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Boosting the Power Sector in Sub-Saharan Africa

China's Involvement



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Foreword

Access to electricity in Africa is much more than simply providing light bulbs for homes in remote villages. Electricity is an essential enabler of economic development that can lift people out of poverty and support sustainable urbanisation and industrialisation. The low rate of electrification in many African countries today has been identified as the most pressing obstacle to economic growth, more important than access to finance, red tape or corruption. Full electrification will require increased investment in the region, including in large-scale, on-grid electricity generation capacity and networks. In 2014, the International Energy Agency (IEA) released a special report of the *World Energy Outlook* on sub-Saharan Africa. This pioneering publication indicated a pathway to realise the “African century,” in which the entire continent enjoys sufficient and uninterrupted access to electricity. The special report also paved the way for the strengthened IEA work on Africa.

This IEA Partner Country series publication, *Boosting the Power Sector in Sub-Saharan Africa: China's Involvement*, is the first report to study in depth the activities and impact of Chinese companies in Africa's power sector development. It assesses the type of projects developed, the financing used, the technologies employed and the impact on generation, distribution and transmission capacity. The report also includes case studies.

At present, various global initiatives promote increased prosperity and economic development in Africa by improving electricity security. The Power Africa initiative by the United States, the Africa-EU Millennium Development Goals initiative, the Tokyo International Conference on African Development (TICAD) process by Japan, the Sustainable Energy for All initiative (SE4ALL) by the United Nations, and the India-Africa Forum Summit (IAFS) are good examples of efforts by the global community to support and promote economic growth in Africa. In this context, the active role of Chinese companies in Africa's power sector is notable, both in terms of magnitude and impact on new electricity capacity additions, mostly coming from renewable energy, including large hydroelectric plants.

Enhancing energy access in Africa was also one of the G20 initiatives under the Turkish presidency in 2015, and it is currently being discussed as an important topic under China's 2016 G20 presidency. It is my hope that by providing key information and analysis about the role of Chinese companies in Africa's power sector development, the IEA can support and facilitate discussion on how stakeholders from China and other countries can co-ordinate and work in a highly complementary fashion to contribute to African power sector development, help governments of African countries and assist multilateral co-operation among African economies and beyond in an appropriate, transparent and environmentally sustainable manner.

Given Africa's rich energy resources, the potential is huge. Greater global co-operation can deliver benefits for all, ultimately promoting increased energy access and economic growth. In the end, this can only succeed if addressed in a positive way by leaders of African countries. African energy, in particular access to clean energy, has been a key topic of analysis for the IEA for close to two decades now. Under its “open doors” policy, the Agency will continue to support expanded energy access and clean energy technology development in Africa.

Dr. Fatih Birol
Executive Director
International Energy Agency

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Executive summary

Due to the scarcity of capital and other factors, access to electricity in sub-Saharan Africa still lags behind the rest of the world. Economic growth and living conditions are severely constrained by a lack of power generation, transmission and distribution capacity. Over 635 million people live without electricity in the region. The sub-Saharan Africa power sector needs greater access to capital funds, technologies and capacity building. Significant investments are needed to massively support power sector development, and ultimately enable economic breakthroughs.

Power projects built by Chinese companies in sub-Saharan Africa have significantly contributed to the region's power sector capacity expansion in recent years. The People's Republic of China (hereafter "China") has become an important source of financing in Africa. Chinese engagement in power covers all primary sources except nuclear, and all sizes of projects, while donors from Organisation for Economic Co-operation and Development (OECD) countries avoid financing large hydropower dams or coal-fired power plants.

This report analyses China's engagement in the sub-Saharan Africa power sector by examining its recent and planned support for power projects in the region over the 2010-20 period. It provides an overview of Chinese projects based on a unique dataset, and highlights the current status and major trends of these projects in the first-ever consolidated effort to map them. This study also identifies key Chinese stakeholders and assesses implications for development in sub-Saharan Africa.

Chinese companies operating as the main contractor were responsible for 30% of new capacity additions in sub-Saharan Africa in 2010-15. Greenfield power projects contracted to Chinese companies are widespread in sub-Saharan Africa: more than 200 projects over the 2010-20 time period have been included in the scope of this report. Chinese contractors have built or are contracted to build 17 gigawatts of generation capacity in sub-Saharan Africa from 2010 to 2020, equivalent to 10% of existing installed capacity in sub-Saharan Africa, or to Finland's total installed capacity. In power transmission and distribution, Chinese companies are active in the entire power-grid chain, from cross-border transmission lines like between Ethiopia and Kenya, to local urban and rural distribution networks, such as in Angola or Equatorial Guinea.

Projects by Chinese companies cover almost the entire electricity mix, dominated by hydropower. Renewable sources account for 56% of total capacity added by Chinese projects between 2010 and 2020, including 49% from hydropower. Chinese-built greenfield projects increase the diversity of the sub-Saharan Africa power capacity mix and accelerate the development of renewables in the region (wind, solar, biomass and hydropower). In a country like Ethiopia, Chinese projects in biomass and waste-to-energy are unique in the region. Moreover, new hydropower dams such as in Gabon or Zambia, and other renewables projects like in Senegal or South Africa, have helped avoid carbon dioxide (CO₂) emissions. Hydropower has also played an important role in the early stages of electrification in several regions of the world, even though concerns over large dams, including environmental and social impacts, must be addressed.

A substantial proportion of Chinese power projects in sub-Saharan Africa are aimed at expanding access to electricity. Over the period 2010 to 2020, a total of 120 million people will gain access to electricity through the power grid, enabled by grid development and increasing power generation capacity, of which Chinese contractors are responsible for 30%. Expanded access to electricity can in turn facilitate industrialisation and economic development. China also supports rural off-grid solutions with solar energy kits donated in countries like Rwanda and Comoros.

China's involvement in Africa, as in other regions around the world, bolsters the internationalisation of Chinese companies as well as the government's "going abroad" strategy. The current economic slowdown in China and overcapacity in various sectors is impelling Chinese companies to search for new markets overseas. Over 90% of Chinese-built power projects in the region are contracted by Chinese state-owned enterprises (SOEs). Africa is the largest overseas market for some major Chinese energy infrastructure SOEs, which provide integrated services centred on turnkey projects. Africa's industrialisation and economic development is seen by Chinese stakeholders as important for Chinese exports of manufactured goods in the region.

Generally with Chinese government support, Chinese stakeholders provide integrated solutions in power generation capacity and in transmission and distribution (T&D) through a combination of Chinese development assistance (loans), government-driven investment and equity investment. China's approach to development assistance differs from OECD countries. For example, China is not covered by the Arrangements on Officially Supported Export Credits, which guides OECD countries in export credit financing.

In the 2010-15 period, loans, buyer/seller credits and foreign direct investment (FDI) from China for sub-Saharan Africa power sector development (generation and T&D) amounted to around USD 13 billion, or around one-fifth of all investments in the sector in the region. Most power facilities built by Chinese companies are financed by Chinese stakeholders, essentially through public lending from the Export-Import Bank of China (Exim Bank). Construction costs of power plants built by Chinese builders are lower overall than in other parts of the globe but higher than those for plants built in China.

Although sometimes challenging in the absence of reliable power off-takers, project financing is increasingly diversified and moving progressively away from public lending. The majority of Chinese-built power projects are still financed by sovereign loans guaranteed by African governments. As more Chinese commercial banks and funds enter the market, the development-lending model is trying to progressively switch to more equity financing. Some Chinese companies operate as independent power producers, like in Ghana.

While increasing power generation and grid capacities, and supporting electricity access for economic development, Chinese-built power projects also raise local challenges for African governments, especially in the potential context of higher constraints on the budgets of sub-Saharan African countries. The success of power projects depends on the ability of African governments to negotiate, implement and maintain them. Outside of China, stakeholders from other countries can also significantly contribute to African power sector development, but the overall success of Africa's electrification ultimately remains dependent upon leaders of African countries.

In line with the IEA's policy to further open its doors to emerging economies and to become a global hub for clean energy technologies, it is dedicated to supporting Africa's electricity sector development. With more than 1 billion inhabitants and vast energy resources and potentials, the region needs better and wider access to energy to sustain its economic growth and improve living conditions. The deployment of renewable energy such as hydro, solar, and wind can further enable economic development in Africa.

Introduction

Chinese companies are increasingly active in overseas markets, including in Africa. Chinese projects and financial support contribute to power sector development in sub-Saharan African countries, extending energy access and facilitating economic growth.

This report describes China's activity in the sub-Saharan Africa power sector; by measuring and analysing the engagement of Chinese energy infrastructure companies in the region, it aims to better understand the role of China in strengthening electricity supply security. This study also identifies key Chinese stakeholders and assesses implications for development in sub-Saharan Africa. Based on a unique dataset, this analysis focuses primarily on:

- mapping Chinese companies' support for power projects (by country and by primary energy source)
- measuring the impacts on host country power supply by quantifying electricity generation capacity (in GW) and grid infrastructure (in kilometres [km]) added by Chinese stakeholders (completed after 2010, under construction or planned and financially secured to come online before 2020)
- assessing Chinese companies' engagement in comparison with other stakeholders (share of additional generation capacity and contracted greenfield projects)
- analysing the particularities of Chinese power sector involvement: financing modalities, technologies and equipment, and challenges for host countries.

Sub-Saharan Africa's call for electrification

Over the past 15 years, sub-Saharan Africa's GDP doubled. GDP growth accelerated substantially towards the end of the 1990s, to an average of 5% per year between 2008 and 2015 (IMF, 2015). Growth slowed to 3.5% in 2015, but it is expected to increase to 4% in 2016 (IMF, 2016). Factors such as the Ebola epidemic in West Africa, terrorism and the drop in oil and other commodities prices contributed not only to slowed growth but also to uneven growth among the four regions of sub-Saharan Africa (Central, East, Southern, West). Limited access to electricity is, however, currently a significant constraint to sustained economic growth across the continent.

In sub-Saharan Africa, the problem lies especially in shortage of supply. Over 635 million people live without electricity in the region. Due to limited infrastructure for generation, T&D, economic growth is constrained by frequent electricity shortages. Additionally, the agriculture sector remains largely unmodernised, although it continues to be the biggest sector in sub-Saharan economies, accounting for 20% of regional GDP and 65% of employment. This sector has the potential to be much more productive with sustainable energy sources (IEA, 2015a).

According to the IEA New Policies Scenario in the *World Energy Outlook*, sub-Saharan electricity demand is expected to more than triple by 2040, to reach 1 300 terawatt hours (TWh) under current and proposed government policies and measures. By 2040, demand from industry will double while residential demand will grow by more than five times current levels. At a rate of 6% per year, electricity demand growth will therefore exceed GDP growth throughout the next 25 years to 2040 (IEA, 2014a).

Sub-Saharan Africa has ample primary energy resources to meet this demand: recoverable oil resources will be sufficient for the next 100 years, coal for over 400 years and gas for 600 years, and renewable energy sources (geothermal, hydro, wind and solar) are abundant (IEA, 2014a).

Technological innovations are expected to help establish sustainable and modern renewable energy.

By 2040, total power generation capacity is expected to quadruple to 385 GW. Capacity additions average 7 GW per year until 2020, and then increase to around 10 GW per year in the 2020s and over 13 GW yearly in the 2030s. The sub-Saharan power sector is thus expected to expand progressively, though it will remain far behind those of other developing countries. Economic breakthroughs can happen in sub-Saharan countries if massive power sector development is successfully supported; significant investments are therefore needed (IEA, 2014a).

China's increased energy engagement overseas

China's overseas energy engagement can be divided into two main categories: upstream activities (mainly oil and gas), and power projects in host countries (power generation, transmission and distribution). Chinese upstream investments help secure energy resources overseas to feed its growing energy demand, which is estimated to more than double over the next 30 years and is the single most important driver of global energy demand growth (IEA, 2015a). Between 2011 and 2013, Chinese oil companies invested USD 73 billion in oil and gas projects overseas (IEA, 2014b).

China's engagement overseas is part of the "going abroad" policy incorporated for the first time in the 10th Five-Year Plan (2001-05); it also aims to extend internationalisation of Chinese companies. In addition, enlarged Chinese overseas involvement is encouraged under the "Belt and Road" initiative launched by President Xi Jinping in 2014 (Clover and Hornby 2014).

Although its energy engagement in Africa is driven by the need for overseas markets, China's activities contributes to power sector development in emerging countries through construction of new generation capacity and new grids. Chinese involvement in a wide range of power plants such as hydropower dams, gas-fired power plants and biogas appliances in rural villages, and construction of transmission lines and distribution networks, tends to diversify the power generation capacity mix and increase energy access in urban as well as rural areas. China also plays a growing role in developing cross-border energy infrastructure.

Power projects by Chinese companies in Africa include, among others: biomass projects in Ethiopia; a 600-megawatt (MW) coal-fired power plant in Botswana; the 400-MW Bui Dam in Ghana; a 100-MW diesel-fired power plant in Niger; the 244-MW wind farm in Northern Cape, South Africa; involvement in geothermal projects in Kenya; national and cross-border transmission lines; and rehabilitation and expansion of distribution networks in several cities such as Addis Ababa and Libreville.

Analytical framework

This publication focuses on Chinese power projects built by Chinese companies as the main contractor in the sub-Saharan African region. Power projects included in the analysis are either completed, under construction, or planned and financially secured for completion by 2020.

This report is based on real projects within 2010 to 2020 and combines quantitative and qualitative analysis. It adopts a supply-driven approach to analyse Chinese companies' power projects in sub-Saharan countries and resulting opportunities for all stakeholders. First-hand, evidence-based and cross-checked findings have been compiled and examined to map and quantify power projects by location and by electricity capacity added to the grid; both capacity additions (in GW) and number of contracted projects are examined.

Quantitative analysis focuses on power projects completed by a Chinese company (with parent company headquartered in China) as main contractor. The study therefore includes projects contracted to Chinese companies, either directly by host countries or by China, or financed by international development partners. The quantitative analysis does not incorporate subcontractors or equipment suppliers. In terms of sectors, this report covers greenfield projects in generation, transmission and distribution; the entire electricity mix, except nuclear, is covered.¹

This report begins with an overview of Chinese projects in the sub-Saharan Africa power sector. It evaluates the share of greenfield projects contracted to Chinese companies and the main characteristics of Chinese-built power generation and transmission projects. The report then analyses the key drivers underlying Chinese involvement. Policy implications in terms of energy access, economic development and technologies employed are assessed in the third part of this publication, and financing modalities and challenges are described in a separate section. The report closes with two country case studies (Ghana and Ethiopia).

Projects modalities have been analysed through existing literature and interviews with key stakeholders in China and Africa, and selected iconic projects are highlighted. The IEA based this analysis on primary and secondary sources in English, French, Portuguese and Chinese, as well as on interviews in Beijing, Accra and Addis Ababa (a list of interviewees can be found at the end of the references section). Unless otherwise stated, all figures in this report are derived from IEA calculations and based on the New Policies Scenario of the *World Energy Outlook 2015*. All amounts have been converted into 2014 USD.

The report provides analysis from the point of view of electricity capacity and does not aim to assess trade practices or environmental and social impacts of specific power projects.

¹ In sub-Saharan Africa, only South Africa currently has nuclear power reactors.

Overview of Chinese power projects

Greenfield power projects contracted to Chinese companies are widespread over sub-Saharan Africa. Between 2010 and 2020, Chinese companies secured projects in at least 37 countries out of 54 (Map 1). The few countries without Chinese involvement in the power sector account for less than 5% of sub-Saharan Africa's electricity output (IEA, 2015c).

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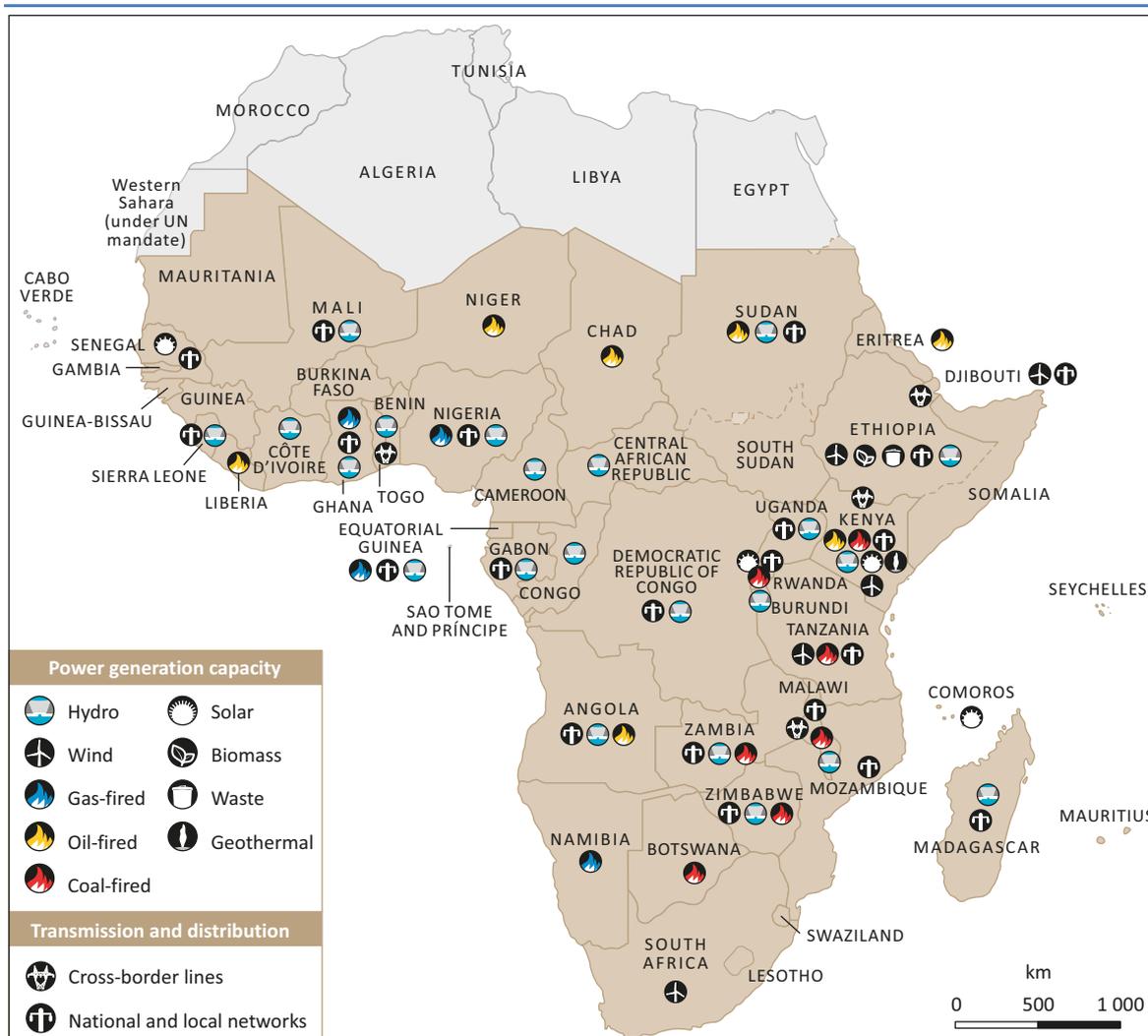
More than 200 Chinese power projects are included in the scope of this report. Over the 2010-20 decade, Chinese construction and energy infrastructure companies are the main contractors (mostly engineering, procurement and construction [EPC] contracts) for about 150 projects in power plants, and transmission and distribution (T&D) lines. The remaining projects do not relate directly to electricity generation or T&D, but to wider electricity systems such as street lighting, electrical equipment supply, or training. Chinese companies are also active in projects as suppliers, which is not taken into account in the scope of this analysis.

More than half of the 150 power plants and T&D projects were already completed between 2010 and 2015. The remaining ones are either already under construction, or planned and financially secured (Table 1). Announced projects which have not yet reached financial closure are not counted.

This section highlights the main characteristics of Chinese power projects in sub-Saharan Africa. It focuses on generation and transmission capacities added to electricity grids, the share of projects contracted by Chinese companies, and the electricity mix of Chinese-added capacities. This section also provides an overview of the main Chinese companies involved.

Table 1 • Overview of Chinese power projects in sub-Saharan Africa, 2010-20

	Generation capacity			T&D capacity		
	Completed projects	Under construction	Planned and financed	Completed projects	Under construction	Planned and financed
East Africa	14	9	5	10	10	1
West Africa	17	4	2	6	2	2
Central Africa	8	5	2	5	1	2
Southern Africa	15	7	8	4	5	1
Total	54	25	17	25	18	6
	96			49		

Map 1 • Greenfield power projects contracted to Chinese companies, 2010-20

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.
Note: Multiple projects in the same technology are represented by a single symbol in each country.

Key message • Chinese companies contracted greenfield power projects in more than three-quarters of sub-Saharan African countries.

A significant portion of capacity additions

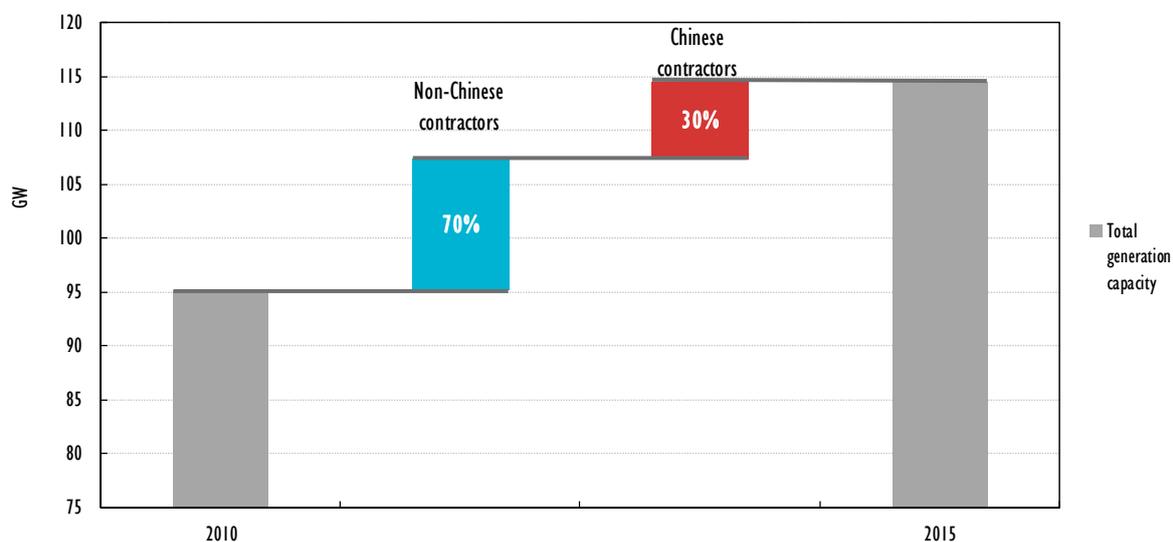
Chinese contractors contribute significantly to total new capacity additions in sub-Saharan Africa over the 2010-20 period. The share of Chinese contracted greenfield projects is substantial compared with that of other foreign contractors. Notably, the share of hydropower plants is highest.

Large capacity additions in generation, transmission and distribution

This section looks at additional installed capacity, measured in GW. Total Chinese generation capacity additions are high — some 17 GW between 2010 and 2020, equivalent to 10% of existing capacity in sub-Saharan Africa, or to Finland's total installed capacity. Among these additions, more than two-thirds have either been completed or are under construction. Between 2010 and 2015, Chinese contractors constructed and connected more than 7 GW of generation

capacity additions. These completed power plants represent 30% of sub-Saharan African capacity additions in this five-year period (Figure 1) (46% if South Africa is excluded).

Figure 1 • Power generation capacity additions in sub-Saharan Africa, 2010-15



Key message • Over the last five years, Chinese contractors were responsible for 30% of new capacity additions in sub-Saharan Africa

In power T&D in the 2010-20 period, Chinese contractors add at least 28 000 km of electricity lines. Projects can be found in the entire power grid chain, from cross-border transmission lines to local urban or rural distribution networks. Lines are contracted to be built by Chinese companies but are rarely owned by them. Between Ethiopia and Kenya, for instance, the State Grid Corporation of China (SGCC) is installing a new 500-kilovolt (kV) line from the Gibe III dam. Funded by the World Bank and the African Development Bank (AfDB), the 1 100-km line will have a capacity of 2 000 MW, and some equipment are supplied by Siemens and Isolux Cortan. Other cross-border lines connect Ethiopia and Djibouti, Benin and Togo. Such international projects can improve the operation of power pools in the region.

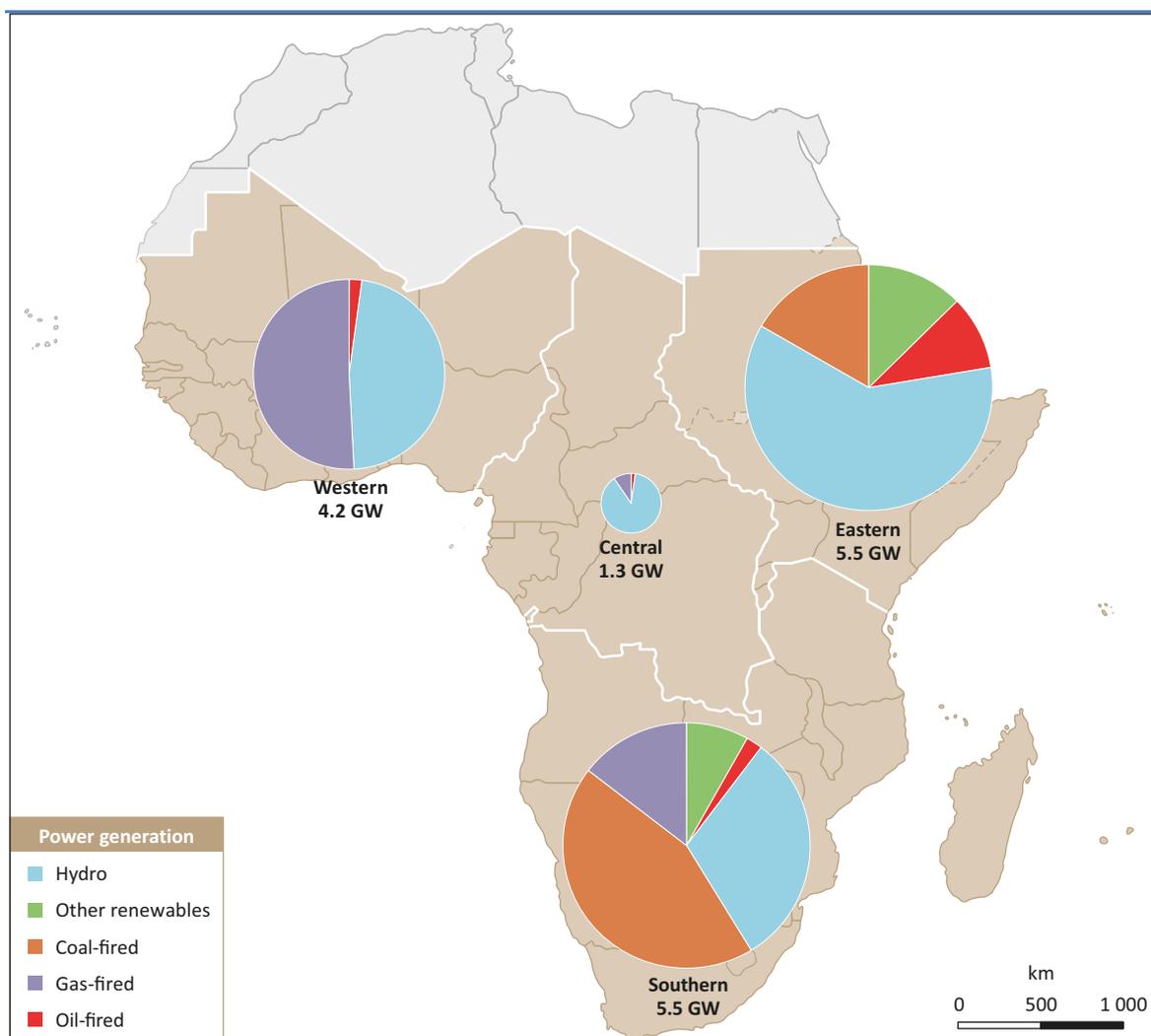
Although there are Chinese projects throughout sub-Saharan Africa, generation capacity additions by Chinese contractors are most important in East Africa and Southern Africa (33% each), followed by West Africa (26%) and Central Africa (8%). The distribution of Chinese projects corresponds to greater economic growth in East Africa and Southern Africa. There is also a wider mix of technologies from Chinese projects, including in non-hydro renewables, in East and Southern regions (Map 2).

With a few exceptions, projects by fuel type are in most cases consistent with locally available resources. Almost three-quarters of Chinese-built additional coal-fired capacity are in Southern Africa, a region with high coal resources. For example, during the Chinese president's visit to Zimbabwe on 1 December 2015, the expansion of the 600-MW Hwange coal power station was announced (Macdonald, 2015). In West Africa, most Chinese-built capacity is in gas-fired power plants, especially in Nigeria which has enormous natural gas resources. In Nigeria alone, Chinese companies have completed three projects totalling 1.5 GW, with some advanced technologies provided by Western original equipment manufacturers (OEMs) such as General Electric (GE). In East Africa, a wider share of Chinese hydropower projects accounts for 60% of generation capacity additions. In Uganda, the Karuma hydropower dam, to be completed in 2018, will add

600 MW of capacity. The wider range of Chinese projects in renewables in East Africa, especially in Ethiopia, will generate electricity from wind, hydro, biomass and waste when projects currently under construction are completed.

Meanwhile, coal-fired power projects, despite being only at the planning stage, are being promoted in countries with little or no exploited coal resources, such as Kenya and Ghana. If implemented, these projects would rely on imported coal, at least in the early stage. Infrastructure for coal transport would also be needed, such as for the 900-MW coal-fired project in Lamu, Kenya. The opportunity cost would need to be carefully evaluated against the long-term environmental impacts.

Map 2 • Distribution of Chinese projects in power capacity, by sub-region, 2010-20



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Key message • More generation capacity is added by Chinese builders in Eastern and Southern Africa, the sub-regions with higher economic growth.

In terms of capacity size, Chinese projects are mostly large, utility-scale, even though some companies have built small-scale projects in countries like Sierra Leone and Burundi. Although Chinese projects range from very small (0.4 MW) to very large (1 250 MW), the average size of all projects completed, under construction or planned is 188 MW. At an average of 221 MW, hydropower projects are essentially large-scale, with only 15% being small-scale (below 10 MW).

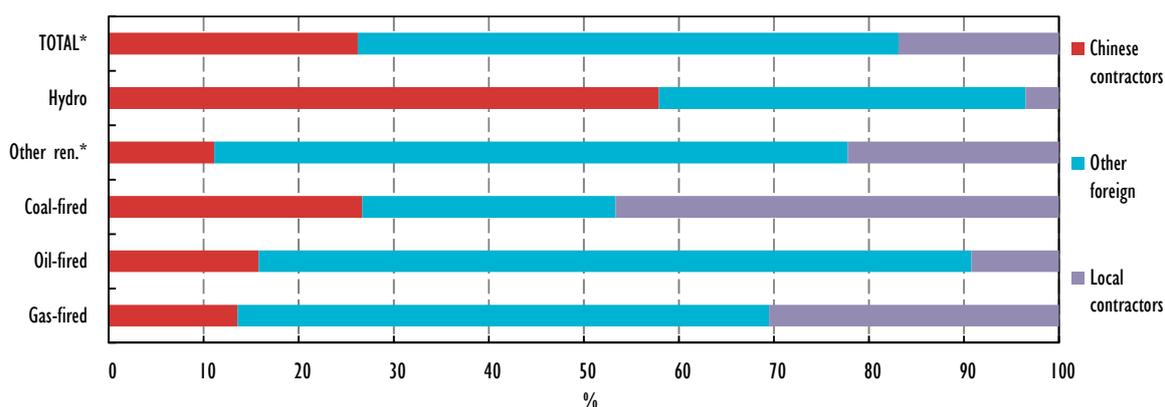
Notably, wind projects are only utility-scale, ranging from 30 MW to more than 150 MW, while completed solar projects are limited to off-grid solar kits or small rooftop photovoltaic (PV), with the exception of a 20-MW solar PV project connected to the Ghanaian grid in April 2016.

A significant share of power plants contracted to Chinese companies

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Chinese contractors have the largest share in the greenfield power plants market within sub-Saharan Africa. This section looks at projects from a contracting perspective, by number of projects regardless of size. It is possible to examine the market share of Chinese companies in this way because the average size of Chinese-built and non-Chinese-built projects is comparable. Wind and solar PV projects, which are more difficult to track, have not been taken into account for this part of the analysis to avoid presenting any misleading findings. About one-quarter of all non-wind and non-solar PV greenfield power plants built since 2010 or currently under construction in sub-Saharan Africa are Chinese-built (Figure 2). All other foreign contractors combined represent a share of nearly 60%, while local contractors account for less than 20%. Chinese contractors are dominant in the construction of hydropower dams (58%) and important in that of coal-fired power plants (27%). Other foreign contractors built 75% of all greenfield oil-fired power plants, and Chinese firms built only 16%. Chinese company involvement is less important in gas-fired, biomass and geothermal power plants. Overall, the average generation capacity sizes of Chinese and non-Chinese projects do not present major gaps.

Figure 2 • Share of greenfield power plants contracted to Chinese companies, 2010-15

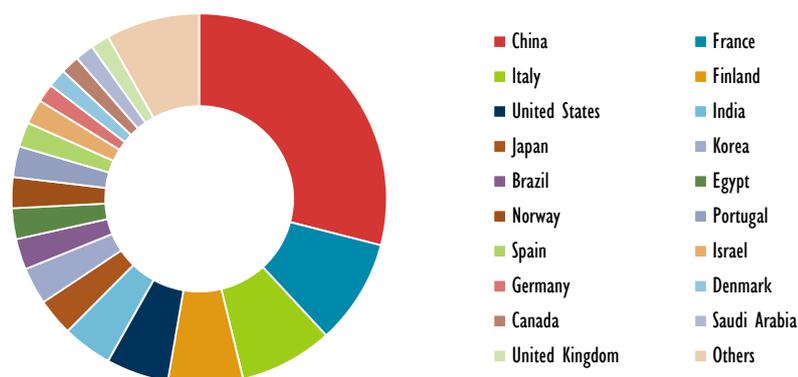


*Excluding wind and solar PV.

Notes: The large share of projects contracted by local companies in the coal-fired sector reflects mostly South African projects. Calculation is based on plants completed or under construction (larger than 10 MW).

Key message • Chinese companies construct about one-quarter of greenfield power plants in the region from 2010 to 2015.

From 2010 to 2015, companies from China were more active in sub-Saharan Africa than companies from any other country. Foreign contractor market shares (all foreign companies, excluding local ones) in all subsectors—apart from solar and wind—show that Chinese companies contracted almost 30% of greenfield power plants, the remaining being built mostly by firms from industrialised countries and only a few from emerging countries (Figure 3). The share of greenfield power projects contracted by Chinese companies equals those contracted by companies from the next four largest countries combined: France, Italy, Finland and the United States. This overall share is made larger partly by hydropower projects, in which Chinese companies largely dominate. Even though Chinese companies lead in the construction of greenfield projects, they still rely partially on foreign equipment suppliers, mostly from OECD countries.

Figure 3 • Headquarters of foreign contractors for greenfield power plants in sub-Saharan Africa, 2010-15

Note: Share by number of contracted projects completed or under construction between 2010 and 2015 (larger than 10 MW, excluding wind and solar PV).

Key message • Among foreign companies, the share of greenfield power plants contracted by Chinese companies equals those contracted by companies from the next four largest countries – in terms of contracted projects – combined: France, Italy, Finland and the United States.

Box 1 • Chinese companies in the Southeast Asia power sector

Africa is not the only region where China is active. Chinese projects in the Association of Southeast Asian Nations (ASEAN) power sector have increased significantly over the last decade, with China emerging as the dominant financier of coal and hydropower projects in the region. While exact financial figures are difficult to track—whether due to lack of information or lack of public disclosure—the sheer number and size of existing and planned power plants being built or financed by Chinese enterprises in Southeast Asia suggest that the scale of Chinese projects in the ASEAN power sector is significant.

It is estimated that China provided at least USD 4.34 billion in public financing to coal plants in Indonesia alone between 2008 and 2013 (Ueno, 2014). Some of these projects are very large-scale coal-fired power plants, such as the USD 860 million 990-MW Indramayu plant in West Java, involving China National Machinery Industry Corporation (Sinomach), China National Electric Engineering (CNEEC) and a loan facility provided by the China Development Bank (CDB) (UNCTAD, 2015). Another USD 700-million coal project called Cilacap, in Central Java, is being funded by a non-collateral loan from CDB to the Indonesian coal company Sumber Segara Primadaya (UNCTAD, 2015).

In Viet Nam, China Exim Bank, CDB and Sinosure have provided around USD 3.89 billion of public financing for coal projects (Ueno, 2014). Chinese companies have won numerous EPC contracts, and Chinese manufacturers are currently the top exporters of thermal power plant equipment to Viet Nam; the scale of Chinese hydropower projects is also very large.

China's involvement in the ASEAN power sector, as in other regions around the world, is primarily driven by the desire to access new markets and natural resources, and support the internationalisation of Chinese companies as well as the government's "going abroad" strategy. But importing electricity from neighbouring countries like Myanmar or Laos is also a key driver. The flexibility of financing terms offered by Chinese policy banks and the cost-competitiveness of Chinese contractors are helping Chinese investors gain a larger foothold in the ASEAN power sector.

Meanwhile, the reception of Chinese projects by ASEAN power sector stakeholders has been mixed. While some see Chinese involvement as essential to support economic development in their countries, others are wary of China's increasing influence in local power development.

A green mix of Chinese-added generation capacities

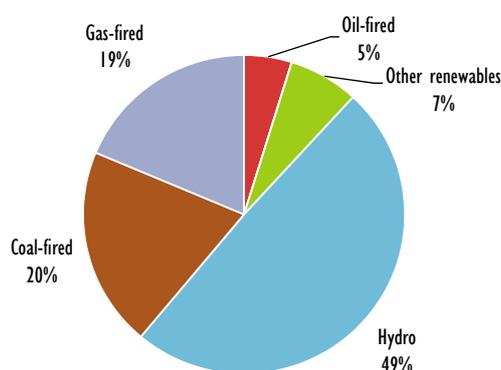
Chinese projects in the sub-Saharan region cover the whole electricity mix except nuclear. In assessing Chinese-built projects completed, under construction or planned over the 2010-20 period, 56% of additional generation capacity uses renewable energy sources, essentially from hydropower (Figure 4). Chinese companies completed more than 20 dams since 2010, and close to 20 more are currently under construction, such as the Soubre dam in Côte d'Ivoire built by Sinohydro. Regarding projects completed or under construction only, additions from renewables reach 67%. From the African governments' perspective, hydropower projects are more attractive than coal- or gas-fired projects, which imply the construction of railways or pipelines. Hydropower projects use low-cost and abundant local resources, are a potential source of electricity for export, and avoid fuel supply issues, although the environmental and social impacts of large dams, such as impacts on local communities, need to be thoroughly addressed.

The relatively small share of non-hydro renewable projects may reflect the smaller size of solar PV projects, and the difficulty in tracking them. In solar PV, Chinese companies are mostly engaged as suppliers and technology providers rather than as construction contractors.

The mix of Chinese-built projects diversifies over the decade with increased coal additions. The increase in coal generation projects can be explained by the need for Chinese energy infrastructure companies to find overseas markets in the least-developed countries due to existing limitations on new coal-fired power plants in China. Additional capacity of 2.4 GW from coal generation is already planned, including the 600-MW Hwange station in Zimbabwe. Such projects have become more uncertain, however, in the post-COP21 Paris Agreement context of strengthened international action against climate change.

Chinese-built greenfield projects increase the diversity of the sub-Saharan African power capacity mix and help to accelerate the development of renewables in the region. IEA data shows that 37% of total capacity additions between 2010 and 2015 in sub-Saharan Africa come from renewable energy (IEA, 2015a), but in fact Chinese companies account for a disproportionate part of the deployment of renewables with significant involvement in hydropower development. The clean energy transition in the region could advance rapidly if the current pace of renewables deployment is maintained and if factors such as policy, environmental sustainability and business environment are well addressed.

Figure 4 • Chinese-added generation capacity mix in sub-Saharan Africa, 2010-20



Notes: Other renewables includes solar, wind, biomass and waste.

Key message • Chinese projects cover almost the entire capacity mix, but hydropower dominates. Renewable sources make up 56% of total capacity added by Chinese companies between 2010 and 2020.

A presence in the whole value chain

Chinese companies provide integrated services centred on turnkey project delivery. For most plants, they have the capacity to undertake the whole project cycle: preliminary studies and design, equipment commissioning, construction, and operations and maintenance (O&M). By having close ties with governments both in China and Africa, they also facilitate financial agreements with banks for funding, including debt management. Although most projects are carried out through EPC contracts, other models such as build–operate–transfer (BOT) and public–private partnerships (PPPs) can also be used.

Besides installed capacity, transmission and distribution, Chinese companies are engaged in a wide range of projects related to electricity systems, such as street lighting, smart metering, biogas appliances and the training of technicians. For instance, companies like Huawei or ZTE have provided street lighting systems in Burundi, Cameroon, Malawi, Mauritania and Senegal, mostly in the form of donation-in-kind from the Chinese government. In Addis Ababa, the SGCC designed and built the power lines and electrical systems of the 32-km urban light railway inaugurated in 2015. Also in 2015, Chinese and Kenyan investors launched a technology transfer and training centre in an industrial park of Nairobi. Beyond the training of local technicians, the centre aims to establish an assembly plant for solar lighting systems (Xinhua, 2015a). Short-term training is also held for African government officials and technicians in China: for instance, the North China Electric Power University hosted one-month training for officials from eight French-speaking African countries in June 2015, sponsored by the Ministry of Commerce (Comnews, 2015).

As part of its active promotion of Chinese standards overseas, the Chinese government's policy paper on African policy released in December 2015 specifically encourages Chinese companies to co-operate with Africa on technical standards (Government of the People's Republic of China, 2015a). In addition to engagement as contractors, an increasing number of Chinese companies supply equipment as subcontractors. For example, the private company CHINT Electrics (CHINT) provides substations in various countries including the Democratic Republic of Congo (DR Congo), Tanzania and Zambia. Chinese suppliers equip projects by Chinese contractors, but are also active in projects contracted by foreign companies. Conversely, Chinese contractors procure machinery such as turbines from major foreign suppliers like GE (formerly Alstom Hydro) (for instance, Alstom Hydro won a contract to supply CNEEC with four 175-MW Francis turbines for the Zungeru dam in Nigeria). Nonetheless, as local content is a prerequisite for Chinese public funding, foreign suppliers have to manufacture their equipment in China to be eligible for export credits.

In South Africa, Chinese companies have become increasingly active in the supply of solar PV over the years. Such projects benefit both Chinese companies, by helping them move up the value chain, and African countries which then have access to affordable equipment. Chinese solar power technology has gained more attention in recent years thanks to higher quality and low prices (Esterhuysen, 2013, 2014). South Africa has been China's entry point into the sub-Saharan solar power market; in 2010, Yingli Solar was a sponsor of the World Cup in South Africa. The South African government's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) aims at attracting more private company in renewables projects. In 2014, for instance, the private Chinese company Jinko Solar invested in a PV factory capable of producing 120 MW per year of solar PV cell in South Africa. The project has reportedly created at least 250 jobs directly, as well as additional indirect employment. Chinese companies directly participate in the REIPPPP (Burgess and Esterhuysen, 2015), and in wind generation projects. China's Longyuan Power Group Corporation (Longyuan Power) is building a wind park in co-operation with multiple South African companies: De Aar Wind Power Projects 1 and 2 near

Cape Town are currently under construction, both to be completed by 2017. Phase I will add capacity of 100 MW, and Phase II 144 MW.

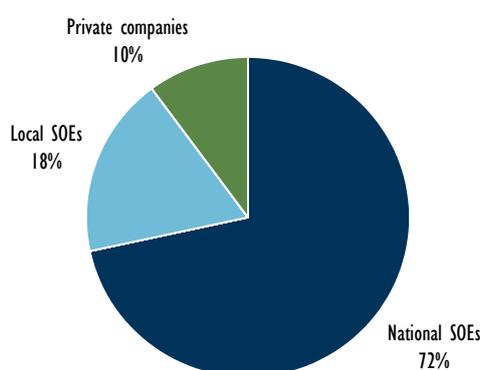
To reduce labour and logistics costs, some Chinese suppliers are willing to set up solar panel and wind tower and blade factories in sub-Saharan countries. Projects are envisaged in Kenya, Ethiopia and Congo, although none have yet materialised.

The major role of Chinese SOEs

Africa is the largest overseas market for many major Chinese energy and construction SOEs. Among Chinese companies, SOEs largely dominate the sub-Saharan African energy market, completing almost all large-scale Chinese projects. Private firms are only responsible for 10% of the projects within the scope of this report (Figure 5).

Projects are mostly undertaken by national-level SOEs, while the engagement of provincial- or municipal-level SOEs is still limited. National SOEs also tend to contract larger projects in various fuel types and countries. Local SOEs, on the other hand, tend to get involved in a specific type of project in one country. The companies are mostly energy infrastructure firms, and there are also some construction and civil engineering firms that are familiar with energy projects. Conversely, energy infrastructure firms are also active in non-energy projects such as roads, airports, railways, and water sanitation systems. These firms can use their own design institutes. Aside from a few exceptions, private companies undertake fewer projects, mostly in T&D.

Figure 5 • Types of Chinese contractors in the sub-Saharan power sector



Key message • Over 90% of Chinese-built power projects are contracted by Chinese SOEs.

Among Chinese companies, five lead the market in the sub-Saharan power sector: Sinohydro, China Gezhouba Group Corporation (Gezhouba), China National Electric Engineering (CNEEC), China International Water and Electric Corporation (CWE), and Shandong Electric Power Construction Corporation (SEPCO). Both Sinohydro and SEPCO are part of the parent company Power Construction Corporation of China (PowerChina). These five companies together added or are completing three-quarters of the Chinese-added generation capacity between 2010 and 2015 (Table 2). On average, their projects are three times larger than projects carried out by other companies.

Out of the leading five, Sinohydro is the largest within the African market. Founded in 1952, the company was incorporated into PowerChina as its international flagship in 2012 with operations in 80 countries. Sub-Saharan Africa is Sinohydro's first overseas market, in which it generates 39% of its overseas revenue in hydro, oil-fired plants and grids. Twenty-four projects and a total

capacity of 3.8 GW have been built by Sinohydro since 2010 or are under construction, and the company has several T&D projects.

Table 2 • Main Chinese power plant contractors in sub-Saharan Africa, 2010-15

Company	Parent company	Number of projects*	Average scale (MW)	Total capacity added (MW)
Sinohydro	PowerChina	24	160	3 832
Gezhouba	CEEC	7	379	2 654
CNEEC	Sinomach	5	204	1 020
CWE	CTGC	5	368	1 838
SEPCO	PowerChina	4	448	1 790

* Completed or under construction.

Notes: CEEC = China Energy Engineering Corporation; CTGC = China Three Gorges Corporation.

Key message • The top five Chinese power plant contractors in sub-Saharan Africa are responsible for three-quarters of Chinese-added capacity.

To strengthen the overseas engagement of Chinese energy infrastructure companies, the Chinese government has encouraged large corporations. In recent years, the three main dam builders, Sinohydro, Gezhouba and CWE, have been incorporated into the larger corporations of PowerChina, CEEC and CTGC, respectively. These mergers have enhanced the international rankings of Chinese energy infrastructure construction firms, and large Chinese SOEs are increasingly investing overseas, including beyond Africa.

Box 2 • SGCC in Brazil's transmission sector

Chinese power sector involvement extends to Latin America as well. The SGCC is one of the world's largest utility companies. It entered Brazil in December 2010 by acquiring seven Brazilian power transmission companies for a total of USD 989 million (Financial Times, 2010; IHS Global Insight, 2010). This interest was reinforced in 2012 with the acquisition of another seven electricity transmission assets, previously owned by the Spanish company Actividades de Construcción y Servicios SA (ACS).

In March 2012, SGCC and Companhia Paranaense de Energia (COPEL) were granted licences to build 1 600 km of transmission lines and four substations in the Amazon's Tele Pires river basin. This was the SGCC's first greenfield project of large-scale transmission in Brazil, with a total investment of USD 1.1 billion (Dow Jones International News, 2012; SGCC, 2012). In December 2012, SGCC—along with minority partners COPEL, Paraná state's utility company and Furnas Centrais Elétricas SA—successfully bid on a project to build a 967-km transmission line, with an investment of Brazilian reais (BRL) 910 million (USD 438 million).

In November 2013, SGCC won the Lot P auction to construct Marechal Rondon substation (MRT), another transmission asset located in São Paulo and Mato Grosso do Sul, with an investment of BRL 11.5 million (USD 5.5 million). The company's second greenfield project was realised in co-operation with local companies.

In February 2014, SGCC won the first dipole of the ±800 kV Belo Monte ultrahigh-voltage direct current (UHVDC) transmission project in partnership with Furnas and Electronorte. The BRL 5 billion (USD 1.25 billion) contract includes a 2 092-km, ± 800-kV transmission line and the converter stations at both ends, from the northern state of Pará to the south-eastern state of Minas Gerais. In this first line, SGCC owns 51%, Eletronorte 24% and Furnas 24% (BNAmericas, 2016). In July 2015, SGCC won a USD 2.2 billion contract to build a second line, as a stand-alone bidder. This second line of 2 518 km, ± 800 kV, projected to be fully operational in January 2019, will be Brazil's largest power line (BNAmericas, 2016).

Also in July 2015, SGCC acquired two operational electricity transmission concessions: ACTE (Atlântico Concessionária de Transmissão de Energia do Brasil SA), 79 km long and 230 kV, and LTMC (Linhas de Transmissão de Montes Claros SA), 151 km and 345 kV. With these acquisitions, SGCC is the fifteenth-largest wholly owned transmission company in the world, with a total of 9 145 km of transmission lines in Brazil.

SGCC's involvement in Brazil currently makes it the fourth-largest transmission operator in Brazil, covering the load centres in Brasília, Sao Paulo and Rio de Janeiro (SGCC, 2015). The 2010 deal with Plena Transmissoras was China's first investment in the Brazilian energy sector, whereby it not only secured assets but also operated and managed them (China Economic Review, 2011). SGCC's main concern is profitability: according to internal sources, the company expects returns on overseas projects to be considerably higher than those within the Chinese home market due to more advantageous pricing policies in the energy sector in other countries (China Daily, 2012). According to one SGCC international division official, a fundamental company principle is that an overseas project is only considered if expected returns are at least twice or three times what can be achieved in China (Caixin Online, 2010).

Aside from establishing itself in a market more lucrative than at home, SGCC will gain expertise in developing systems separating power grid and generation facilities in its Brazilian venture. This could be beneficial for further operations within the country, as well as for reforms to China's own power system. As the company's first overseas UHV DC transmission project, the Belo Monte project is an important milestone in innovation and technology. The project constitutes the first export of Chinese UHV transmission technology, equipment and experience, supporting a key expansion in the Brazilian grid. Similar development can be expected in Africa.

Key drivers underlying Chinese investment

The Chinese government strongly supports and encourages investment in Africa. This is in line with China's "going abroad" policy that has been promoting Chinese companies' activities overseas since the 1980s, mainly for economic reasons. Frameworks like the FOCAC are in place to facilitate co-operation between China and Africa specifically. Beyond this, China's new "Belt and Road" initiative plans to connect whole continents through revived trade routes, including Africa, as stated in Chinese official documents (NDRC, 2015; Eyler, 2015).

Institutional support to Chinese companies overseas

China-Africa relations have been closer since the early 2000s. The volume of trade has increased steadily from 2000, and in 2009 China became Africa's biggest trading partner. From 2009 to 2011, total Chinese investments in Africa grew by 19.3% annually (Information Office of the State Council, 2013). Trade reached a record USD 222 billion in 2014, although economic slowdown caused a sharp decline in 2015 (GACC, 2015). China's involvement in Africa is wide-ranging and, according to official Chinese statements, "suited to African needs."

Infrastructure, including for power, plays a large role in Chinese involvement and is currently the third-largest involvement sector, after mining and financial services (Information Office of the State Council, 2013). The Chinese government has encouraged Chinese enterprises to invest in infrastructure in Africa, specifically in the transportation, communication and power sectors. Investments in energy and mineral exploitation have long been considered key to growth in resource-rich African countries. According to official Chinese policy papers, power projects can take various forms: hydropower, grid construction, street lighting, electrical equipment supply, and training (Government of the People's Republic of China, 2006, 2015).

Incited by the government, Chinese companies look for business opportunities overseas and Africa benefits from Chinese infrastructure projects enabling industrialisation (Tang, 2014; Liu, 2015). The relationship between China and Africa is described as mutually beneficial by the Chinese government and many African heads of state although some concerns have been raised by civil society in some African countries. China does not belong to the OECD Development Assistance Committee (DAC) and has its own approach to co-operation with Africa, a combination of development assistance, trade and investments (Brautigam, 2011).

Energy co-operation has gained importance, as indicated by the four governmental policy papers on Africa published in 2006, 2010, 2013 and 2015. In 2006 and 2010, involvement in power projects was encouraged or mentioned as meriting increase; in 2013, past efforts in renewable energy were taken into account in addressing climate change (Information Office of the State Council, 2013). Power projects received exclusive attention in China's second Africa policy paper released in 2015 (Government of the People's Republic of China, 2015). The paper mentions the construction of national and regional power grids, and close co-operation in the development of renewable and low-carbon, green energy (wind, solar and hydropower in particular). Official documents, for instance, present the Boali hydropower dam III in the Central African Republic and the Malabo gas plant as flagship projects.

The implementation of China's Africa policy is encouraged under the FOCAC umbrella. FOCAC was established in 2000 and was instrumental in establishing the China-Africa Development Fund, economic agreements opening up China to African imports and investments and vice versa, and closer political co-operation.

Within the platform, in 2009 China proposed a China-Africa partnership in which China would, among other things, “enhance the utilisation of new energy sources,” and China has since built 100 clean energy projects (Information Office of the State Council, 2013). China has also been working very closely with South Africa: in 2014, the China National Nuclear Corporation (CNNC) and the Nuclear Energy Corporation of South Africa signed a memorandum of understanding (MoU) on nuclear co-operation.

The latest FOCAC in 2015 in Johannesburg emphasised greater co-operation in energy and natural resources. Mutually beneficial co-operation aims to enhance the proper use of resources through technology transfers and capacity building (training programmes for “African Energy Practitioners,” as well as research and development exchanges). Additionally, the establishment of a China-Africa forum on energy and natural resources under the FOCAC framework was discussed.

For the past 20 years, Chinese foreign ministers have paid their first foreign visit of the year to Africa. In February 2016, Minister Wang Yi visited Malawi, Mauritius, Mozambique and Namibia following the FOCAC summit in Johannesburg. During his visit to Mozambique, co-operation in the energy industry and in manufacturing were highlighted as the two priorities in China-Mozambique relations. In Malawi, co-operation in power stations was discussed, and in Namibia the two parties discussed co-operation in renewable energy (wind and solar power generation capacity specifically). In Mauritius, no specific details were discussed regarding energy co-operation, but the importance of addressing climate change was highlighted (FOCAC, 2016).

Box 3 • Chinese nuclear power engagement in Africa: A long-term prospect?

China is trying to develop its own nuclear technology and is looking at future export markets. For instance, unit 5 of the Fuqing nuclear power plant in Fujian province, using Hualong One technology, is under construction, and two export contracts with Pakistan and Argentina and five co-operation framework agreements have already been drawn up by China (World Nuclear Association, 2015).

South Africa is the only country with nuclear power in sub-Saharan Africa: the country has two nuclear reactors responsible for generating 5% of its electricity. Economic growth is partly constrained by power shortages, so the South African government has decided to pursue extensive plans to add 9.6 GW of nuclear generation capacity across the country by 2030 at a cost of between USD 37 billion and USD 100 billion. China has signed MoUs to develop skills and strategic partnerships (but the Russian Federation [hereafter “Russia”], France, the United States, Canada, South Korea and Japan have also already done so or are preparing similar agreements). China and South Africa specifically extended their nuclear co-operation in 2014: the agreement initiated the preparatory phase for possible use of Chinese technology, and China has started training South African experts in nuclear plant operations (World Nuclear Association, 2014).

In 2015, China also signed agreements with Kenya to assist in its nuclear power ambitions. After South Africa, Kenya seems to be the country in Africa most actively planning a nuclear power future. China is willing to assist Kenya in capacity building and will provide technical support with site selection and feasibility studies (Xinhua, 2015b). Kenya could be one of the first countries in Africa to import the Chinese-designed reactor, although this may not occur in the short or medium term. The affordability, sustainability and feasibility of nuclear power projects in Africa have been controversial internationally.

Economic incentives to investing in Africa

The Chinese government financially supports Chinese companies' involvement in Africa: Chinese contractors interested in being active in Africa receive financial support from public banks and dedicated funds. The financial landscape now includes newly established institutions such as the Asian Infrastructure Investment Bank (AIIB) and the New Development Bank BRICS (NDB BRICS).

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The current economic slowdown in China is impelling Chinese companies to search for new markets overseas. With overcapacity in various sectors, Chinese companies need to seek new markets to sustain growth. The economic slowdown has also led to a change in China's international economic policies, as the need for new markets adds to energy security requirements. In 2007, energy diplomacy became a crucial component of China's international discourse. Technological innovation and economic growth are important factors when considering efficient energy use. Since China went from being a net exporter to net importer of crude oil, reducing its dependency on oil-rich nations by investing in energy technology has been of great importance. New technologies are needed to make energy use more efficient, and more efficient energy use is needed to stimulate economic growth and new technologies (Xu, 2013).

China's "going abroad" policy was first incorporated in the 10th Five-Year Plan which lays out development strategies for the 2001-05 period. Since the opening up of the economy in the 1980s, Chinese enterprises are allowed to establish subsidiaries abroad as long as they possess the necessary capital and technical and operational capacity. Initially, a cap limited the number of projects from China abroad. The cap was lifted over time and finally removed. The "going abroad" policy alleviates domestic overcapacity issues. In some areas, such as the building of hydropower dams or coal-fired power plants, some Chinese energy infrastructure companies had reached bottlenecks in their domestic opportunities. In addition, China has the world's largest foreign currency reserves, which support the government-driven internationalisation policy. Investing in infrastructure is consistent with the long-term strategy of investing foreign reserves in a secure and stable financial return. As encouraging Chinese contracts abroad has been a clear objective of President Xi Jinping, investments abroad have risen in recent years.

Box 4 • OECD and Chinese development assistance practices

The OECD Development Assistance Committee (DAC) has grouped the world's main donors, defining and monitoring global standards in key areas of development. DAC seeks to enhance the quality and effectiveness of development assistance. Guidelines from the OECD limit tied aid; regulate credit practices; impose maximum repayment terms, country risk classification and minimum interest rates; require the exchange of information; and impose social, environmental and governance standards on financing activities. OECD/DAC countries and China all have a long history of development assistance and wider economic co-operation with Africa. Even though collaborations and discussions exist between China and the OECD on development aid, China is not a member of the DAC and is thus not covered by OECD guidelines (OECD, 2016).

China's state-owned banks have provided an increasing amount of export credit financing (preferential export buyers' credits, export sellers' credits, mixed credits, natural resource-backed loans, concessional loans, etc.), which plays an important role in China's "going abroad" policy. In order for African countries to co-ordinate more effectively with development partners, it is important that they have more complete information about levels and conditions of assistance.

Questions have been raised on sustainability and transparency that are important for the full ownership and accountability of the developing countries concerned. While DAC members typically link their assistance to certain criteria such as effective governance, transparency or anti-corruption, Chinese institutions offer support to national governments with fewer conditions (OECD, 2011). When compared to China, DAC members tend to have larger numbers of programme managers and often have higher overhead costs. This allows for more specialisation and co-ordination as well as

more complex programme and project management. With only a very limited number of development staff in the field to manage its portfolio of development projects, China's co-operation is more cost-effective. At the same time, China faces constraints in quality assurance and co-ordination (OECD, 2013).

Both China and DAC members express the objective of ensuring that their assistance is sustainable, although practices and methodologies may differ. In 2009, a China-DAC Study Group was formed to share knowledge and exchange experiences on promoting growth and reducing poverty in developing countries, including how international assistance can be effective in supporting this objective. The China-DAC Study Group is operated on an informal basis by a joint secretariat between the OECD DAC and the International Poverty Reduction Centre in China (IPRCC), an entity jointly initiated and established by the Chinese government and the United Nations Development Programme (UNDP). The study group comprises experts from China and DAC members/observers.

Summaries of Africa-related discussions of the China-DAC Study Group draw lessons for both China and DAC members such as ensuring transparency in aid programming and the terms of financing; helping to implement African and international codes on corruption, resource revenues and corporate social responsibility; strengthening knowledge about African conditions among aid staff working on and in Africa; and working on aid quality agenda, including planning, monitoring and evaluation systems (OECD, 2013).

International community, China and DAC members have many areas in which further exchange and experience-sharing can improve development effectiveness. Maximising development impact using available resources requires a more comprehensive discussion about different "co-operation models" and modes of delivery, and issues of sustainability, ownership and accountability. Building human and institutional capacity and ensuring ownership at local and national levels are important for improving sustainability.

Implications for Africa's development

Power plants and grids built by Chinese contractors in sub-Saharan Africa can have direct impacts on economic, social and environmental development. Those projects have supported energy access and economic development, and renewable power plants built by Chinese firms may also expedite Africa's transition to lower CO₂-emitting electricity systems by establishing relatively low-carbon electricity generation.

Contribution to energy access

Energy access is the availability of reliable and affordable electricity and clean (i.e. less polluting) cooking facilities to households. When a household first gets access to electricity, its consumption is expected to increase over time. The definition differs between developed and developing countries: while in developed countries it means constant access to electricity, heating and cooling, in addition to affordable transportation and communication; in developing countries it can mean access to electricity to run one lightbulb in a household. For sustainable development to be possible in developing countries, energy access and energy security are crucial: energy access is vital for social development, as it improves people's access to lighting, education, health and telecommunication. Energy access is equally necessary for the industrialisation which leads to economic development.

In 2015, sub-Saharan Africa had over 635 million people living without access to electricity, mostly in rural areas. The electrification rate remains at less than one-third of the population. Although the overall rate of access to electricity in sub-Saharan Africa has improved, the number of people living without electricity keeps growing due to rapid population growth. Nevertheless, improvements in electricity infrastructure and greater investment in the power sector in recent years have helped a significant number of people gain access to electricity in the region (IEA, 2015a).

In China, an estimated half-billion people were provided access to electricity from 1980 to 2000, so that China's electrification rate is now over 99%. This achievement can be attributed to the central government's management and execution capabilities. Clear government policy, off-grid solutions, numerous hydropower projects and mobilisation of local governments which became more autonomous and received more funding for construction projects contributed to this fast-paced electrification.

Chinese energy companies are now increasingly active overseas, exporting China's domestic experience to other developing economies. In sub-Saharan Africa, for instance, the Chinese government donated solar energy kits for rural areas in Rwanda and Comoros. In Rwanda, solar kits provided electricity access to 2 000 villagers in 2014; this aid in kind provides off-grid electricity to remote villages. Also, projects in distribution carried out by Chinese companies support networks and connections. In the small town of Cuito Canavale in Angola, for example, Sinohydro has enabled access to 5 000 people by installing lines and substations.

Most Chinese-added generation capacities are through main grids. Even though decentralised solar is progressing in Africa, it can provide only a limited amount of electricity per capita. Electricity demand eventually extends beyond lighting, so there is still a need for centralised electricity systems, especially with the rising middle class in the region.

Chinese companies have taken part in projects to expand access to electricity in sub-Saharan Africa. Over the period 2010 to 2020, 120 million people gain access to electricity through the power grid, enabled by grid development and increasing power generation capacity, of which

Chinese contractors are responsible for 30%. Households which were already connected to the grid can benefit from more reliable electricity supply.

Impact on economic development

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Reliable power supply is vital for economic growth, in particular in sub-Saharan Africa where shortages contribute to slow growth and inefficiency. Adding generation capacity helps economic development by reducing power shortages overall. Increased generation capacity can act as an enabler for industrialisation and the services sector, in addition to increasing standards of living for inhabitants. More reliable electricity also has a positive impact on productivity: 1) for individuals, through improved health care, educational opportunities and time gained through activities replaced by appliances; and 2) commercial, mainly through the increased ability to do business and the decreased cost.

It is commonly believed that Chinese infrastructure involvement in Africa focuses essentially on the resource sector. In fact, as also shown in a report on new and emerging development partners in Africa, less than 10% of Chinese infrastructure projects in the region are linked to resources (NEPAD, 2015). In the power sector specifically, less than 20% of Chinese generation projects intend to supply a specific industry (mine, cement plant, sugar mill, etc.). Other Chinese-built power plants are connected to the grid without a specific purpose, and thus contribute to the economy at large.

Close to one out of five power plants built by Chinese companies aims to supply electricity to a specific industry, mostly in mining. For example, the 600-MW Morupule B coal-fired plant in Botswana supplies the nearby coal mine with power. Another coal-fired plant supporting a mine will be the Mchuchuma power project in Tanzania, attached to iron mining. Though construction has not yet begun, this plant plans to add a capacity of 300 MW in 2019. The 44-MW expansion of Hirgigo thermal power plant supplies gold mines in Eritrea, and several energy projects power cement factories. One example is the Gishoma peat power project in Rwanda; it is the first of its kind in sub-Saharan Africa, and peat would become Rwanda's second-largest source of energy if more of these projects are built. The adjacent cement factory plans to increase its production capacity from 100 000 tonnes to 600 000 tonnes of cement (African Energy, 2014). In Zambia, a 30-MW coal-fired plant built by China National Materials Group Corporation (Sinoma) has been supplying the Dangote-Lafarge cement plant since 2015. Chinese projects also help foster economic growth by building refinery plants, such as the 20-MW Djarmaya refinery in Chad with its own oil-fired generation capacity.

Investments that help modernise the agricultural sector are crucial to development, as it continues to be the greatest employment sector in Africa but still suffers from high inefficiency. Biomass projects in Ethiopia can play a role in agriculture modernisation: the Welkait biomass plant is one of the few biomass projects in sub-Saharan Africa and will provide electricity to the sugar cane factory and its irrigation facilities from 2019.

In addition, projects help economic development indirectly through resource-backed loans in which a natural resource serves as collateral. Although a minority, a small number of power plants are financed through raw material exports to China, either agricultural products or mineral resources. In such cases, the loan is repaid with the receipts from exports to China. The two biomass projects in Ethiopia, for example, are backed by sugar cane. The thermal power plant in Eritrea supplying a gold mine with energy is also backed by gold, and the Mchuchuma project linked to iron mining is backed by iron ore. Additionally, Busanga in DR Congo will be backed by copper and cobalt, and in Ghana the Bui hydropower dam was backed by cocoa exports to China.

Less than 15% of Chinese-built power plants for which relevant data are available are financed through resource-backed loans.

In Nigeria, Chinese companies have created free trade zones with industries (Ogun Guangdong Free Trade Zone and Lekki Free Trade Zone). Small gas-fired plants supply the industrial zones directly. Chinese companies also support cross-border trade through transmission lines, such as the one from Ethiopia to Djibouti running parallel to the railway. The rail line was initially French-built, connecting Ethiopia to the Red Sea, but is now being replaced by an electric rail by Chinese companies, to facilitate transportation of goods currently transported by inefficient and polluting trucks.

Technologies employed

The technical level of hydropower turbine suppliers like China Dongfang Electric Corporation (Dongfang Electric), Harbin Electrical Machinery (Harbin Electric) and Shanghai Electric Group Company (Shanghai Electric) has improved in recent years. They have developed close relations with Chinese EPC contractors, and their costs can be up to 30% to 40% lower than those of other international suppliers. Nonetheless, they still have a negative image and are considered as lacking in knowledge in international markets. A study by Chen, Goldstein and Orr (2009) shows that around half of Chinese construction companies in Africa apply international standards to their projects, while the other half use host country or Chinese standards. In the area of gas-fired power plants, Chinese builders develop both open cycle gas turbines (OCGTs), such as the 500-MW Omotosho II plant in Nigeria, and combined cycle gas turbines (CCGTs) such as the 126-MW Malabo plant completed in 2012 by the China Machinery Engineering Corporation (CMEC) with Western equipment manufacturers.

In the coal power sector, the majority of Chinese-built coal plants in Africa are subcritical projects. The IEA recommends building plants at the highest efficiency possible while considering technical and operational limitations in countries. The higher capital expenditure (capex) associated with supercritical (SC) and ultra-supercritical (USC) plants is generally recompensed by the lower operational expenditure (OPEX), and each percentage point of higher efficiency means an over 2% reduction in CO₂ emissions. However, financial scarcity and/or operational limitations such as grid constraints may lead to such configurations as Morupule B in Botswana (four groups of 150 MW). A USC plant of 600 MW (available technology for both pulverised coal [PC] and circulating fluidised bed [CFB] boilers) can increase efficiency by around six percentage points, which may mean a CO₂ emissions reduction over 15%.

Analysis of the Chinese-built coal-fired power plants in Africa shows increased attention to environmental performance, such as reduction of local air pollutant emissions (Fan and Shi 2013). Some plants use CFB boilers, in which sulphur and nitrogen oxide (NO_x) emissions are lower due to the characteristics of the CFB combustion. When plants also incorporate electrostatic precipitators (ESP) to capture particulate emissions, sulphur dioxide (SO₂), NO_x and particulate matter (PM) emissions are at an acceptable level.

Another controversial issue relating to Chinese plants is the technical problems often reported. It is not the purpose of this report to assess the reliability of Chinese-built coal power plants and equipment compared with others, but problems at Morupule B have been reported, as several technical disruptions stopped operations in 2014. The lack of experience of the Chinese EPC contractor CNEEC, and boiler supplier Wuxi Huadong Electric Power Equipment Company, has been pointed out. Even though China has become the largest thermal equipment manufacturer, standard and quality gaps still exist within companies. Wuxi Huadong is not part of the leading

three (Shanghai Electric, Harbin Electric and Dongfang Electric) to have emerged as key manufacturers.

The current slowdown in coal consumption in China could encourage Chinese construction companies and manufacturers to invest more heavily in overseas markets.

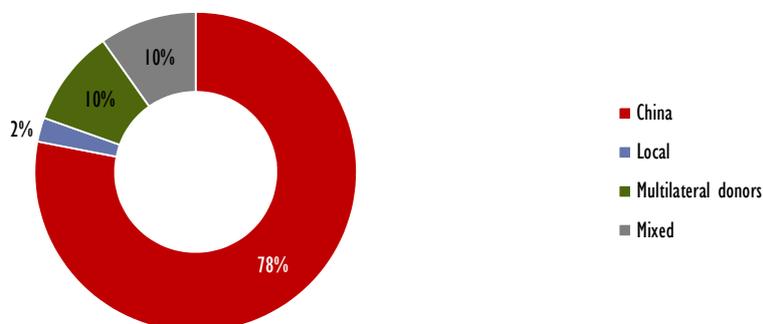
Finance challenges and opportunities

Generally with government support, Chinese companies offer integrated solutions in power generation, transmission and distribution projects financed by a combination of Chinese development assistance (loans), government-driven projects and commercial investment. Chinese financing facilitates the development of power systems but also adds to the public debt load of African states despite lower construction and equipment costs. Chinese-built power projects in sub-Saharan Africa are financed by a variety of stakeholders, with various tools ranging from official development aid (ODA) to equity financing as well as development assistance with Chinese characteristics that differ from OECD guidelines (Brautigam, 2009).

Chinese mixed financing

Most power projects built by Chinese companies are financed by Chinese stakeholders. Different types of Chinese stakeholders provide financing to African governments, or in some cases to their utilities, to enable construction of power projects. This can be explained by the fact that Chinese financing is tied to contracting with Chinese companies. Close to 80% of Chinese-built power projects (generation and T&D) for which relevant data are available are financed by a Chinese bank or institution. The remaining projects are financed by multilateral donors (10%) or by mixed loans coming from China and other bilateral or multilateral donors (10%). Only 2% are financed solely with local funds (Figure 6). The share of Chinese-built projects financed by bilateral or multilateral donors, like the World Bank, the European Investment Bank and the AfDB, could increase in the near future as more Chinese companies bid in international tendering processes.

Figure 6 • Origin of financing for Chinese-built power projects in sub-Saharan Africa



Key message • Most Chinese-built power projects in sub-Saharan Africa are supported by financing from China.

The China Exim Bank is by far the main financier of Chinese-built projects, providing finance to more than 60% of projects for which relevant data are available. The Exim Bank's approach is essentially based on top-down EPC contracts and sovereign loans. The Exim Bank, founded in 1994 as a policy bank fully owned by the Chinese government, is the main channel for Chinese co-operation financing and plays a central role in China's overseas project financing system. The Exim Bank is the only Chinese bank providing concessional loans which are eligible for ODA, but it also provides preferential loans and export buyer and seller credits. Financial products from the bank thus support development, but also trade. The Exim Bank has offices in Paris, Saint-Petersburg and Johannesburg. Concerning Africa, loans are disbursed directly to Chinese companies and then repaid by African governments.

The Exim Bank focuses on supporting construction by providing preferential or concessional loans to African governments for turnkey projects. Export credits are for buyers in countries in which non-sovereign debt is possible. Financing from the bank is tied to a contract with a Chinese company: the capital cost is lent to the developer on the condition that the developer engages a Chinese contractor. These funds are commonly lent on a government-to-government basis (although the cash flow from the bank goes directly to the Chinese company), rather than directly to private developers. Whether due to lack of information or lack of public disclosure, detailed conditions of agreements are generally unknown. According to some converging sources, the bank usually finances 85% of the total project cost, while the remaining 15% is paid directly out of the host country's state budget. Following a grace period, the host country then repays the loan plus interest. This mode of financing relies heavily on sovereign debt, regardless of the economic viability of the projects.

According to a staff member from the Exim Bank, and consistent with the findings of this report, the bank has financed over 6 GW of generation projects contracted by Chinese firms and at least 20 000 km of T&D lines in Africa. This report also finds that additional installed capacity of at least 2 GW is scheduled to be financed and completed by 2020. Although this practice still remains limited, a small number of other power plants are financed jointly by the Exim Bank and a multilateral donor such as the EIB or a Chinese commercial bank like the Industrial and Commercial Bank of China (ICBC).

Non-Chinese source of financing also finance projects won by Chinese companies. For instance, the Banque Ouest-Africaine de Développement (BOAD), the United Nations Industrial Development Organisation (UNIDO), the OPEC Fund for International Development, the World Bank and the French Development Agency (AFD), have been totally or in part involved with Chinese-built power projects. A company like Sinohydro, which is particularly engaged in overseas markets, gets 16% of its global revenue from multilateral financial institutions (interview with Sinohydro, October 2015). The increasing engagement of Chinese companies could foster more active participation in international bidding processes in the future. The AIIB and the Silk Road Fund could also become possible financiers of power and infrastructure projects in Africa.

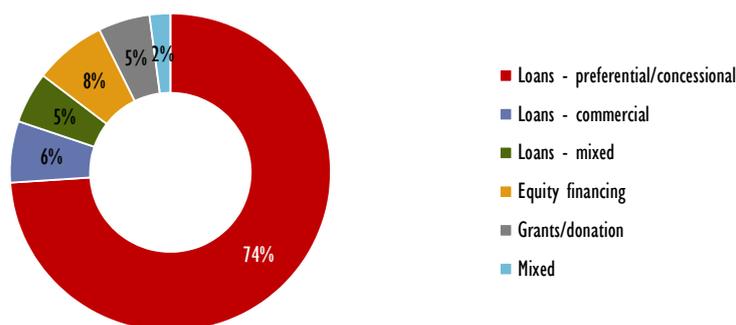
Overall, the majority of Chinese-built power projects are paid out of African countries' national budgets. Nonetheless, China is trying to progressively switch from the public lending style of involvement to more equity financing. The China-Africa Development Fund (CADF), aiming to raise USD 5 billion, was announced by former President Hu Jintao in 2006 at the Beijing Summit of the FOCAC and established the following year. With an initial dotation of USD 1 billion, the fund is operated by the CDB. Its role is to encourage and support Chinese companies' investments in Africa by acquiring stakes, like in joint ventures. The CADF has representative offices in Johannesburg, Lusaka, Accra and Addis Ababa. It is the first and largest equity investment fund in China dedicated to investing in Africa, and has invested in 83 projects so far. As a political arm of the Chinese government, it operates under specific conditions which allow less profitability than a classic equity fund.

Power projects financed by the CADF remain very few; the CADF is more active in the mining and manufacturing sectors, where return on investment is considered higher. So far, the CADF has been supporting the two phases of the Sunon Asogli gas-fired power project in Ghana. Operating as an independent power producer (IPP), Sunon Asogli is a joint venture between Shenzhen Energy Group, a provincial-level SOE, and CADF. On the African side, well-functioning IPPs imply government regulation in the electricity sector.

Chinese commercial banks are increasingly looking at supporting power projects in Africa, and currently finance 6% of projects for which sufficient data are available. ICBC is among the most

active and has an office in South Africa. In 2015, it formed ICBC Standard Bank after buying a controlling stake in South Africa-based Standard Bank. ICBC has, for instance, been funding an 80-MW heavy fuel oil power plant in Nairobi and a 685-km transmission line in Zambia which will allow electricity exports to Malawi. In 2010, ICBC also took part in financing the Morupule B coal plant in Botswana, along with the AfDB and the World Bank. Commercial banks are participating in more viable projects with more certain economic returns. Such projects are, for example, guaranteed by tangible power purchase agreements (PPA) with reliable power off-takers.

Figure 7 • Chinese-built power projects financing modalities in sub-Saharan Africa



Key message • Financing through African countries' sovereign debt remains the most important way of supporting Chinese-built power projects in sub-Saharan Africa.

Box 5 • Can China kick off the Inga III dam project in DR Congo?

In the DR Congo, the Grand Inga Dam scheme as a whole is the largest proposed hydropower project worldwide that aims to add a capacity of 44 GW, in six phases. This equates to almost twice the capacity of the Three Gorges Dam and is estimated to be sufficient to fulfil most of Southern and Central Africa's electricity needs. So far, Inga I and II have been constructed and are operational. Inga I was built in 1972 with a generation capacity of 350 MW and Inga II was built ten years later with a capacity of 1 400 MW. Inga III is currently under discussion and has not yet reached financial closure. Estimates regarding the cost are still imprecise, ranging from USD 5 billion to USD 12 billion.

Inga III will add a capacity of almost 5 GW alone. How the project will be funded remains unclear: the World Bank has agreed to a financial contribution of USD 73 million, and South Africa signed a partnership agreement with DR Congo to purchase 2.5 GW of the electricity output from Inga III. Construction was planned to begin in 2010 but has been postponed due to the economic downturn.

Three consortia expressed interest in the development of Inga III. The Chinese one is made up of China Three Gorges Corporation (CTGC) and Sinohydro, which expect backing from the Exim Bank and various Chinese state-owned banks. This would be the biggest Chinese-funded project if the consortium wins the bidding. Another consortium is made up of South Korean and Canadian companies, and the third one is composed of Spanish companies (Bloomberg, 2015). In April 2016, the Congolese National Electricity Company (SNEL) and CTGC also signed an agreement in Kinshasa to improve electricity distribution in the country.

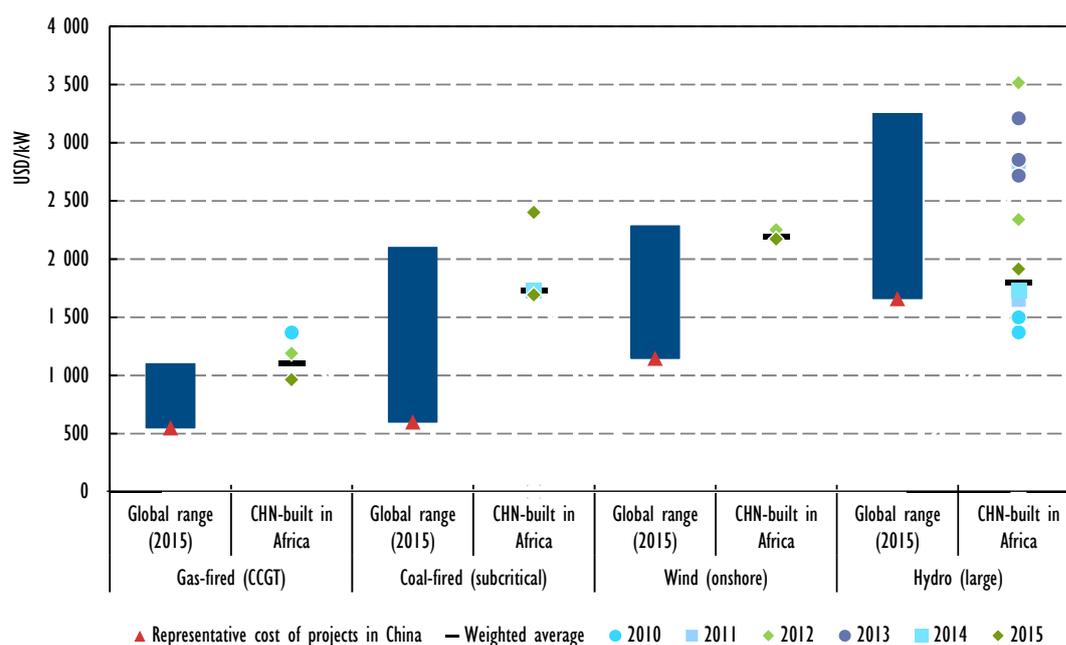
The project is highly controversial, however, due to environmental, social and economic concerns. The World Bank has carried out an environmental impact assessment approving the construction despite criticism over the limited funding of the assessment. Further development of transmission from DR Congo to other regions of sub-Saharan Africa would be required to support this development.

Massive financial flows from China to Africa and lower costs

In the last five years, loans, buyer/seller credits and FDI from China for the development of the sub-Saharan African power sector amounted to around USD 13 billion, or around one-fifth of all investments in the sector in the region (IEA calculations, based in part on IEA, 2015a). This calculation is based on contract values for generation and T&D projects contracted to Chinese companies between 2010 and 2015, converted into 2014 USD. Given the very large engineering capability of Chinese industry and the discrepancy in scale between investments in China and in African countries, moving even a very small proportion of investments from China to Africa can have a major impact on African countries.

Although the cost of power plants depends on various factors, including technology used, construction conditions, labour costs and transportation, the overnight costs² of Chinese-built power plants in sub-Saharan Africa are generally within the range of estimates for typical project costs in a subset of other global economies (Figure 8). The cost of wind, coal and gas-fired projects is generally at the upper end of global cost ranges due to high logistics costs in Africa and imports of Western equipment. The cost of large hydro projects is very much dependent upon the context of each specific dam. Compared to typical projects costs in China, costs of Chinese-built projects in sub-Saharan Africa are higher. Although Chinese companies can be attractive for African governments, Chinese domestic costs are not replicable overseas.

Figure 8 • Overnight costs of Chinese-built power plants in sub-Saharan Africa (USD/kW)



Notes: Global costs range of projects is based on 2015 costs, given in 2014 USD. Costs in China are based on representative projects, with data drawn from various public sources and surveys. Costs of Chinese-built plants in sub-Saharan Africa are based on contracts signed between 2010 and 2015, given in 2014 USD.

Sources: IEA calculations, based in part on IEA (2015), *World Energy Outlook*; IEA (2015), *Renewable Energy Medium-Term Market Report*.

² Overnight costs include pre-construction (owners') costs, construction (engineering, procurement and construction) costs and contingency costs, but does not include interest accrued during construction.

Country case studies

Chinese involvement varies from country to country in sub-Saharan Africa, depending on the country's resources and opportunities, and specificities of relations with China. While Chinese firms invest in a variety of projects in Ghana, they focus purely on generation capacities from renewables in Ethiopia. Examining specific projects in Ghana and Ethiopia illustrates the variety of Chinese projects types and modalities.

Ghana: A variety of Chinese project financing

Chinese engagement in the Ghanaian power sector has rapidly increased in the past ten years. Engagement has involved a variety of fuel types with different modes of financing. Two noteworthy Chinese projects that illustrate the different natures of Chinese involvement are the gas-fired Sunon Asogli plant and the hydroelectric Bui Dam.

Ghana's electricity supply situation

The majority of Ghana's electricity supply comes from hydropower (64%), and is supplemented by thermal power (26% oil-fired generation and 10% gas-fired). At the moment, less than 1% is generated from solar PV. The country faces shortages and needs to increase its installed capacity as well as extend distribution networks, as selective power cuts affect both residents and the productive sector. The government aims to provide universal access to electricity by 2020, but new generation capacity has not followed the pace of economic development over the last 15 years.

Ghana traditionally relied on hydropower produced at Akosombo Dam (commissioned in 1965), and later Kpong (commissioned in 1982). In 2013, a third hydropower project was commissioned at Bui. A fourth project, the Pwalugu Multipurpose Dam on the White Volta River, is currently in the preparatory stage, including feasibility studies and an environmental and social impact assessment. The first thermal plant came online in 1997 with the 330-MW Takoradi plant, followed in 2000 by the 220-MW Takoradi II. The US firm CMS Energy held 90% of Takoradi II until it sold its share to Abu Dhabi's TAQA.

Chinese activities in the Ghanaian power sector

Chinese activities in the Ghanaian energy sector are recent compared with Chinese engagements in other parts of sub-Saharan Africa; they have, however, diversified rapidly. Chinese companies now contribute to energy generation and distribution, and their projects cover hydro, gas- and coal-fired plants.

Natural gas will become a major source of electricity generation in Ghana, a sector in which Chinese firms are deeply involved as contractors and operators. In 2007, Shenzhen Energy and the China Development Fund established the Sunon Asogli Power Company to build a gas-fired plant at Tema. To sustain gas supply, Sinopec is EPC contractor for the Western Corridor Gas Infrastructure Development Project. Phase 1 of the project connects the Jubilee oil fields to a new gas processing plant at Atuabo, and Atuabo with the Takoradi plants. Phase 2 consists of an offshore jetty system which allows the gas to be transported from the Jubilee fields via ship to Tema. Phase 1 was commissioned in April 2015, and the project is funded by the CDB. In the coal-fired sector, Shenzhen Energy is also in discussions to build the Sunon Asogli coal-fired plant. While the agreement has been signed with Asogli, the project has not yet been approved or financed. In hydropower, Sinohydro completed the EPC turnkey Bui hydropower dam in 2013.

In the distribution sector, Chinese firms have provided electricity access to more than one million people. With Exim Bank loans, CWE has been active in rural electrification projects, in particular the government's Self-Help Electrification Programme (SHEP). Under the Upper West Electrification Project, CWE has built a total of 13 000 km of lines (435-kV, 33-kV and 11-kV), connecting about 468 000 households (more than one million people).³ Hunan Construction Engineering Group (CHCEG) has been active in the Northern Regional Electrification Project.

In April 2016, Ghana's 20-MW solar PV plant came online for trial run. A private Chinese company developed the project and signed a PPA with the Electricity Company of Ghana (ECG).

The Sunon Asogli gas-fired plant

Sunon Asogli Power operates as an IPP, as part of the Ghanaian government's attempt to attract electricity producers from the private sector. The Sunon Asogli Power plant is located at Tema, where it adds to the already existing gas-fired plants run by the Volta River Authority and Cenit. Operational since 2010, its first phase was completed in 2007-10 with an installed capacity of 200 MW. A second phase, to be completed from 2015 to 2017, aims to increase installed capacity by 340 MW to 540 MW. The first phase was an OCGT, while the second one is a CCGT. Full load operations will, however, depend on sufficient gas supplies from Nigeria until Ghana has its own supplies (Construction Review, 2015). The plant is equipped with turbines from the Netherlands and generators from England.

The project was financed through equity, one of the first to be financed by the CADF. The plant was constructed by Sunon Asogli Power, a joint venture between Shenzhen Energy, a provincial-level SOE (60% share), and CADF (40%). The total cost of the two phases amounts to around USD 520 million.

The Bui hydro dam

The Bui Dam is located on the Black Volta River in Bui National Park, which made the project particularly controversial. Built by Sinohydro under an EPC turnkey contract, Bui started generating electricity in 2013. It is owned by the Bui Power Authority, although still partially operated by Sinohydro. The purpose of Bui is to improve electrification of Ghana's northern regions with the aim of diversifying economic development from the south to the north. The Bui Dam has an installed capacity of 400 MW with electricity production of 730 gigawatt hours (GWh) in 2014 (Energy Commission of Ghana, 2015). The output from the dam is meant to increase when the reservoir reaches its full capacity. Resettlement problems unresolved by the local authorities have, however, left a large proportion of the resettled population struggling with livelihood restoration.

Project financing consisted of three parts. Of the total project costs of USD 622 million, the government of Ghana contributed USD 60 million. The remaining sum was provided by the China Exim Bank as a mixed package: a concessional loan of USD 263.5 million and a buyer's credit of USD 298.5 million provided by the Exim Bank alone (Hensengerth, 2011). During construction, a funding shortfall of USD 168 million occurred, a sum which the Ghanaian government secured in December 2013. Total project costs therefore rose to USD 790 million (Bui Power Authority, n.d.). The World Bank noted that the project would not affect Ghana's debt sustainability.

Cocoa exports secured the Exim Bank lending facilities until the commissioning of the dam, and the proceeds were placed in the escrow account held by the Exim Bank to service the interest (during the construction period, only the interest had to be paid and not the principal).

³ According to the 2010 population census in Ghana, the average household size was 4.4 (Ghana Statistical Service, 2012).

Overpayments were to be returned to the Ghanaian government. Since the start of operations, 85% of revenues generated by Bui are placed in an Exim Bank escrow account to service the loan and credit, with any overpayments to be returned to the government of Ghana, and 15% are used to meet the Bui Power Authority's administration costs (Hensengerth, 2011; 2013). The exact tariff at which Bui Power Authority is to sell the electricity could not be found. Rough estimates show that the project can be amortised within a 20-year period only if it generates enough electricity.

Bui uses three Alstom Francis turbine generator units with a combined capacity of 400 MW. These turbines are built by Alstom Hydro in China, and are thus eligible for Chinese funding. Power transmission occurs from the Bui Switchyard through 161-kV transmission lines. These will be operated as part of the National Interconnected Transmission System. In total four transmission lines were built, amounting to 240 km.

Box 6 • UNDP trilateral project on solar energy with China and Africa (Ghana and Zambia)

UNDP China has been funding a three-year project (2015-18) on the transfer of renewable energy technology from China to Africa under the UN SE4ALL project. The project focuses on the institutional dimension of technology transfer and aims at enhancing off-grid, community-based electrification. The estimated project budget is USD 6 million (UNDP Ghana (n.d.)).

The trilateral co-operation between UNDP China and African countries (Ghana and Zambia) is a new approach to South-South co-operation, and aims to increase and improve knowledge and technology transfer between China and Africa on renewable energy. UNDP China is carrying out two three-year projects; unlike the more typical Chinese projects exporting hardware, these two projects focus on capacity building and exporting knowledge on institutional frameworks, with the goal of producing technologies on-site in Ghana and Zambia.

According to the UNDP, numerous Chinese technologies can improve electricity access in rural areas, if transferred and deployed appropriately. Electrification in Zambia was largely focused on Lusaka, leaving other key cities with much less electricity and rural areas almost entirely unconnected to the national grid. Zambia's solar power potential is vast: developing technologies to make solar power more accessible is therefore a priority. In Ghana, electricity demand is growing quickly but the existing power plants cannot operate at full capacity, as fuel supplies for thermal plants and water inflows for hydroelectric plants are limited. As part of China's "going abroad" policy, exporting know-how rather than hardware is gaining more attention. Recently, the Chinese deputy director of the State-owned Assets Supervision and Administration Commission (SASAC), the entity supervising SOEs, acknowledged that "if China does not start addressing the issue of responsibility and sustainability, other people will." Zambian and Ghanaian energy experts are invited to China to observe and learn from Chinese experience, at the same time as Chinese experts aim to better transfer their knowledge (Schroeder, 2015).

Ethiopia: Flagship projects in renewable energy

With Ethiopia's energy potential predominantly in renewable energy, Chinese (and other) companies have invested in a variety of renewable energy projects. The most notable Chinese projects have been in transmission lines, hydropower, biomass and waste, the latter being unprecedented in the country, and in sub-Saharan Africa as a whole.

Ethiopia's electricity supply situation

Almost 100% of Ethiopian energy comes from renewable resources: hydropower makes up most of the supply (about 96%), 4% comes from wind energy, and geothermal and thermal sources make up less than 1% of the national supply. The country is currently building significant additional generation capacity, with very large projects like the 6-GW Great Renaissance dam.

In the Growth and Transformation Plan 2 (GTP II, 2015-20), the national five-year plan, the Ethiopian government aims to increase installed generation capacity from 2.3 GW in 2015 to 17.3 GW by 2020.

Because of Ethiopia's vast hydro resources, the country is considered the "water tower of East Africa" and has potential to become a hub for renewables in the region. The government plans to make electricity one of Ethiopia's greatest exports; the country currently exports close to 1 000 GWh to neighbouring countries. The Ethiopian government envisions expanding foreign currency reserves by further developing electricity exports into one of three main sources of foreign currency. Ethiopia currently has low currency reserves, although debt remains sustainable according to the International Monetary Fund (IMF). Electricity is exported to Sudan and Djibouti, and to a lesser extent to Kenya, with tariffs ranging from 6 cents to 8 cents per kWh. Exports to Kenya will increase, however, as Ethiopia and Kenya signed a PPA for 400 MW annually, and SGCC is building a new transmission line with a capacity of 1 000 MW to help turn the PPA into a reality in the near future.

The Ethiopian government's strategy relies on sub-regional absorption capacity, but this clearly export-oriented model has important implications for the local population. Less than 30% of the population has reliable access to electricity, and mainly in urban areas, largely due to an underdeveloped distribution network. The GTP II aims to develop the number of connections from 2.5 million in 2015 to 6.9 million in 2020 (National Planning Commission, 2015), however, the Ethiopian Electric Utility (EEU) has little incentive to develop the distribution network. According to various energy experts in Addis Ababa, with domestic tariffs currently at only 3 cents per kWh, supplying electricity domestically is less profitable than exporting at 6 cents to 8 cents per kWh. As a result, the local population continues to have limited access to electricity, particularly in rural areas, with selective power cuts in urban areas depending on the supply of electricity.

Chinese activities in the Ethiopian energy sector

Power plants and grids built by Chinese companies in Ethiopia are 100% in renewable energy, with additions of almost 1.5 GW in generation capacity and close to 2 600 km in T&D lines.

According to a senior official from the Ethiopian Ministry of Water, Irrigation and Energy, Chinese companies dominate in the construction of transmission lines above 132 kV. Chinese transmission lines are both national and international, connecting Ethiopia with Kenya and Djibouti. An additional over 1 000 km in lines from Ethiopia to Kenya are contracted to SGCC and supported by the World Bank and the AfDB. A railway power transmission line is under

construction between Ethiopia and Djibouti, and multiple projects focus on Addis Ababa's urban grid. Chinese projects in distribution in Africa are comparatively low compared with transmission, but in Addis Ababa they add at least 1 000 km in distribution lines.

Chinese companies add generation capacity in four sectors: hydropower and wind, but also biomass and waste. Two of the hydropower projects have already been completed in Fincha (100 MW, by Gezhouba) and at the Tekeze River (300 MW, by Sinohydro). The two companies are also joining forces in Oromia in the construction of the Geba hydroelectric complex that adds 400 MW in generation capacity to be completed in 2020. Additionally, the Genale Dawa III hydropower dam (254 MW) and the significantly smaller Aba Samuel (7 MW) are under construction by Chinese companies, and China is involved in the Gibe III dam, not as the main contractor but as the subcontractor for electro-mechanical work.

Ethiopia is the only country in sub-Saharan Africa in which China is investing in biomass and waste generation capacity. Currently, two projects in Southern Ethiopia (60 MW) and in Addis Ababa (50 MW) are being constructed. The Rappie waste-to-energy project in Addis Ababa is designed by Cambridge Industries, a UK company specialised in clean power generation and waste management, and is being built by CNEEC. It will have a treatment capacity of 1 400 tonnes of waste per day, while the municipality of Addis Ababa has committed to provide 700 tonnes per day. The plant may not run at full capacity in the early stages.

The Adama wind farm

The Adama wind farm is one of the biggest wind energy projects in Ethiopia, located 90 km south-east of Addis Ababa. HydroChina Corporation, a subsidiary of PowerChina, was awarded an EPC contract by the Ethiopian Electric Power Corporation (EEPCo), now Ethiopian Electric Power (EEP), in 2009 for the first phase. Phase I was completed in 2012, with a capacity of 51 MW and equipped with 34 Goldwind turbines (GW77/1 500, diameter 77 m). According to HydroChina East Africa, the average annual generation of Adama I wind farm is 163 MWh, 4% higher than expected; the site thus benefits from favourable wind conditions. The construction of phase I employed 2 100 local workers and received regular visits from professors and students from local universities for educational purposes. Adama Phase II was constructed from 2013 to 2015 as an expansion with three times the added capacity of Adama I (153 MW). Phase II was also constructed by HydroChina, in partnership with CGC Overseas Construction Group (CGCOC). Adama II consists of 102 Sany turbines.

The cost of the two phases amounted to USD 460 million, funded by a buyer's credit from the Exim Bank. HydroChina is now considering construction of a Phase III, which would include the construction of tower and blade factory. The contractor of this third phase will be decided by EEP, the owner, through a bid process. With adequate grid integration, the Adama wind farm can enable industries in Ethiopia to get reliable power supplies by feeding the centralised network. The first phase was handed over to EEP in 2012 and is now operated by local staff that has received adequate training. Whether EEP will be able to maintain the farm in the long term remains uncertain.

Figure 9 • The Adama wind farm, Ethiopia



Source: Photo credit @David Bénazéraf, 2015.

The Welkait biomass plant

China's largest project in biomass is the Welkait biomass plant. Construction started in 2016 and is expected to end in 2019. The plant is a sugar cane integrated project combining sugar and electricity production. Electricity will be produced from bagasse, the dry pulpy residue left after the extraction of juice from sugar cane.

The project will be completely carried out by China's CAMC Engineering (CAMCE) and is the first project of this sort for CAMCE in Africa. CAMCE is building the mill and adjacent power plant, with equipment essentially sourced from China. The power plant will consist of four 30-MW units. Half (60 MW) will be operational in 2018 and the other half from 2019 onwards. 70% of the electricity output will be used to run the sugar mill and 30% will connect the area through a 132-kV line built by EEP.

This project is described as "win-win" by the Chinese manager in charge. It aims to build the largest sugar mill in Ethiopia, with a processing capacity of 24 000 tonnes of cane per day (TCD), and will employ 2 000 people in the area and ultimately contribute to the development of a small new town. In the meantime, the project secures sugar exports for China. Funded by the China Exim Bank through a master loan, the project is attached to sugar exports. In China, sugar production is highly subsidised due to rising labour costs and low global sugar prices which make sugar production no longer economically sustainable in China. Producing in Ethiopia contributes to local economic development and is more affordable for China.

Conclusion

In the last 15 years, China has significantly enhanced its engagement in Africa, covering a wide range of sectors. Chinese companies are active in power sector capacity expansion at an unprecedented scale, and although Chinese involvement presents advantages, it also raises new challenges for African governments.

At the same time as Chinese companies benefit from comparative advantages outside of China, several factors make Chinese power projects in sub-Saharan Africa attractive to African governments. Costs of power plants built by Chinese companies tend to be lower, strongly supported by Chinese loans issued by policy banks with generally lower interest rates (although rates are sometimes similar to those offered by other countries). The shorter delivery time of Chinese firms also makes them more competitive and suited to short-term political agendas. Due to government support, Chinese companies are less risk-averse, and Chinese engagement in power covers all primary sources except nuclear, and all sizes of projects, while sources of financing from other countries are not keen to finance large hydropower dams or coal-fired power plants. The Chinese co-operation system is said by Chinese experts to be “simple” – that is to say, involving fewer phases and lower costs for design, capacity building, social and environmental assessments, while focusing essentially on tangible outcomes.

While increasing generation and grid capacities, and supporting electricity access for economic development, Chinese-built power projects also raise local challenges for African governments, especially in the potential context of slowing economic expansion in sub-Saharan Africa. These projects have traditionally been carried out in the context of commodity price boom and have relied heavily on sovereign debt. Additional electricity capacities fall under public sector spending from a country's national budget; however, as some countries are reaching external debt limits and may face difficult financial situations, project financing remains challenging and is tending to diversify and move progressively away from public lending towards more equity financing. However, the latter remains challenging in the absence of reliable power off-takers and adequate, stable local regulation. Concerns over competition, transparency and sustainability in Chinese project financing have been raised. The success of power projects depends on the ability of African governments to negotiate, implement and maintain them.

How African countries can manage relations with Chinese stakeholders to ultimately maximise the generation and distribution systems is a pending question. The lack of local skills needed to put operation and maintenance services in place can compromise the sustainability of power plants built by foreign companies. More resources have to be spent on capacity building in the region to develop stronger regulatory frameworks, including streamlining and speeding up the IPP and PPA processes. Training of local technicians is essential to maintain efficiency and performance of plants as well as to help countries build a strong service industry for maintenance, ensuring plant sustainability and supporting broader industrial development.

The sub-Saharan Africa power sector needs greater access to capacity building, capital funds and technologies from experienced manufacturers. To achieve SE4ALL objectives in sub-Saharan Africa by 2030, enabling energy access and economic growth, all foreign stakeholders should join forces to increase power generation capacities and grid infrastructure. Greater emphasis from Chinese and other investors should be placed on T&D grids, as this will be the critical constraint to expanding access to power and generating higher levels of economic growth.

Stakeholders from China and other countries can be highly complementary in contributing to African power sector development. While China has the ability to finance and build projects at a massive scale and lower cost, industrialised countries can provide high-value technologies, contribute to capacity building and create an adequate regulatory environment to ensure the

success of all projects, to ultimately promote energy access and economic growth in sub-Saharan Africa. Triparty co-operation among African and OECD countries and China has the potential to deliver triple benefits.

Acronyms, abbreviations and units of measure

Acronyms and abbreviations

AFD	Agence française de développement
AIIB	Asian Infrastructure Investment Bank
AfDB	African Development Bank
ASEAN	Association of Southeast Asian Nations
BOAD	Banque ouest-africaine de développement
CADF	China-Africa Development Fund
CAMCE	China CAMC Engineering
CCGT	combined cycle gas turbine
CDB	China Development Bank
CEEC	China Energy Engineering Corporation
CGCOC	CGC Overseas Construction Group
CHINT	CHINT Electric
CMEC	China Machinery Engineering Corporation
CHCEG	Hunan Construction Engineering Group
CNEEC	China National Electric Engineering
CNNC	China National Nuclear Corporation
CTGC	China Three Gorges Corporation
CWE	China International Water and Electric Corporation
DAC	OECD Development Assistance Committee
Dongfang Electric	China Dongfang Electric Corporation
EEP	Ethiopian Electric Power
EEU	Ethiopian Electric Utility
EIB	European Investment Bank
EPC	engineering, procurement and construction
Exim Bank	Export-Import Bank of China
FOCAC	Forum on China-Africa Cooperation
GE	General Electric
Gezhouba	China Gezhouba Group Corporation
GTP	Growth and Transformation Plan (Ethiopia)
Harbin Electric	Harbin Electric Machinery
HYDROCHINA	HydroChina Corporation
ICBC	Industrial and Commercial Bank of China
IMF	International Monetary Fund
IPP	independent power producer
Longyuan Power	China Longyuan Power Group Corporation
MOFCOM	Ministry of Commerce (China)
NDB BRICS	New Development Bank BRICS
NDRC	National Development and Reform Commission (China)
O&M	operations and maintenance
OCGT	open cycle gas turbine
ODA	official development aid
OEM	original equipment manufacturer
PowerChina	Power Construction Corporation of China
PPA	power purchase agreement
PPP	public-private partnership

REIPPPP	Renewable Energy Independent Power Producer Procurement Programme (RSA)
SASAC	State-owned Assets Supervision and Administration Commission (China)
SE4ALL	Sustainable Energy for All initiative
SHEP	Self-Help Electrification Programme (Ghana)
SEPCO	Shandong Electric Power Construction Corporation
SGCC	State Grid Corporation of China
Shanghai Electric	Shanghai Electric Group Company
Shenzhen Energy	Shenzhen Energy Group
SINOHYDRO	Sinohydro Corporation
Sinoma	China National Materials Group Corporation
SINOMACH	China National Machinery Industry Corporation
SOE	state-owned enterprise
SSA	sub-Saharan Africa
UHVDC	ultrahigh-voltage direct current
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
WB	World Bank
YGE	Yingli Solar
ZTE	Zhongxing Telecommunication Equipment Company

Units of measure

GW	gigawatt
GWh	gigawatt hour
km	kilometre
kV	kilovolt
kWh	kilowatt hour
MW	megawatt
TCD	tonnes of cane per day
TWh	terawatt hours

Regional groupings

Central Africa

Cameroon, Central African Republic, Chad, Congo, Democratic Republic of Congo, Equatorial Guinea and Gabon.

East Africa

Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan and Uganda.

Southern Africa

Angola, Botswana, Comoros, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, United Republic of Tanzania, Zambia and Zimbabwe.

West Africa

Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Sao Tome and Principe, Senegal, Sierra Leone and Togo.

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Main interviewees

September 2015, Ebenezer APPAH-SAMPONG, Deputy Director, Ghana Environmental Protection Agency, Accra.

September 2015, Paul W. K. YANKSON PhD, Professor, University of Ghana, Accra.

October 2015, TANG Xiaoyang, Professor, Tsinghua University, Beijing.

October 2015, WANG Haifeng, Division Director, Institute of international economic research (IIER), NDRC, Beijing.

October 2015, WAN Duanyang, Vice President of Global Power China, GE (formerly Alstom), Beijing.

October 2015, WEN Haimo, deputy Division Chief of African Buyer's Credit Division, China Exim Bank, Beijing.

October 2015, ZHA Rui and WANG Xinhuai, Africa VP, Sinohydro, Beijing.

October 2015, ZHAO Jing, deputy Director of international project development division (Africa) and other staff, SGCC, Beijing.

November 2015, Bernard BARANDEREKA, Expert Energy, African Union, Addis Ababa.

November 2015, Yiheyis ESHETU, Senior Energy Analyst, Ministry of Energy of Ethiopia, Addis Ababa.

November 2015, Zelalem GEBREHIWOT, Technical Director, Eastern Africa Power Pool (EAPP), Addis Ababa.

November 2015, Gosaye MENGISTIE ABAYNEH, CEO, Ethiopian Electricity Utility, Addis Ababa.

November 2015, LIU Xiao'an, Deputy General Manager, HydroChina East Africa, Addis Ababa.

November 2015, HU Huan, CMAC Ethiopia, Addis Ababa.

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Boosting the Power Sector in Sub-Saharan Africa

China's Involvement

Lack of energy access and frequent electricity shortages are major impediments to economic growth in sub-Saharan Africa. Over 635 million people live without electricity in the region. Because the overall electrification rate remains at less than one-third of the population, the region needs increased investment in the power sector.

As part of their increasing activity in overseas markets, companies from the People's Republic of China have significantly enhanced their engagement in Africa in the last 15 years, covering a wide range of sectors, including the electricity industry. Chinese-built projects and financial support from China are contributing to power sector development, extending energy access and facilitating economic growth.

This report analyses China's engagement in the sub-Saharan Africa power sector, including the key drivers underlying Chinese investments. An overview of Chinese projects (generation, transmission and distribution) during the 2010–20 period is provided in this first-ever consolidated effort to map them. The report identifies the key Chinese stakeholders and assesses their impact on policies affecting energy access, economic development and financing modalities. Two case studies examine Chinese investment at the country level in Ghana and Ethiopia.