China's involvement in the transition to large-scale renewable energy in Africa

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China's involvement in the transition to large-scale renewable energy in Africa

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Abstract

China is playing an increasing role in the ongoing transition toward large-scale renewable energy (RE) in Africa. Previous research on China's involvement in this transition has focused mainly on hydropower projects and much less on other rapidly emerging RE technologies, such as solar PV and wind power. Further, previous studies have focused on the underlying drivers, the volume, and the political economy of Chinese RE investments in Africa. This report contributes to the literature by adopting a detailed and systematic assessment of Chinese investments in hydro, wind and solar power projects in Africa. It adopts a perspective distinguishing between three types of China-Africa flows in relation to specific RE projects: *capital*-related flows; *technology*-related flows*;* and *production*-related flows. The report presents illustrative examples of specific projects to assess the nature and functioning of these flows. It finds that the Chinese actors involved not only include investors, but involves a variety of additional actors, including technology suppliers, engineering contractors and construction companies. Further, the report identifies a Chinese model of investments characterised by a high degree of imported content from China in terms of investments, technology and contractors. The report provides a basis for further research on whether such a dominant pattern of full-package provision is generalizable more broadly and how it compares with the involvement of non-Chinese actors. Finally, the report points at very limited Chinese investments in productive assets for RE technologies in Africa.

1. Introduction

Improving access to affordable, reliable, and sustainable sources of energy is widely regarded as an urgent and critical challenge in order to promote social and economic development in Africa. This challenge is further exacerbated by the estimated increase in the energy demand of up to 80% by 2030. In sub-Saharan Africa (SSA) alone, the energy demand grew by 45% from 2000 to 2012 (Avila et al., 2017).

Against this backdrop, an interesting recent development can be observed involving a rapid and significant increase in the development of large-scale, grid-connected renewable energy (RE) projects across SSA. While large hydropower plants are responsible for the majority of the existing and the newly planned and constructed RE projects, other RE technologies - in particular solar PV and wind power - are gaining increasing importance in terms of investments, installed capacities and number of projects (IEA, 2016). Underlying the emergence of solar PV and wind power plants in SSA (and globally) is the rapid and substantial decrease in the costs of core components, such as solar panels and wind turbines. The increasing use of competitive tender schemes have further contributed to reduce prices as reflected in continuously lower bids submitted by project developers (IRENA, 2016).

A growing body of research has specifically analysed Chinese investments in large-scale RE projects in SSA. Previous research in this field has focused mainly on large hydropower projects (see e.g. Hensengerth, 2018), and according to Tan et al. (2013) much less on solar PV and wind power projects. Further, previous studies have focused on the underlying drivers behind the increasing Chinese RE investments in Africa (Shen and Power, 2017), the volume of investments at an aggregate level (e.g. IEA, 2016) and the political economy of Chinese investments (Power et al., 2016; Newell and Bulkeley, 2017).

This report contributes to the literature on the growing significance of China in the RE sector in Africa by presenting a more detailed and systematic assessment of Chinese investments in hydro, wind and solar power projects. While previous research has focused specifically on Chinese investors involved in various projects, the report aims at improving the understanding of the involvement of other Chinese actors, including technology suppliers, engineering contractors and construction companies. This focus is based in the argument put forward in Hansen et al. (2018) that the specific nature and forms of investment seem to be directly related to the opportunities for local benefits. Accordingly, the report makes use of a framework distinguishing between different types of China-Africa flows pertaining to specific hydro, wind and solar power projects analysed. The report is exploratory in nature and aims at providing a set of tentative findings, which can be substantiated and challenged in further empirical research. The research question guiding the report is as follows: *How do Chinese actors operate in the RE sector in Africa*?

The report is structured as follows. Section 2 provides the analytical framework and the research methods adopted. Section 3 briefly presents the status of investments, projects and installed generating capacity from RE in SSA in relation to hydropower, solar PV and wind power. Section 4 present the main findings of the report on the role of China in the RE sector in SSA. Finally, Section 5 provides a summary of the main conclusions of the report and suggestions for further research.

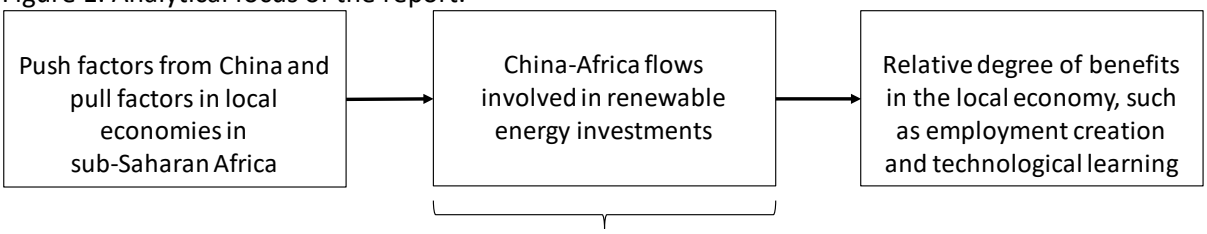
2. Analytical framework and research methods

To assess the role and involvement of Chinese actors in the RE sector in SSA, we draw broadly on the literature on international technology transfer, which typically distinguish between the cross-border *flow* of tangible items, such as capital goods and equipment, and immaterial items, such as know-how and expertise (Bell, 2009; Ockwell et al., 2010). We focus in this report on the

former: i.e. the flow of tangible items from China to Africa, distinguishing between the following three main types of flows.

Firstly, we analyse the flow of financial investments by Chinese companies in RE projects in Africa. Such *capital*-related flows may according to Lema et al. (2018) be considered direct investments in the local 'deployment system' of RE technologies in Africa, which can take various forms, such as loans, grants and equity investments. Secondly, we address the involvement of Chinese project turnkey contractors and technology hardware suppliers in specific RE projects. Such *technology*-related flows refer specifically to the business activities of specific Chinese engineering and construction companies. Finally, we analyse investments in local RE manufacture and assembly plants undertaken by Chinese companies in Africa. Such p*roduction*-related flows may be regarded as investments in the local 'manufacturing system' (Lema et al., 2018), which are typically not related to specific projects. While these three types of flows are overlapping and closely interconnected, we argue that they can be separated for analytical purposes in this report. While other types of flows could be of equal interest and relevance, such as the flow of labour from China to Africa in relation to specific RE projects, such flows are not addressed due to lack of available data. Further, as shown in Figure 1, we posit that a causal connection exist between (i) the underlying push and pull factors for Chinese engagement in the RE sector in Africa; (ii) the specificity and nature of China-Africa flows in specific RE projects; and (ii) the resulting developmental benefits in the local economy. However, as a first step the report focuses exclusively on the nature and functioning of these flows in the centre of this proposed causal chain.

Figure 1. Analytical focus of the report.



The report draws mainly on secondary sources of data in the form of a review of available reports on the role of China in Africa in general, and in the RE sector in particular, published in the grey literature and journal papers published in the peer-reviewed literature. The report especially draws on in-depth research conducted on specific RE plants constructed in Africa, which are analysed in this report against available data from aggregate-level databases on technical and investment-related parameters of RE plants in Africa. To the extent possible, information obtained from these sources has been compared with available data from primary sources obtained through the IREK project carried out in Kenya, which include fieldwork on various RE plants (Hansen, 2018).

3. The status of large scale RE projects in SSA

The total combined installed capacity of hydropower in Africa has according to IRENA (2019) increased from around 26 GW in 2009 to around 35 GW in 2018. The projects are typically very large infrastructure projects involving the construction of the dam and the area to be used as water reservoir (Hydropower and Dams, 2014). An example is the Grand Inga project on the Congo River, which is expected to involve a total installed capacity of 40 GW. Angola, Ethiopia, South Africa and Zambia are among the countries in Africa with the highest share of installed capacity of hydropower in Africa. Globally, the development of such large

scale hydropower projects is mostly taking place in Asia and Latin America in terms of the total installed generating capacities while Africa is responsible for a relatively smaller share[1].

In relation to wind power, the total installed capacity based on (onshore) wind turbines in Africa was estimated by IRENA (2015,2019) to have increased from 739 MW in 2009 to 2.4 GW in 2014 and to 5.5 GW in 2018. Morocco leads the market in terms of total installed wind generating capacity, followed by South Africa, Egypt, Tunisia and Ethiopia. A number of projects are currently being constructed with a total capacity of 21 GW, which is expected to become operational between 2014 and 2020.

The development of utility scale solar PV power plants in Africa has grown exponentially in recent years albeit from a very low level. Indeed, until recently, the largest grid-connected solar power plant that had been constructed in Africa was a 250 kWp installed capacity plant in Rwanda (Hankins et al., 2009). According to IRENA (2015,2019), the cumulative installed solar power capacity in Africa has increased from 108 MW in 2009 to 1.7 GW in 2014 and to 6.1 GW in 2018. South Africa, Morocco, Egypt, Algeria and Kenya are among the leading countries in terms of their share of the total installed capacity of solar PV in Africa.

While the involvement of Chinese actors in the RE sector in Africa has previously been relatively modest except from hydropower, a new wave of Chinese non-hydropower RE plants, including solar PV and wind power, are currently underway in Africa (Conrad et al., 2011; Shen and Power, 2017). In the following, we explore in further detail the nature of the involvement of Chinese actors in these RE projects.

4. China's involvement in the RE sector in Africa

This section analyses the flow of financial and technological resources from China to SSA in relation to hydropower, solar PV and wind power projects, distinguishing between: (i) Flows of financial investments, (ii) Flows of firms and their business activities; and (iii) Flows of productive assets. The section makes use of project examples in order to illustrative the nature and functioning of these flows

4.1. Flows of financial investments

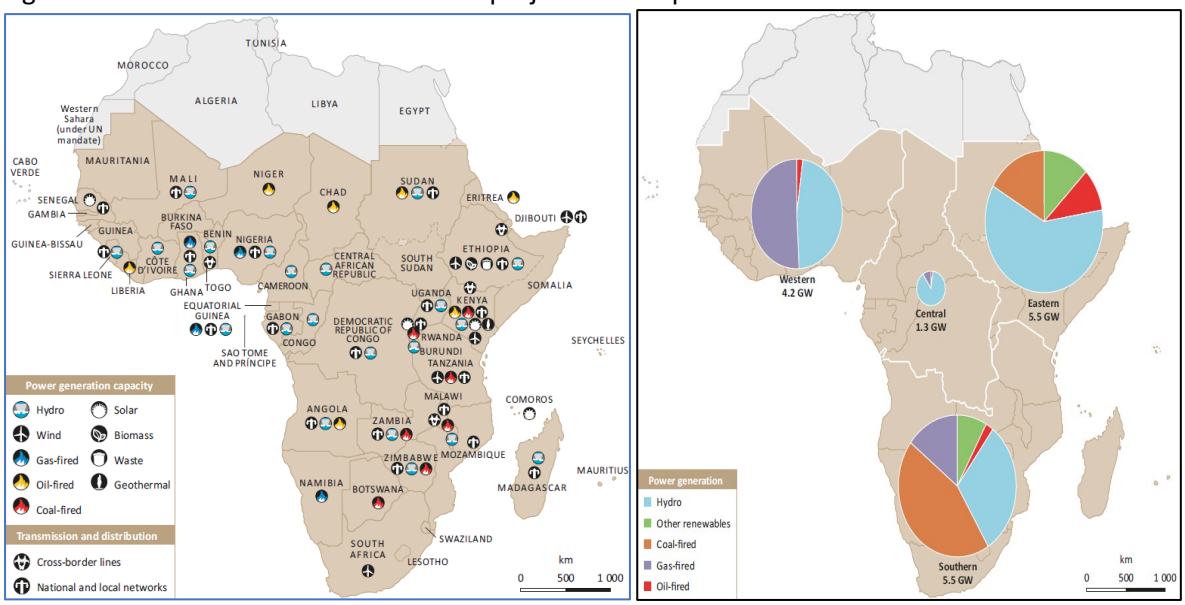
The most comprehensive and up-to-date overview of investments undertaken by Chinese investors in new installed RE capacity in Africa is provided in a recent report prepared by the International Energy Agency (IEA, 2016). This report includes information about 150 greenfield, grid-connected power plants built by Chinese companies as the main contractor in the SSA region. The analysed projects are either completed, under construction, or planned and financially secured for completion by 2020. According to the report, total investments in newly installed generating capacity in SSA by Chinese contractors have increased significantly over the past decade, amounting in total to USD 13 billion in the period from 2010 to 2015. China thereby accounts for 30% of the total added RE capacity in Africa in the period from 2010 to 2015. Further, 56% of the projects identified over the 2010-2020 period use RE sources, mainly from hydro-power (49%), while other renewables, which include solar power, wind, biomass and geothermal, reflect a relatively smaller share (7%) (including solar power projects in Ghana, Rwanda, Ethiopia, Kenya, DRC, and Senegal, and wind power projects in Djibouti, South Africa and Kenya) (Pike, 2018). As reflected in a report conducted in 2011 on the topic (WWF, 2012;20), the increase in RE projects other than hydro-power is a recent phenomenon: "*Currently there are few Sino-African renewable power projects actually taking place on the ground in Africa outside of the large hydropower sector*" (see also Conrad et al., 2011). The majority of the recent investments in new installed RE generating capacity are located in projects implemented in a limited number of countries mainly in East Africa, West Africa and

[1] https://www.bbc.com/news/world-45019893

Southern Africa (see Figure 2). The Chinese investments in these regions generally follow a pattern according to the availability of local resources, such as coal, gas, geothermal, biomass, water and wind. These investments are urgently needed: the electricity sector in SSA is projected to require capital investment of about USD 835 billion by 2040 to meet the growing electricity demand and specified targets (Castellano et al., 2015).

In terms of financing, the China Exim Bank is by far the main investor in projects constructed by Chinese contractors, providing finance to more than 60% of the projects analysed in IEA (2016). The main investment model is based on concessional/preferential loans and export credits provided to project developers. To this come direct equity-based investments, commercial loans and grants.

Figure 2. Distribution of Chinese built RE projects in SSA planned and under construction.



Source: IEA (2016).

The main Chinese contractors involved in RE projects in SSA typically include large state-owned enterprises (SOE): 90% of the power projects analysed in IEA (2016) are contracted and constructed by Chinese SOEs, which include companies such as State Grid Corporation. The remaining 10% of the projects are constructed by private Chinese developers, which are specialised in large-scale infrastructure, construction and civil engineering projects in the energy sector. Five of these companies are in combination responsible for three-quarters of the total added generation capacity by Chinese developers between 2010 and 2015 in SSA (IEA, 2016). These five companies include: 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) (see Table 1 below). The Chinese contractors undertaking these investments typically develop the projects on a turnkey basis under so-called engineering, procurement and construction (EPC) contracts. Under such EPC contracts, the developers are responsible for all aspects of the project from the initial feasibility stage, to the plant engineering and subcontracting of components and related services, and the final commission of the plants.

Table 1. Main Chinese power plant contractors in SSA (2010-2015).

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

Source: IEA (2016)

In terms of capacity size, most of the RE power plants constructed by Chinese developers are large, utility-scale plants: while the average size of hydropower plants are 221 MW, wind power projects range from 30 MW to more than 150 MW installed capacities whereas the capacity of solar power projects vary between 10 and 60 MW (IEA, 2016). In the following, we will analyse the involvement of specific Chinese investors in a selected projects within these three technologies in a number of countries in SSA.

According to Urban (2018), around 330 hydro-power projects funded by Chinese investors are currently at various stages of the project cycle globally of which 85 (26 %) are located in Africa (see also International Rivers, 2012). The main Chinese investors involved in these projects include the China Export-Import Bank (China Exim Bank), Chinese Development Bank (CDB), Sinosure, Industrial and Commercial Bank of China (ICBC) and Bank of China (BoC) (Tan-Mullins et al., 2017). A prominent example of a Chinese-funded hydropower project in Africa is the Bui hydro dam in Ghana, which is located on the Black Volta River in Bui National Park (Obour et al., 2016). The dam has been constructed by Sinohydro under an EPC turnkey contract and went into operation in 2013. The hydropower plant is owned by the Bui Power Authority and operated by Sinohydro. With an installed capacity of 400 MW, the plant generated electricity corresponding to 730 gigawatt hours in 2014 (Kirchherr et al., 2016). Before commissioning of the plant, total project costs amounted to USD 622 million, which comprised of USD 60 million from the government of Ghana and the remaining project costs provided by the China Exim Bank as a concessional loan of USD 263.5 million and a buyer's credit of USD 298.5 million (Hensengerth, 2013). During the construction phase, which started in 2007, the Ghanaian government provided additional funding of USD 168 million (in 2013), thereby raising the total project costs to USD 790 million (IEA, 2016). Similarly, in Uganda, two hydro-power projects are currently being constructed, with installed capacities respectively of 600 MW (Karuma) and (183 MW (Isimba), which are financed by China Exim Bank in the form of debt financing and the Government of Uganda who has provided 15% of the total financing (Meyer et al., 2018). The plants are currently being constructed by Sinohydro and CWE under an EPC turnkey contract and are expected finalised in 2019.

A number of wind power projects have been constructed and more are under way in SSA, which involves a Chinese investor. Indeed, according to Pike (2018), Chinese investors are involved in a number of wind power projects in the pipeline in Djibouti, South Africa and Kenya. The so-called Adama wind project in Ethiopia provides an illustrative example as it has been financed through credit financing provided by the China Exim Bank (Chen, 2016, 2018). The total project costs amounts to USD 460 million and the plant has been constructed by HydroChina Corporation (a subsidiary of PowerChina) in two phases: phase I, which was completed in 2012 with a capacity of 51 MW and phase II, which was constructed from 2013 to 2015 with added the installed capacity of the plant with 153 MW (EIA, 2016). The average annual generation of Adama I wind farm is 163 MWh, which is somewhat higher than expected initially. Further, the Longyuan Mulilo De Aar wind power

projects (244 MW) in Northern Cape South Africa involves China Longyuan Power Group as the investor (Baker and Shen, 2017)[2].

In the area of solar PV, a number of solar power plants are currently being constructed or in operation which involves a Chinese investor. The Garissa plant in Kenya, for example, is located in Garissa County about 20 kilometres, north of the town of Garissa, which involves a 55 MW solar plant. China Jiangxi, a Chinese construction company, was awarded the construction contract at a budgeted cost of KSh13.7 billion (USD 135.7 million), borrowed from Exim Bank of China. Construction was expected to begin in the fourth quarter of 2016 and was expected to last one year. Due to prolonged negotiations in securing a power purchase agreement from Kenya Power and Lighting, construction of this project was delayed. However, in February 2019, the Garissa plant went into operation[3]. Meanwhile, in Ghana, a 20 MW solar plant involved the Chinese investor Beijing Xiaocheng Company (BXC) who covered the total project costs of USD 30 million[4]. In Algeria, a consortium consisting of Sinohydro Corp (PowerChina), Yingli and HydroChina are responsible for developing a 233 MW solar plant.

4.2. Flows of firms and their business activities

Chinese RE technology suppliers and EPC contractors have increasingly become prominent actors on a global scale (IEA, 2016). A number of Chinese companies have become specialised in different parts of the project cycle from project development, technology supply to plant operation. Here we focus on turnkey technology suppliers and EPC contractors involved in specific hydro power, wind and solar PV projects in SSA.

With a saturated domestic market and fierce competition in European and US markets, Chinese companies have increasingly advanced into Africa (Shen and Power, 2017). A key motivational (push) factor for the Chinese companies involves the various types of state support mechanisms provided to the companies to engage in export markets. These include concessional loans and export finance as well as export credit insurance and guarantee services to project developers provided by the China Exim Bank, the China Export and Credit Insurance Corporation (Sinosure) and the China Development Bank and its subsidiary institution, the Sino-African Fund (SAF). A critical pull factor includes favourable national RE policies encouraging investments in large-scale RE projects, such as feed in tariff systems and auction schemes.

In the area of hydropower projects in SSA, prominent Chinese EPC contractors include leading Chinese dam-builders, such as Sinohydro (also known as PowerChina), PowerChina Resources Limited, China Huaneng Group, China Huadian Corporation, China Three Gorges Corporation. These Chinese dam-builders are internationally renowned for their hydropower engineering skills and expertise (Kirchherr and Matthews, 2018). Less prominent EPC contractors include technology suppliers and grid operators, such as Dongfang, China Southern Grid and China State Grid. Chinese suppliers of hydropower turbines in these projects include companies such as China Dongfang Electric Corporation (Dongfang Electric), Harbin Electrical Machinery (Harbin Electric) and Shanghai Electric Group Company (Shanghai Electric). Very often, Chinese technology suppliers and EPC contractors follow Chinese investors in specific hydropower projects constructed in Africa, which is not least due to requirements for investors to produce the equipment in China in order to be eligible for export support (EIA, 2016). Non-Chinese contractors can also receive economic support from the Chinese state if the equipment used in the project has been produced in China, which is the case in the Bui hydro dam project in Ghana, which use turbines produced by Alstom Hydro in China (IEA, 2016; Han, 2018).

[2] https://www.timeslive.co.za/news/south-africa/2017-11-30-de-aar-wind-power-projects-start-feeding-electricity-to-northern-cape/

[3] https://energysiren.co.ke/2019/02/16/chinas-link-in-55mw-garissa-solar-plant/

[4] https://cleantechnica.com/2016/04/17/ghanas-largest-solar-pv-project-just-connected-to-the-grid/

An increasing number of leading Chinese EPC contractors and wind turbine suppliers have been involved in wind power projects constructed in SSA, including Sinovel, Goldwind, Sany, Guodian United Power and China Longyan Engineering. Indeed, according to Hua (2015), 14.6% of the total global export of wind turbines from China in 2014 was sold in Africa. The presence of these leading Chinese wind turbines suppliers in Africa reflects their generally increasing importance on the wind power market globally (Baker and Sovacool, 2017). For example, Goldwind provided 51 (MW 3-blade) wind turbines in the first phase of the Adama wind power project in Ethiopia while Sany provided 153 (MW 3-blade) turbines in the second phase (the EPC contractor of the project was HydroChina) (Chen, 2018). Similarly, in South Africa, China Longyan Engineering was the EPC contractor in two wind power project entitled De Aar Wind Power Projects 1 and 2, which make use of wind turbines supplied by Guodian United Power[5]. Also in South Africa, Sinovel, Goldwind and Guodian United Power respectively supplied the wind turbines to the projects entitled Dassiesklip (developed by Iberdrola Renewables/WPO) and Van Stadens, Excelsior and Mulilo De Aar Maanhaarberg (developd by Longyuan) (see also Table 2)[6]. In Kenya, the recently constructed Lake Turkana project (310 MW) makes use of wind turbines that have been produced by Vestas in China while the China Machinery Engineering Corporation was contracted as the EPC contractor in the so-called Kipeto Energy Wind Park, which has yet to be constructed.

Table 2. Involvement of Chinese wind energy companies in South Africa.

Company	Type of involvement	Capacity of involvement (MW)	Type of ownership	Listed
China Longyuan Power (China Guodian Corporation)	Project developer/sponsor	244	SoE (57% owned by China Guodian Corporation)	Hong Kong stock exchange
United Power (China Guodian Corporation)	EPC/ OEM	244	SoE (China Guodian Corporation)	Hong Kong stock exchange
Goldwind	EPC/OEM	149	Not directly state-owned but is owned by a number of SoEs	Hong Kong and Shenzhen stock exchanges,
Sinovel	EPC/ OEM	53	Private	Shanghai stock exchange
Sany	OEM	None	Private	Hong Kong stock exchange

Source: Baker and Shen (2017).

In the area of solar PV, an even larger population of Chinese companies have supplied solar panels and modules to a number of large scale solar projects in Africa, including Yingli Solar, Suntech Power, BYD, Jinko Solar, Trina, Chint, Hanwha Solar, Renesola and PowerWay (Shen and Power, 2017; Baker and Sovacool, 2017). The prominence of the Chinese companies is according to Baker and Shen (2017) a reflection of the role of China as the world's largest manufacturer of solar panels and the highly export-oriented nature of the industry. In South Africa, for example, Trina provided the solar panels to a project developed by Spain's Gestamp Solar in Northern Cape Province while Suntech supplied panels to the De Aar solar plant (100 MW)[7] (see Table 3). Similarly, in Kenya the (0.6 MW) plant at Strathmore University and the so-called Garissa project (55 MW) made use of solar panels supplied by Jinko Solar, the latter currently being constructed by the Chinese EPC contractor.

[5] http://www.engineeringnews.co.za/article/de-aar-wind-projects-connected-to-the-grid-2017-11-28/rep_id:4136

[6] https://www.thewindpower.net/windfarm_en_22849_excelsior.php

[7] http://www.solarni.co.uk/wp-content/uploads/2014/11/Bankability-Book-0328.pdf

Further, the 8.5 MW Rwamagana solar plant constructed in Rwanda involved the Chinese solar panel supplier BYD.

Table 3. Involvement of Chinese solar PV companies in South Africa.

Company	Type of involvement	Capacity of involvement (MW)	Type of ownership	Listed
Jinko	Technology supplier, manufacturer	260 MW	Private	New York Stock Exchange
BYD	Technology supplier	247.2 MW	Private	Shenzhen Stock Exchange
GCL-Poly	Technology supplier, equity investor	150 MW	Private	Hong Kong Stock Exchange
Hanwha Solar One	Technology supplier	139 MW	Private	NASDAQ
Suntech (taken over by Shunfeng International Clean Energy Limited)	Technology supplier	89 MW	Private	Hong Kong Stock Exchange
JA Solar	Technology supplier	86 MW	Private	NASDAQ
Yingli Solar	Technology supplier	75 MW	Private	New York Stock Exchange
Chint	Technology supplier, equity investor	30 MW	Private	
Trina Solar	Technology supplier	20 MW	Private	New York Stock Exchange
Powerway	EPC	75 MW	Private	

Source: Baker and Shen (2017).

4.3. Flows of productive assets

As mentioned previously, Chinese suppliers of hydropower, wind and solar PV technology to large-scale projects constructed in Africa typically import the equipment from manufacturing plants in China, which is supplied directly to the specific projects. In other cases, foreign companies source the technology from their production facilities in China, which is then imported into Africa in relation to the specific projects (Baker and Shen, 2017). Hence, in most cases, the main components, such as wind turbine blades, solar panels or hydropower turbines (and auxiliary components, such as charge controllers and generators) are not manufactured by Chinese technology suppliers locally in Africa.

In the case of large-scale hydropower projects constructed in Africa, for example, the turbines used have been imported from China and other countries. Indeed, to our knowledge, the local manufacture of hydropower turbines in Africa is entirely absent, except from (pico) turbines used in small-scale hydropower projects, which may involve local producers of equipment (Ahlborg and Sjöstedt, 2015).

In relation to wind turbines, there is evidence of local production of small-scale turbines across Africa and import of complete small-scale wind turbines from abroad (including from China) (Hansen, 2018). However, none of the Chinese suppliers of wind turbines, such as Goldwind, Sinovel, Longyuan, Sanya and Guodin, have established local production of key components in Africa. It

should be noted however that HydroChina is evidently considering establishing a local tower and blade manufacturing plant in Ethiopia as part of Phase III of the Adama wind project. Similarly, Conrad et al (2011) notes that Longyuan have been planning to establish a blade and turbine manufacturing facility in South Africa (in Western Cape).

The establishment of local solar PV assembly plants by Chinese companies in Africa is limited to the cases of Wuxi Suntech and Jinko Solar in South Africa (Baker and Sovacool, 2017). The plant by Jinko Solar involves an investment of 80 million USD in a facility set up in 2014 in Cape Town and represents the company's first plant outside of China[8]. The production capacity was designed for 1,300 panels a day corresponding to 120 MW per year. The plant by Wuxi Suntech involves a new warehouse facility, was initially able to store 500 kW of modules and the storage capacity was later expanded to 1 MW in 2015. Other known examples of Chinese investments in productive assets for RE in SSA have apparently been aborted. This includes a previously planned module assembly plant in Nairobi in Kenya by a Chinese company, which was cancelled following the post-election violence in 2008 (Ockwell and Byrne, 2016). Similarly, in Egypt, a solar PV manufacturing facility involving a Chinese investor was evidently planned but has not materialised[9].

Table 4 below provides a summary of the key findings presented in Section 4.

Table 4. Main findings presented in Section 4.

	Hydro	Wind	Solar
Flows of financial investments	• Most of Chinas involvement in RE in Africa is related to hydro: 49% of all Chinese-funded RE projects is hydropower • Of the 330 hydro-power projects funded by Chinese investors globally, 85 (26 %) are located in Africa • Large infrastructure projects (average size of 221 MW) • Exim Bank of China main investor	• Exact number of Chinese-funded wind power projects unknown* • Chinese-funded wind power projects under construction in Djibouti, South Africa and Kenya • Average size around 30-150 MW • Exim Bank of China main investor (e.g. Adama project)	• Exact number of Chinese-funded solar power projects unknown* • Chinese-funded solar power projects under construction in Ghana, Kenya and Algeria • Average size around 10 and 60 MW • Exim Bank of China main investor (e.g. Garissa project)
Flows of firms and their business activities	• Well-known Chinese suppliers of hydro dams are involved leading Chinese dam-builders, such as Sinohydro • Project examples include Bui hydro dam project (Ghana)	• Key suppliers include Sinovel, Goldwind, Sany, Guodian United Power Longyan, • Reflect the generally increasing importance of Chinese suppliers globally • Project examples include Adama project (Ethiopia), Dassiesklip (South Africa),	• Key suppliers include Yingli Solar, Suntech Power, BYD, Jinko Solar, • Reflect the global prominence of export-oriented Chinese suppliers • Driven by market saturation • Project examples include De Aar solar plant (South Africa), Garissa project (Kenya)
Flows of productive assets	• Absence of Chinese-owned local production facilities in Africa	• Absence of Chinese-owned local production facilities in Africa	• Two plants established in South Africa by Wuxi Suntech (warehouse) and Jinko Solar (assembly)

[8] https://www.brandsouthafrica.com/investments-immigration/business/investing/solar-060814

[9] https://www.esi-africa.com/egypt-develop-solar-pv-manufacturing-facility/, https://www.reuters.com/article/us-egypt-solar/egypt-signs-mou-with-chinas-gcl-for-2-billion-solar-panel-factory-idUSKBN1IB1WI

Source: Authors own elaboration. *While the exact share is unknown, 7% of the Chinese-owned projects identified in IRENA (2016) include a number of solar and wind power projects, some of which are described in this report.

5. Summary discussion

As shown above, the increasing influence of China in the RE sector in SSA can be observed across the three RE sub-sectors analysed in this report. Indeed, China is responsible for around 30% of the total added RE capacity in SSA, although mainly related to the development of hydropower plants. Interestingly, the majority (90%) of these projects involves state-owned enterprises from China as project investors. Recently, however Chinese actors have started to play an increasing role in the development of other types of RE plants, as illustrated above in relation to solar PV and wind power projects. Chinese actors are furthermore expected to play an increasing role in the development of such non-hydropower projects across SSA in the coming years.

Chinese actors such as investors, EPC turnkey contactors and technology suppliers are responsible for providing key financial and technological resources in various RE projects in SSA. Interestingly, we see a tendency for Chinese investors and contactors to supply projects on a turnkey basis delivered as a bundled package comprising a considerable representation of Chinese investors, engineering companies and technology suppliers. Illustrative examples have been identified across the three RE sub-sectors analysed. For example, the De Aar Wind Power Project in South Africa involves Longyan as the investor and EPC contractor while the turbines are supplied from United Power. Similarly, the Garissa solar power project in Kenya involves the Chinese construction company China Jiangxi, is funded through a loan from Exim Bank of China and the solar panels are supplied by JinkoSolar. Hence, based on a review of secondary sources, a dominant 'Chinese model' of fully imported finance, knowledge and equipment appears evident. A possible reason for the development of such a Chinese model may be found in the Chinese funding support requirements, which stipulate that investors are eligible for export credits only if the equipment used is manufactured in China. While such a model resembles a traditional 'tied aid' approach in development cooperation, the Chinese version could be argued to differ with respect to the dominance of the involvement of state-owned enterprises (see Sun, 2014).

However, it is central to note that the report is not comprehensive, which means that not all Chinese-built hydropower, solar PV and wind power projects have been analysed in detail. So, whether the suggested Chinese model is generalizable to all projects within these sectors is indeed an outstanding empirical question. Further, the report has not compared Chinese-dominated RE projects with projects developed and dominated by other actors. Hence, projects with a strong dominance of German or French actors, for example, may potentially follow a similar pattern of turnkey investments with significant imported content or conversely follow a pattern of lower on-average imported content.

The report points at very limited Chinese investments in local assembly and equipment manufacturing facilities for RE technologies. Such investments are confined to South Africa where local content requirements may have played a key role. Future research could benefit from pursuing this issue further by analysing the main determinants for Chinese lead firms to establishing local production in SSA countries.

Finally, while the developmental impacts have not been assessed in this report, further analyses could potentially pursue an improved understanding of the implications for learning and upgrading of local actors related to Chinese involvement in RE projects in SSA. Such research could focus on whether and how local firms gain access to knowledge and acquire capabilities from Chinese actors in order to analyse the contribution of China to local industrial development in Africa. This could form part of a broader research agenda based on

in-depth empirical research, which involves pursuing the question of whether and how economic co-benefits arise when RE projects are developed by Chinese investors compared, for example, to investors from Europe and the US.

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