF Database to track Chinese power finance projects in the region,[8] examining only completed and operational electric power projects from 2012-2020, worth over $8.5 billion, for our empirical analysis.[9] For each project financing entry in the CODF database, we reference the S&P GPP Database to gather additional attributes of the generation units, which the CODF Database does not provide (an approach similar to that of Chen et al. 2020). The analysis includes 26 power plants in 18 African countries, totaling a capacity of 11 GW and comprising 89 power generation units (see Table 3 and Table A1 for

[8] Three projects committed before 2012 are not included by the CODF Database but are documented in the CGP Database: the Merowe Hydro Plant in Sudan, the Olorunsogo Gas Plant in Nigeria and the Finchaa-Amerti-Neshe (Fan) Hydro Plant in Ethiopia. We also include them in the empirical analysis.
[9] Some projects also include distribution and transmission components.

the full list of plants). In 2020, these power units had the potential to generate 45 TWh of electricity. In the empirical analysis, we use 1,000 MW as the unit to estimate the marginal effect and 100 MW for robustness checks.

Table 3: Operating Capacity of China-Financed/Co-Financed Electric Power Plants in Africa, 2020

Fuel Type	Country	Operating Capacity, MW	Subtotal, MW	Generation Potential, TWh	Subtotal, TWh
Coal	Morocco	350	5,150	1.2	18.2
	South Africa	4,800		17.0	
Oil	Sudan	200	200	0.7	0.7
Gas	Nigeria	530	530	1.9	1.9
Geothermal	Kenya	140	140	0.8	0.8
Solar	Kenya	55		0.1	0.1
Hydro	Angola	12	5,178	0.1	22.7
	Cameroon	15		0.1	
	Côte d’Ivoire	270		1.2	
	Dem. Rep. Congo	150		0.7	
	Equatorial Guinea	120		0.5	
	Ethiopia	351		1.5	
	Gabon	160		0.7	
	Ghana	400		1.8	
	Guinea	240		1.1	
	Rep. of the Congo	20		0.1	
	South Africa	1,332		5.8	
	Sudan	1,250		5.5	
	Uganda	183		0.8	
	Zambia	375		1.6	
	Zimbabwe	300		1.3	
Wind	Ethiopia	204	204	0.6	0.6
Total	**Total**	**11,457**	**11,457**	**45.0**	**45.0**

Source: Authors’ elaboration, based on Decomposition Analysis of the CODF Database version 2.0, S&P GPP and the EIA.

Table 3 shows that most power plants financed or co-financed by Chinese FDIs in Africa are hydropower plants. However, when looking at operational capacity, the three coal-fired power plants in Morocco (Jerada Steam Plant) and South Africa (Kusile Steam Plant and Medupi Steam Plant) have high nominal capacity. The average annual increase in operating capacity of power plants is approximately 1.1 GW over the observed period, with a notable surge in 2017 that reached a record high of 2.7 GW. While we do not aim to compare the operating years of individual power plant units with the project commitment year, there is significant variation in the time between commitment and operation across units.

Control Variables

In addition to China-financed or co-financed electric power plants, we account for the operating capacity of other power plant units in Africa, measured in 1,000-MW units, following a similar geoprocessing approach using the S&P GPP Database. We also use annual changes in population density (UNDP GeoHub 2024), the Terrain Ruggedness Index (Esri 2024), and distance to metropoles (OECD/SWAC 2024) to account for the confounding impact of electricity demand and geographical attributes on energy poverty.

We obtain the 71 metropoles defined by Africapolis, which are defined by their economic, political and cultural significance (see Table A2 for the full list of the metropoles). From the perspective of urban agglomeration, these 71 metropoles account for 31 percent of Africa's total urban population (224 million people). The distance from the nearest metropole is calculated based on the geographical distance between the centroid (i.e., the geometric center of the subnational region's polygon) of each subnational region and each metropole. Descriptive statistics are provided in Table 4.

Table 4: Summary Statistics

Variable Name	Unit	Mean	Standard Deviation	Minimum	Maximum	Observations
ΔEP	percentage	0.32	3.49	-24.99	31.13	6,266
CHN	1,000 MW	0.01	0.10	0.00	3.20	6,266
$Other$	1,000 MW	0.23	1.25	0.00	30.57	6,266
ΔPD	persons/km2	9.62	43.10	-268.39	1008.97	6,266
TRI	/	3.34	1.55	1.00	6.83	6,266
Distance to Metropole	km	247.37	211.73	1.66	1181.62	6,266

Source: Authors' elaboration.

EMPIRICAL STRATEGY

We adopt an empirical model to test whether China's energy finance has alleviated energy poverty at the local level. The empirical model is given as follows:

$$EP_{ist} = \alpha_1 \sum_j CHN_{jist} \times N_{jist} + \alpha_2 \sum_u Other_{uist} \times N_{uist} + \alpha_3 X_{ist} + \theta_{is} + \delta_{is} \times T + \theta_s \times T + \tau_t + \varepsilon_{ist} \quad (3)$$

where EP_{ist} is the energy poverty indicator in the subnational region i in country s at time t, which is calculated as the average predicted likelihood of each settlement being electrified in the region i. CHN_{jist} is the operating capacity (in 1,000 MW) of China-financed/co-financed electric power generation unit j in the subnational region i in country s at time t. N_{jist} is the total number of years in which the power generation unit j has been in operation until time t. Similarly, $Other_{uist}$ is the operating capacity (in 1,000 MW) of the non-China-financed electric power generation unit u in subnational region i in country s at time t. N_{uist} is the total number of years in which the power generation unit u has been in operation until time t, and X_{ist} is a vector of covariates, i.e., annual changes in population density and time-invariant geographical attributes. For specification , we interact these time-invariant characteristics with the linear time trend so that they are not differenced out in the first difference. θ_{is} denote region fixed effects, T denotes a linear time trend, and $\delta_{is} \times T$ are region-specific linear time trends. θ_s denote country fixed effects that absorb various potential shocks to all regions of the country, τ_t denote year fixed effects, and ε_{ist} is the stochastic error term.

A more tractable version is estimated in the first differences:

$$\Delta \boldsymbol{EP}_{ist} = \boldsymbol{\alpha_1}\, \boldsymbol{CHN}_{ist} + \boldsymbol{\alpha_2}\, \boldsymbol{Other}_{ist} + \boldsymbol{\alpha_3}\, \Delta \boldsymbol{X}_{ist} + \boldsymbol{\delta}_{is} + \boldsymbol{\theta}_s + \boldsymbol{\vartheta}_t + \Delta \boldsymbol{\varepsilon}_{ist} \tag{4}$$

where ΔEP_{ist} is the change in energy poverty in the subnational region i in country s at time t. CHN_{ist} is the total operating capacity of electric power generation units financed by China, and $Other_{ist}$ is the total operating capacity of other generation units. The sum of CHN_{ist} and $Other_{ist}$ is the total operating capacity of electric power generation units (see Figure A2 for an example of 2020). $\vartheta_t = \tau_t - \tau_{t-1}$ is a new set of year fixed effects. Given that grids can connect several administrative regions within one country and the existing data on grid infrastructure fail to match this study's spatial and temporal coverage, we cluster standard errors at the country level to allow for arbitrary spatial and temporal correlation among all regions within a country. With the first difference, the sample covers the period from 2013 to 2020.

For the robustness check, we also account for the generation potential of various fuel types. We calculate the generation potential (in TWh) for each electric power generation unit using the average capacity factor ($CF_{t,f}$) for the corresponding fuel type. The estimated model is

$$\Delta \boldsymbol{EP}_{ist} = \boldsymbol{\beta_1}\, \boldsymbol{CHN\ Gen}_{ist} + \boldsymbol{\beta_2}\, \boldsymbol{Other\ Gen}_{ist} + \boldsymbol{\beta_3}\, \Delta \boldsymbol{X}_{ist} + \boldsymbol{\delta}_{is} + \boldsymbol{\theta}_s + \boldsymbol{\vartheta}_t + \Delta \boldsymbol{\varepsilon}_{ist}$$

$$\boldsymbol{CHN\ Gen}_{ist} = \frac{\sum_f \sum_j \boldsymbol{CHN}_{jist,f} \times \boldsymbol{CF}_{t,f} \times \mathbf{8760}}{\mathbf{1000}},\ \boldsymbol{Other\ Gen}_{ist} = \frac{\sum_f \sum_u \boldsymbol{Other}_{uist,f} \times \boldsymbol{CF}_{t,f} \times \mathbf{8760}}{\mathbf{1000}} \tag{5}$$

$CHN\ Gen_{ist}$ and $Other\ Gen_{ist}$ are the generation potentials in subnational region i in country s at time t. Generation potential is used to account for the variation in efficacy of various technology types, and it does not reflect actual electricity generation.

RESULTS

Table 5 reports the estimated results for the relationship between China-financed/co-financed electric power projects and energy poverty in African countries, with different model specifications. In summary, each additional 1,000 MW of operating capacity financed/co-financed by China leads to a 0.4 percentage point increase in the average likelihood of electrification in the subnational regions of Africa.

In all specifications except Column (1), we control for the impact of other operating capacities. Column (2) shows that each additional 1,000 MW of operating capacity financed or co-financed by China leads to a 0.4 percentage point increase in the average likelihood of electrification in African subnational regions, significant at the 95 percent level. Columns (3) and (4), which control for relevant covariates, show that the effect and its direction remain consistent. In the most rigorous specifications reported in Columns (6) and (7), we also account for unobserved heterogeneous shocks that may occur in individual countries in a given year. The estimation remains robust, though with a lower statistical significance.

The direction of covariate effects generally aligns with our expectations. For example, higher population density and spatial proximity to metropoles negatively affect energy poverty, as less dense urban areas, remote locations or complex terrains often opt for off-grid solutions and receive unreliable power services. The inclusion of the ruggedness variable is based on Nunn and Puga (2012). However, we cannot confirm whether our estimated result follows the same pathway as the effect of terrain ruggedness on economic development in Africa. Nevertheless, none of the covariates show statistically significant effects on energy poverty at the 95 percent confidence level in the multivariate specifications.

Table 5: Estimated Results for Eq. (4) with Various Specifications, CHN = 1,000 MW

	Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Operating capacity	**Chinese-funded**	**0.420** **(0.196)**	**0.418** **(0.197)**	**0.433** **(0.208)**	**0.441** **(0.208)**	**0.389*** **(0.216)**	**0.359*** **(0.181)**	**0.366** **(0.182)**
	Other		-0.010 (0.053)	-0.032 (0.073)	-0.043 (0.076)	0.003 (0.061)	-0.011 (0.086)	-0.023 (0.089)
Population density				0.003 (0.002)	0.002 (0.002)		0.003* (0.002)	0.002 (0.002)
Ruggedness				0.009 (0.025)	0.010 (0.024)		0.008 (0.025)	0.009 (0.024)
Distance from metropole					-0.016 (0.019)			-0.016 (0.019)
Subnational region fixed effects		Y	Y	Y	Y	Y	Y	Y
Country fixed effects		Y	Y	Y	Y	Y	Y	Y
Year fixed effects		Y	Y	Y	Y	Y	Y	Y
Country-year fixed effects		N	N	N	N	Y	Y	Y
AIC		34645.05	34647.04	32554.14	32555.45	33240.15	31242.98	31244.16
BIC		34692.68	34701.48	32621.57	32629.62	33253.76	31269.95	31277.88
Observations		6,666	6,666	6,266	6,266	6,666	6,266	6,266

Source: Authors' elaboration.

Note: *** p<.01, ** p<0.05, * p<0.1; robust standard errors clustered at the country level are reported in parentheses. In the most conservative specification, year fixed effects and country fixed effects are absorbed by country-year fixed effects.

One striking observation is that there is no statistically significant relationship between energy poverty and operating capacity that is not financed or co-financed by Chinese DFIs. We believe the reasons are complex. First, much of this capacity is outdated and inefficient. In 2020, about 40 percent had been in operation before 2000, and 13 percent was contributed by plants that began operating before 1980. However, the currently available data do not reflect the inefficiency of this outdated capacity, as we cannot obtain plant-level generation data or CFs. Second, many Chinese projects include a distribution component (Figure 6), increasing the likelihood that capacity financed or co-financed by Chinese DFIs is distributed to end users, thereby enhancing access to electricity services. In contrast, it is unclear how much of the capacity not financed or co-financed by Chinese DFIs has been accessible to end users.

We test whether our results are sensitive to the using different units of the variable of interest. The Third Belt and Road Forum, held in 2023 to mark the initiative's 10th anniversary, confirmed a shift in focus toward "small and beautiful" or "small and impactful" projects. This represents a move away from large infrastructure megaprojects in favor of smaller-scale initiatives that deliver greater impact. As for the power projects, China's flagship project sizes range from 100 MW to over 500 MW. Thus, we re-estimate Eq. (2) using 100 MW as the unit of operating capacity financed or co-financed by China. Table 6 displays the results. Across all columns, the effect of operating capacity financed or co-financed by China on reducing energy poverty is positive and statistically significant.

Table 6: Estimated Results for Eq. (4) with Various Specifications, CHN = 100 MW

	Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Operating capacity	**Chinese-funded**	**0.042** **(0.020)**	**0.042** **(0.020)**	**0.043** **(0.021)**	**0.044** **(0.021)**	**0.039*** **(0.022)**	**0.036*** **(0.018)**	**0.037** **(0.018)**
	Other		-0.010 (0.053)	-0.032 (0.073)	-0.043 (0.076)	0.003 (0.061)	-0.011 (0.086)	-0.023 (0.089)
Population density				0.003 (0.002)	0.002 (0.002)		0.003* (0.002)	0.002 (0.002)
Ruggedness				0.009 (0.025)	0.010 (0.024)		0.008 (0.025)	0.009 (0.024)
Distance from metropole					-0.016 (0.019)			-0.016 (0.019)
Subnational region fixed effects		Y	Y	Y	Y	Y	Y	Y
Country fixed effects		Y	Y	Y	Y	Y	Y	Y
Year fixed effects		Y	Y	Y	Y	Y	Y	Y
Country-year fixed effects		N	N	N	N	Y	Y	Y
AIC		34645.05	34647.04	32554.14	32555.45	33240.15	31242.98	31244.16
BIC		34692.68	34701.48	32621.57	32629.62	33253.76	31269.95	31277.88
Observations		6,666	6,666	6,266	6,266	6,666	6,266	6,266

Source: Authors' elaboration.

Note: *** p<.01, ** p<0.05, * p<0.1; robust standard errors clustered at the country level are reported in parentheses. In the most conservative specification, year fixed effects and country fixed effects are absorbed by country-year fixed effects.

We substitute the independent variable with a calculated generation potential for each year as an additional robustness check. The results, presented in Table 7, show that each 1 TWh increase in generation potential financed or co-financed by China results in a 0.1 percentage point increase in the average likelihood of electrification in African subnational regions at the 95 percent confidence level. However, this estimation assumes that all generation units of the same fuel type have the same CF. The actual generation of each generation unit may vary, but we lack an adequate measure to observe these variations.

Table 7: Estimated Results for Eq. (5) with Various Specifications

	Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Generation Potential (Unit: 1 TWh)	**Chinese-funded**	**0.135** **(0.057)**	**0.134** **(0.057)**	**0.138** **(0.060)**	**0.140** **(0.059)**	**0.120** **(0.056)**	**0.107** **(0.045)**	**0.109** **(0.04)**
	Other		-0.010 (0.053)	-0.032 (0.073)	-0.043 (0.076)	0.003 (0.061)	-0.011 (0.086)	-0.023 (0.089)
Population density				0.003 (0.002)	0.002 (0.002)		0.003* (0.002)	0.002 (0.002)
Ruggedness				0.009 (0.025)	0.010 (0.024)		0.008 (0.025)	0.009 (0.024)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Distance from metropole				-0.016 (0.019)			-0.016 (0.019)
Subnational region fixed effects	Y	Y	Y	Y	Y	Y	Y
Country fixed effects	Y	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y	Y
Country-year fixed effects	N	N	N	N	Y	Y	Y
AIC	34645.95	34647.95	32554.04	32555.35	33240.08	31242.93	31244.11
BIC	34692.58	34701.39	32621.47	32629.53	33253.69	31269.90	31277.83
Observations	6,666	6,666	6,266	6,266	6,666	6,266	6,266

Source: Authors' elaboration.

Note: *** $p<.01$, ** $p<0.05$, * $p<0.1$; robust standard errors clustered at the country level are reported in parentheses. In the most conservative specification, year fixed effects and country fixed effects are absorbed by country-year fixed effects.

CONCLUSION AND POLICY IMPLICATIONS

China-financed power generation capacity effectively alleviates energy poverty in Africa at the subnational level. To the best of our knowledge, this paper is the first empirical analysis of the effectiveness of Chinese power projects in Africa. Specifically, each additional 1,000 MW of operating capacity financed or co-financed by China leads to a 0.4 percentage point increase in the average likelihood of electrification. This positive and significant effect remains robust even after controlling for power generation capacity financed by other sources, urbanization, geographical attributes, proximity to metropoles, fuel-specific capacity factors and under several more demanding specifications.

However, this progress in electrification has largely been driven by fossil fuels. In 2020, the last year covered by our analysis, fossil energy had a nominal capacity of 0.6 GW, representing 51 percent of the total operating capacity financed or co-financed by Chinese DFIs that year. Of that, 0.5 GW came from coal-fueled plants. Hydropower was the second-largest contributor, accounting for 45 percent of total capacity. By contrast, progress in reducing energy poverty through renewable sources, such as wind and solar, was relatively limited during the observed period. The renewable generation capacity needed to replace and expand the existing fossil fuel-centric electricity infrastructure remains substantial.

Chinese DFIs can further contribute to Africa's energy transition in three ways. First, they can leverage their expertise and domestic experience to help host countries refinance and repurpose aging fossil energy generation capacity with renewables. Second, they can engage in dialogue and work toward decarbonizing the coal plants they have financed or co-financed. Third, as noted in the Beijing Action Plan (Ministry of Foreign Affairs of the People's Republic of China 2024), they can intensify efforts to increase the adoption of renewable energy across the continent. Moreover, they can help shape the market to enable the private sector to participate in renewable manufacturing and unleash the potential for sustainable industrialization in Africa.

While our study provides partial insights into the two research questions specified in the introduction, it has several limitations. First, due to data availability, we do not estimate the impact of power generation projects not financed by Chinese DFIs. Future studies could offer comparative insights into the effectiveness of projects funded by various development partners, whether bilateral or multilateral. Additionally, we are unable to assess the impact of renewable versus non-renewable power generation projects in reducing energy poverty on the ground. To better understand the green transition of China's overseas infrastructure investments, future research on renewable energy projects could offer clearer perspectives on China-Africa development cooperation as well as good practices for knowledge sharing and institutional changes.

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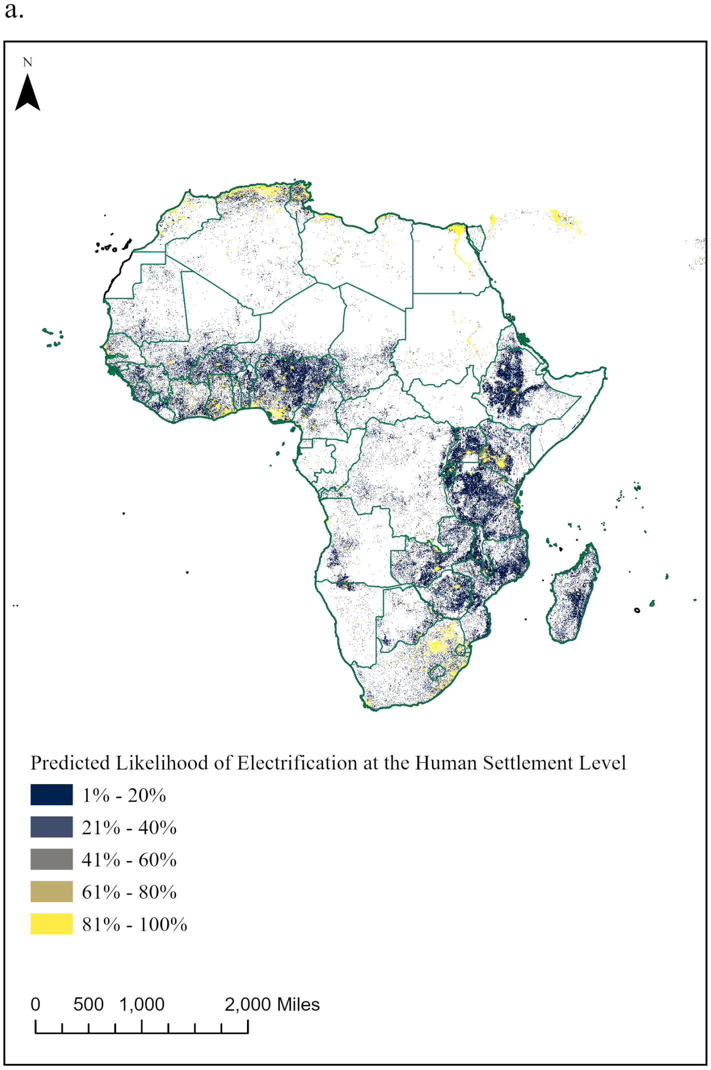
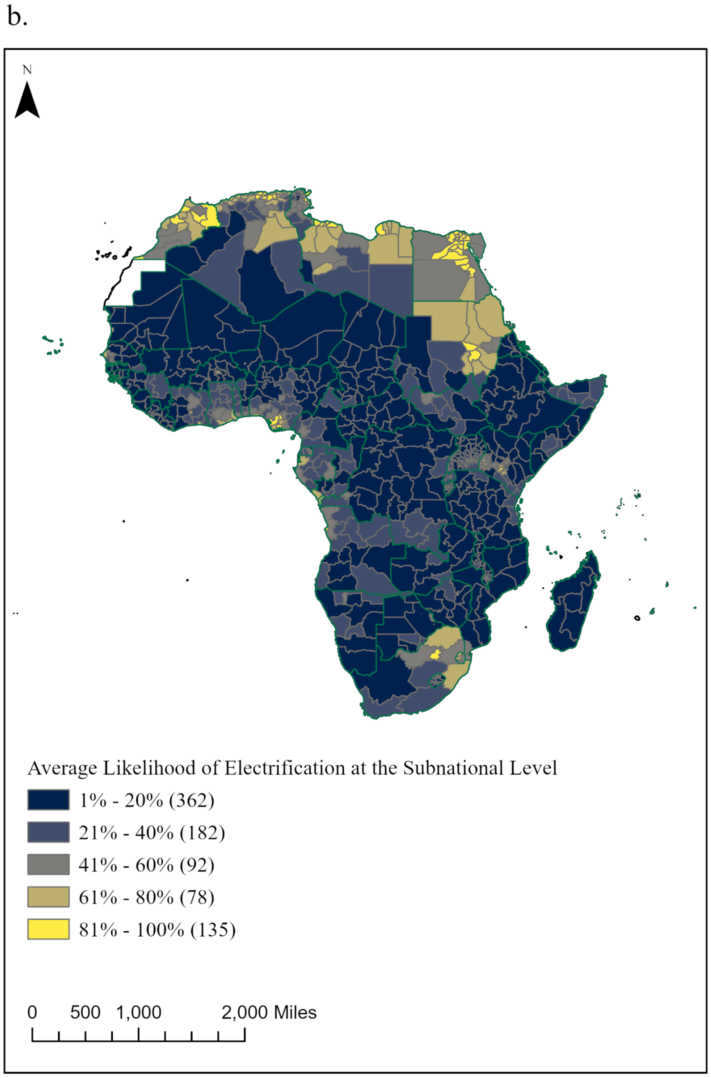
APPENDIX

Figure A1 : Energy Poverty at the Subnational Level in Africa, 2020, Equal Interval

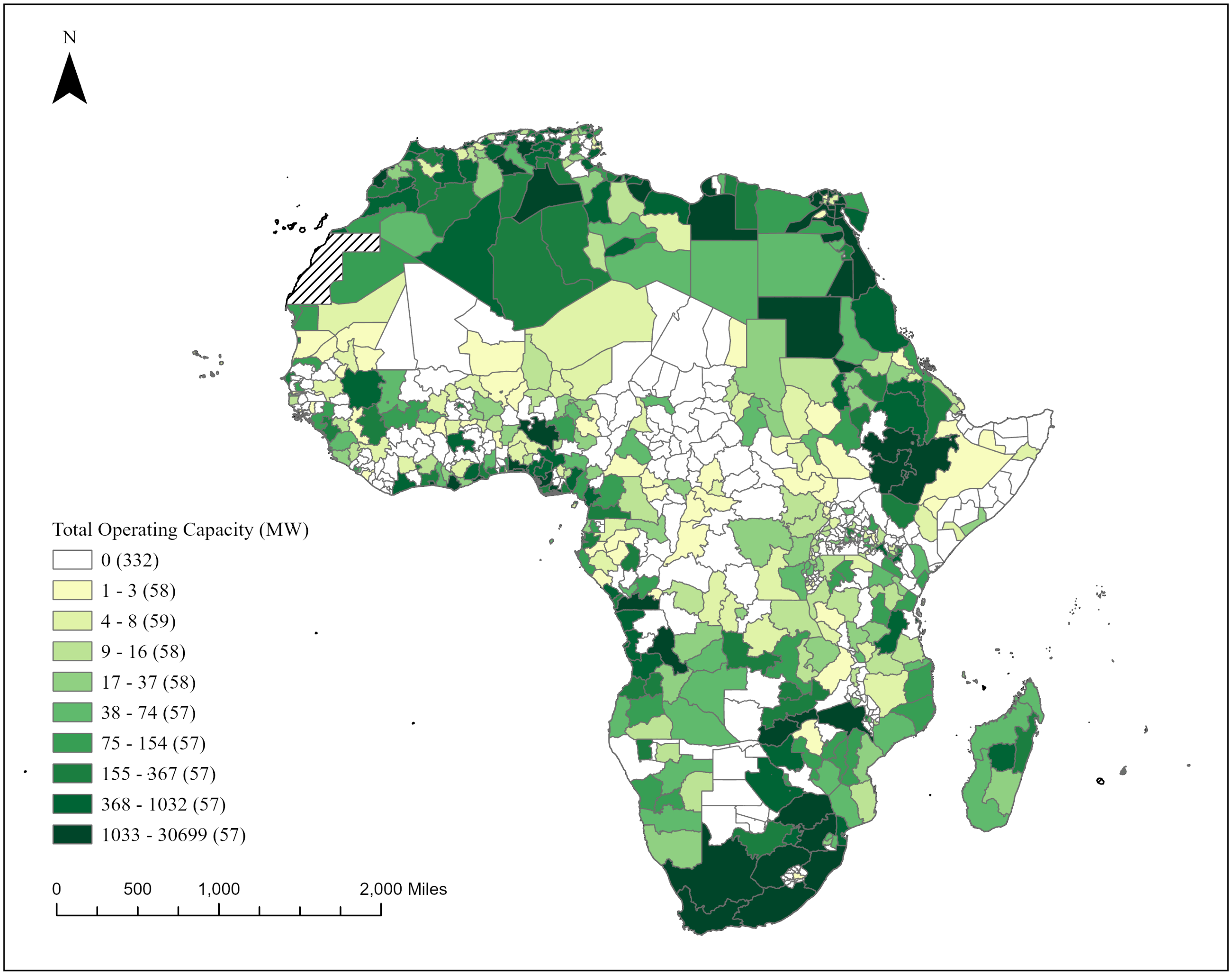




Source: Authors' elaboration, GADM version 4.1; energy poverty calculated based on Min et al. (2024).

Note: The projection is based on the World Geodetic System 1984. Panel a reports the predicted likelihood that a settlement is electrified at a 1-kilometer spatial resolution. Panel b reports the average likelihood at the subnational level using zonal statistics in ArcGIS Pro. The numbers of regions in each group are reported in parentheses.

Figure A2: Total Operating Capacity in Africa, 2020, Decile



Source: Authors' elaboration, GADM version 4.1, and S&P Capital IQ Pro Global Power Markets Database.

Note: The projection is based on the World Geodetic System 1984. The numbers of regions in each group are reported in parentheses.

Table A1: Power Plants Financed/Co-Financed by China, Included in the Empirical Study

Plant	Country	Fuel Type	Operating Capacity, MW
Jerada Steam Plant	Morocco	Coal	350
Kusile Steam Plant	South Africa	Coal	1,600
Medupi Steam Plant	South Africa	Coal	3,200
Olorunsogo -I Gas Plant	Nigeria	Gas	195
Omotosho-I Gas Plant	Nigeria	Gas	335
Mahmoud Sharif Steam Plant	Sudan	Oil	200
Kiwanda Cha Umeme Wa Jua Cha Garissa	Kenya	Solar	55
Adama Wind Power Plant	Ethiopia	Wind	204
Olkaria IV Geothermal Power Plant	Kenya	Geothermal	140
Bui Dam Hydro Plant	Ghana	Hydropower	400
Central Hidroeléctrica do Chiumbe Dala (Tchihumbwe)	Angola	Hydropower	12
Centrale Hydroélectrique De Djibloho	Equatorial Guinea	Hydropower	120
Centrale Hydroélectrique De Grand Poubara	Gabon	Hydropower	160
Centrale hydroélectrique de Kaleta	Guinea	Hydropower	240
Centrale hydroélectrique de Liouesso	Rep. Of the Congo	Hydropower	20
Centrale Hydroélectrique De Soubre	Côte d'Ivoire	Hydropower	270
Centrale Hydroélectrique De Zongo-II	Dem. Rep. Congo	Hydropower	150
Finchaa-Amerti-Neshe (Fan) Hydro Plant	Ethiopia	Hydropower	97
Genale-Dawa-III Hydro Plant	Ethiopia	Hydropower	254
Hydro-Mekin Plant	Cameroon	Hydropower	15
Ingula Pumped Storage Plant	South Africa	Hydropower	1,332
Isimba Hydropower Station	Uganda	Hydropower	183
Kariba North Hydro Plant	Zambia	Hydropower	360
Kariba South Hydro Plant	Zimbabwe	Hydropower	300
Lunzua Upgrade Hydro Plant	Zambia	Hydropower	15
Merowe Hydro Plant	Sudan	Hydropower	1,250

Source: CODF Database version 2.0.

Table A2: Metropoles in Africa

ID	Metropole	ISO/Country Code	Longitude	Latitude
1	Lagos	NGA	3.241489	6.66942
2	Abuja	NGA	7.44602	9.062758
3	Casablanca	MAR	-7.64282	33.52901
4	Rabat	MAR	-6.86088	33.99356
5	Tunis	TUN	10.57864	36.64077
6	Tripoli	LBY	13.21437	32.70152
7	Algiers	DZA	3.135672	36.67089
8	Cairo	EGY	31.34043	30.13713
9	Malabo	GNQ	8.765116	3.730737
10	Bata	GNQ	9.789901	1.850128
11	Juba	SSD	31.58514	4.832184
12	Bangui	CAF	18.54842	4.415092
13	Khartoum	SDN	32.54451	15.52198
14	Brazzaville	COG	15.24534	-4.22003
15	Pointe Noire	COG	11.8939	-4.81882
16	Ndjamena	TCD	15.06721	12.12678
17	Yaounde	CMR	11.54897	3.918972
18	Douala	CMR	9.750962	4.059658
19	Libreville	GAB	9.46574	0.425634
20	Kinshasa	COD	15.29604	-4.41043
21	Lubumbashi	COD	27.49005	-11.6557
22	Victoria	SYC	55.46959	-4.66543
23	Sao Tome	STP	6.7293	0.333172
24	Antananarivo	MDG	47.52224	-18.9295
25	Praia	CPV	-23.5159	14.93621
26	Mindelo	CPV	-24.9846	16.87803
27	Port Louis	MUS	57.52652	-20.2188
28	Moroni	COM	43.26408	-11.6939
29	Luanda	AGO	13.38492	-8.92392
30	Harare	ZWE	31.03435	-17.8797
31	Bulawayo	ZWE	28.57463	-20.1711
32	Blantyre	MWI	35.0088	-15.7865
33	Lilongwe	MWI	33.76555	-13.9796
34	Maputo	MOZ	32.48442	-25.8317
35	Gaborone	BWA	25.89606	-24.624
36	Windhoek	NAM	17.08083	-22.5582

ID	Metropole	ISO/Country Code	Longitude	Latitude
37	Johannesburg	ZAF	28.08316	-26.0579
38	Cape Town	ZAF	18.52671	-33.9762
39	Durban	ZAF	30.99647	-29.8475
40	Manzini	SWZ	31.29742	-26.455
41	Mbabane	SWZ	31.21379	-26.3553
42	Maseru	LSO	27.51552	-29.3498
43	Lusaka	ZMB	28.25497	-15.3992
44	Kigali	RWA	30.03766	-1.78901
45	Asmara	ERI	38.93297	15.33318
46	Mogadishu	SOM	45.31306	2.058726
47	Hargeisa	SOM	44.05498	9.558777
48	Bujumbura	BDI	29.35155	-3.52766
49	Kampala	UGA	32.56672	0.334337
50	Djibouti	DJI	43.09775	11.5677
51	Addis Ababa	ETH	38.77079	8.884383
52	Dar es Salaam	TZA	39.17777	-6.80792
53	Nairobi	KEN	36.79371	-1.19838
54	Mombasa	KEN	39.70804	-3.98719
55	Banjul	GMB	-16.7341	13.34446
56	Accra	GHA	-0.07846	5.746204
57	Kumasi	GHA	-1.62433	6.670937
58	Bissau	GNB	-15.587	11.89549
59	Niamey	NER	2.127841	13.51079
60	Freetown	SLE	-13.0199	8.347426
61	Lomé	TGO	1.1653	6.235264
62	Bamako	MLI	-7.88817	12.63137
63	Abidjan	CIV	-3.9597	5.368937
64	Ouagadougou	BFA	-1.49514	12.36407
65	Bobo-Dioulasso	BFA	-4.28641	11.19659
66	Cotonou	BEN	2.338214	6.537449
67	Porto-Novo	BEN	2.651729	6.57239
68	Dakar	SEN	-17.3644	14.76983
69	Nouakchott	MRT	-15.9226	18.08027
70	Monrovia	LBR	-10.6937	6.351428
71	Conakry	GIN	-13.5239	9.702599

Source: OECD/SWAC (2024).

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