DEVELOPMENT REIMAGINED

Transforming Africa into a Photovoltaic Manufacturing Hub with China's Support

DISCUSSION PAPER

July 2024

DEVELOPMENT REIMAGINED

CONTENTS

ACKNOWLEDGMENTS

We are grateful for and acknowledge the opinions and insight provided by our practitioner and expert interviewees that contributed to the thinking and analysis expressed in this report through their own work as well as joint and one-to-one discussions with the team.

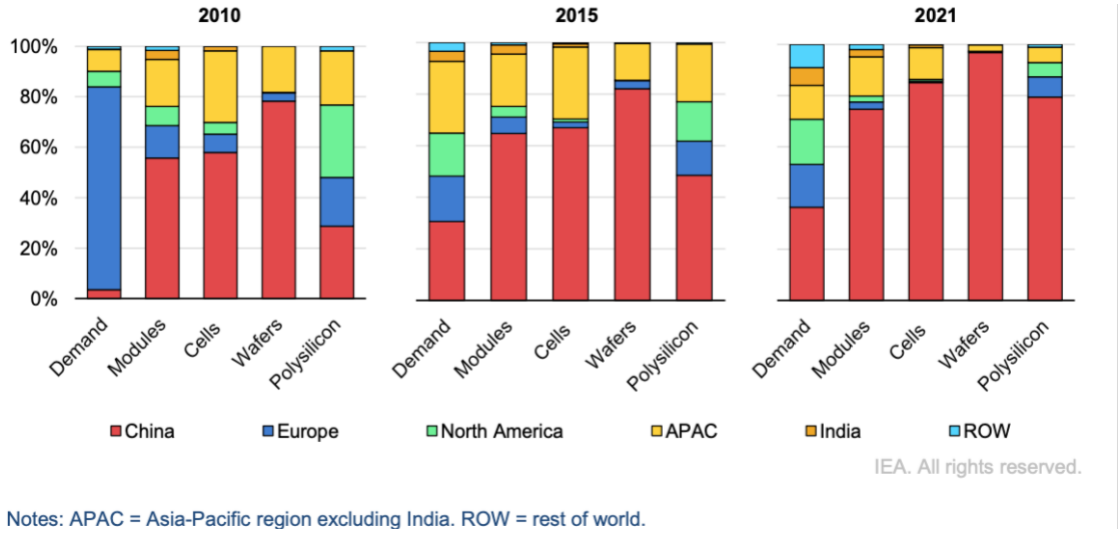
However, our opinions, insights, conclusions, recommendations, and errors are ours alone.

Special thanks also go to our excellent researchers Sophia, Kladaki, Yixin Yu, Yunong Wu, and Jiaying Zheng. Hannah Ryder, Leah Lynch and Yike Fu are also to be thanked for help with editing and production.

1 INTRODUCTION

In an era where the international community has stepped up its efforts to mitigate the impact of climate change on communities and champion the transition towards Net Zero and renewable energy sources, the solar energy sector has emerged as a beacon of hope. Central to this transition are photovoltaic ("PV") technologies, which harness the abundant energy of the sun to generate electricity for households and businesses alike. In this evolving landscape, China has emerged as the global leader in the PV manufacturing industry (see Figure 1). This is evident by the fact that China has committed, since 2011, over USD 50 billion to new PV supply capacity, a figure that is tenfold that of Europe, and has generated more than 300,000 manufacturing jobs throughout the solar PV value chain.[1] In addition, at present (2024) China's share in all the manufacturing stages of solar panels (such as polysilicon, ingots, wafers, cells and modules) exceeds 80% while the country boasts the world's top ten suppliers of solar PV manufacturing equipment.[2] China's dominance in this sector is driven by its positioning in the global solar supply chain, its technological advancements, it's relatively low energy cost and low labor cost vis-a-vis its competitors. According to Wood MacKenzie, in 2024, China will manufacture solar panels able to generate one terawatt of PV capacity which will be enough to cover the annual global demand for new solar panels until 2032.[3]

Figure 1: Solar PV Manufacturing Capacity by Country and Region, 2010-2021



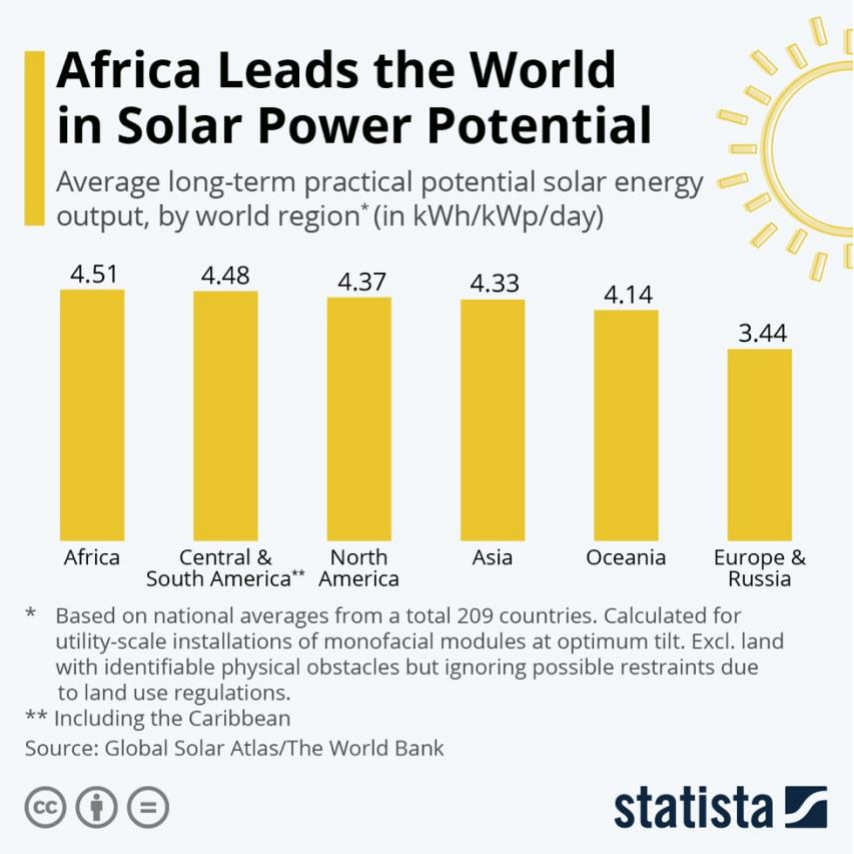
Source: IEA. Special Report on Solar PV Global Supply Chains

As a consequence of that, the abundance of solar manufacturing capacity in China has caused profit margins for many Chinese solar panel manufacturers to plunge in the last months. As things stand, Chinese manufacturers are selling PV modules near cost levels.[4] That increases the risk of Chinese PV manufacturers being crowded out of the market as a result of the oversupply. On

[1] IEA. Special Report on Solar PV Global Supply Chains. Available from: https://www.iea.org/reports/solar-pv-global-supply-chains/executive-summary
[2] ibid
[3] Wood MacKenzie (2023), "China to hold over 80% of global solar manufacturing capacity from 2023-2". Available from Wood MacKenzie.
[4] Caixin Global (2023), "Chinese Solar Firms Feel Squeeze on Profits as Overcapacity Hits". Available from Caixin Global.

the other hand, and based on data from the Global Solar Atlas by the World Bank[5], Africa has the highest average potential for solar energy globally. By using consistent and high-resolution data[6], the study provides a comprehensive and harmonized view of countries' and region's solar resources and potential for utility-scale PV power plant development. The outcomes of this study, as shown in Figure 2, show that Africa leads the way with an average long-term practical yield of 4.51 kWh/kWp/day for utility-scale PV plans. This is higher than Central & South America's average of 4.48 kWh/kWp/day and North America's 4.37 kWh/kWp/day.

Figure 2: Africa's vs Other Region's Solar Power Potential



Source: Global Solar Atlas / World Bank

To put these figures into perspective, around 20 percent of the global population lives in 70 countries with "excellent conditions" for solar power, meaning a long-term output exceeding 4.5 kWh/kWp per day. On a regional level, only the countries in Africa alone have an average that surpasses this threshold. While much of this potential in Africa's less developed nations remains untapped, as the study emphasises, this offers a "*unique opportunity for solar PV manufacturers*

[5] The World Bank:" Global Photovoltaic Power Potential By Country". Available from: https://documents1.worldbank.org/curated/en/466331592817725242/pdf/Global-Photovoltaic-Power-Potential-by-Country.pdf
[6] Data used in the" Global Photovoltaic Power Potential By Country" study are available from: https://datacatalog.worldbank.org/search/dataset/0038379

and investors to provide affordable, reliable, and sustainable electricity services to a large share of humanity where improved economic opportunities and quality of life are most needed".[7]

This data indicates that Africa is poised to become one of the largest markets for solar renewable investments and therefore investing in its PV industry and supporting the localization of the PV value chain will not only result in significant cost savings and cost efficiencies but will also provide a significant first-mover advantage to any investor (Chinese and non) that takes the decision to expand its operations in new markets and invest in Africa.

With this in mind, it becomes clear that investing in Africa's solar PV industry presents a ripe opportunity for both parties involved - China and Africa. On the one hand, Africa presents a compelling alternative for Chinese PV manufacturers who are grappling with the critical decision of either ceasing operations or expanding into new markets such as the African market. This expansion could serve as a strategic decision, enabling these "first-mover" manufacturers to enhance their profit margins by helping African countries develop but also eventually localise their PV value chains. Localising the PV value chain can significantly reduce costs associated with importing the necessary equipment for PV production. According to IRENA and Solar Power Europe, import duties on PV modules can range from 5% to 35% depending on the country, adding substantial cost burdens to solar projects.[8] Moreover, the heavy reliance on imports makes the PV industry vulnerable to substantial price disruptions and exchange rate fluctuations, especially during and after events like the COVID-19 pandemic.[9] Therefore, investing in Africa's PV industry and supporting countries to localise the PV value chain can create significant cost efficiencies, mitigate these risks and stabilize the industry.

On the other hand, African nations could enhance their capacity to manufacture and eventually localise the PV value chain in return of offering Chinese PV manufacturers access to their expanding consumer base. This will not only fuel growth for African economies, but it will also have a number of other socio-economic spill over effects such as job creation in the local market, technology transfer, clean energy transition and more. Therefore, it becomes apparent that relocating PV manufacturing operations from China to Africa and supporting Africa to localise its PV value chain brings opportunities both for Chinese and African stakeholders.

On that basis and given the large number of countries on the African continent, this paper focuses on select African countries and follows a gap analysis approach. In particular, by analysing the current state of African countries across the stages of the PV value chain, this paper is able to identify the gaps (and therefore needs) of those countries as well as the opportunities that exist to "bridge these gaps" and meet their objectives. Understanding these gaps will, on the one hand, enable Chinese investors to make informed decisions and strategically plan their investments when considering relocating their PV manufacturing operations to the African market and, on the other hand, help African countries understand what steps they need to take to facilitate this development.

[7] The World Bank:" Global Photovoltaic Power Potential By Country". Available from: https://documents1.worldbank.org/curated/en/466331592817725242/pdf/Global-Photovoltaic-Power-Potential-by-Country.pdf
[8] International Renewable Energy Agency (2020). RENEWABLE POWER GENERATION COSTS IN 2020. Available from: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_Power_Generation_Costs_2020.pdf
[9] Solar Power Europe (2023). Global Market Outlook For Solar Power 2023 – 2027. .Available from: https://www.solarpowereurope.org/insights/outlooks/global-market-outlook-for-solar-power-2023-2027/detail

This report is structured as follows:

1. First, drawing on from research and consultations with relevant stakeholders, we begin by offering a high-level overview of the gaps and therefore needs of the African region as a whole when it comes to localising the solar PV value chain.
2. Second, we assess the attractiveness and readiness of all African countries to attract Chinese PV manufacturing investment by conducting a thorough evaluation and scoring exercise using a range of criteria outlined in Section 3. Following that, we provide a list of the top 10 countries that ranked first in the African continent.
3. Third, following a brief overview of the three stages of the PV value chain (i.e., Upstream, Midstream and Downstream stage) in which we provide information on the top Chinese companies operating at each of the three stages, we select the top 3 African countries to conduct a deeper analysis. This section analyses the current state of these countries across the three stages of the PV value chain, their existing gaps (and hence needs) and challenges as well as the key actions required to move forward and bridge these gaps effectively.

Finally, upon discussing the advantages of relocating the PV value chain from China to Africa for both parties, we provide detailed and robust recommendations for both Chinese and African stakeholders on the most effective steps moving forward. The recommendations provided are based both on thorough research as well as on insights from interviews with Chinese investors operating in the renewable energy sector.

This report is to facilitate the discussion and encourage the collaboration between China and Africa countries before the ninth Forum on China-Africa Cooperation to accelerate the Africa energy renewable energy development. Other countries are also encouraged to use the analysis and recommendations to support Africa countries solar industry development and expanding renewable energy applications.

2 HIGH LEVEL OVERVIEW OF AFRICA'S GAPS AND THEREFORE NEEDS FOR DEVELOPING ITS SOLAR PV VALUE CHAIN

The development of the PV industry cannot be uniform across all countries as each country has its own needs and specificities spanning from local climate conditions and economic stability to existing infrastructure, and governmental policies – all playing a critical role in shaping the domestic solar PV landscape. For instance, nations with established electrical grids and supportive policy frameworks may focus on integrating solar PV into their existing energy mix, while countries with less developed infrastructure might prioritise standalone solar projects or mini-grids to provide energy access to remote areas.

Due to the distinct characteristics of each country, the following section takes a broader perspective, focusing on the African region as a whole and aims to pinpoint the overarching gaps and therefore needs and opportunities within African countries to develop their solar PV industry. The insights presented are based on comprehensive research combined with consultations with relevant Chinese stakeholders. These findings are intended to provide key insights to Chinese investors interested in relocating their existing manufacturing operations to Africa.

Table 1: Gap analysis - High level overview of Africa's gaps and therefore needs for developing its solar PV value chain

Category	Gaps / Challenges in Africa	Needs / Opportunities in Africa
Limited Awareness Among Investors Regarding PV Market Demand and Limited Awareness of Consumers Regarding PV Benefits and Potential	There is very limited awareness among PV investors (both local and foreign) regarding the specific demand dynamics and market potential for solar PV in the Africa continent. This is driven by the fact that there is either no available detailed and reliable market sizing data and insights specific to the African solar PV market or the access to this data is limited. Moreover, there is limited awareness and adoption of solar PV technologies among consumers and businesses as the benefits of using PV systems and the incentives to do so are limited.	Comprehensive market studies to be conducted and transparent data to be provided to (Chinese) investors with accurate information on market size, growth potential, and consumer demand. Moreover, to further stimulate market demand, initiatives should focus on raising consumer's awareness by demonstrating the benefits of solar PV, offering incentives to consumers, providing educational programs, and implementing pilot projects to showcase impacts and test appetite.
Regulatory and Policy Framework and Weak Institutional Frameworks	Lack of consistent and supportive policies and regulations for renewable energy projects and particularly for solar PV. Weak institutional frameworks and governance structures to support solar PV development.	Establishment of clear, stable, and incentivizing policies to attract investments and streamline processes for solar PV projects. Strengthening of institutions and governance mechanisms to effectively plan, implement, and monitor solar PV projects.
Technological and Technical Expertise	Shortage of local expertise in solar PV manufacturing, technology and project management.	Capacity building through training programs, education, and technology transfer to develop a skilled workforce capable of supporting the solar PV industry – all in collaboration with existing actors and companies operating in the field.
Local Manufacturing and Supply Chain	Heavy reliance on imported materials such PV modules, PV cells and other ancillary equipment and lack of local manufacturing capabilities across the 3 stages of the PV value chain – downstream, midstream, upstream.	Leverage existing supply chains and provide incentives to local and foreign investors to further expand their operations in the PV industry. Facilitate the expansion of existing Special Economic Zones (SEZs) to include dedicated facilities and infrastructure for the manufacturing of PV panels. Attract Chinese investors already operating in the PV industry into the SEZs by providing incentives and streamlining regulatory processes

Category	Gaps / Challenges in Africa	Needs / Opportunities in Africa
Grid Integration and Energy Storage	Challenges in integrating solar PV into existing power grids and lack of energy storage solutions.	Incentivise investments in grid infrastructure upgrades and development of energy storage systems to enhance grid stability and reliability. This is often a prerequisite for further developing the solar PV industry.
Financial Mechanisms and Funding	Limited access and availability of financing for PV projects (both from the regional and international community) and significant high upfront costs for the implementation of solar PV projects.	Development of innovative financial instrument (i.g., green bonds, low-interest-loans), subsidies and incentives such as lower barriers to entry and attract private and public investments.
Infrastructure Development	Insufficient infrastructure for manufacturing, distribution, and installation of solar PV systems.	Investment in roads, power grids, and facilities to support large-scale solar PV manufacturing and deployment. This will also help facilitate trade of PV modules across the region.

3 MOST ATTRACTIVE AFRICAN COUNTRIES FOR CHINESE PV MANUFACTURERS

Countries vary in their endowment for PV manufacturing. Bearing that mind, we have determined five criteria used to better understand which countries would be the most attractive destinations for Chinese stakeholders to invest in. We set out these criteria in the table below.

Table 2: Criteria used to select top 10 most suitable African countries for Chinese PV investments

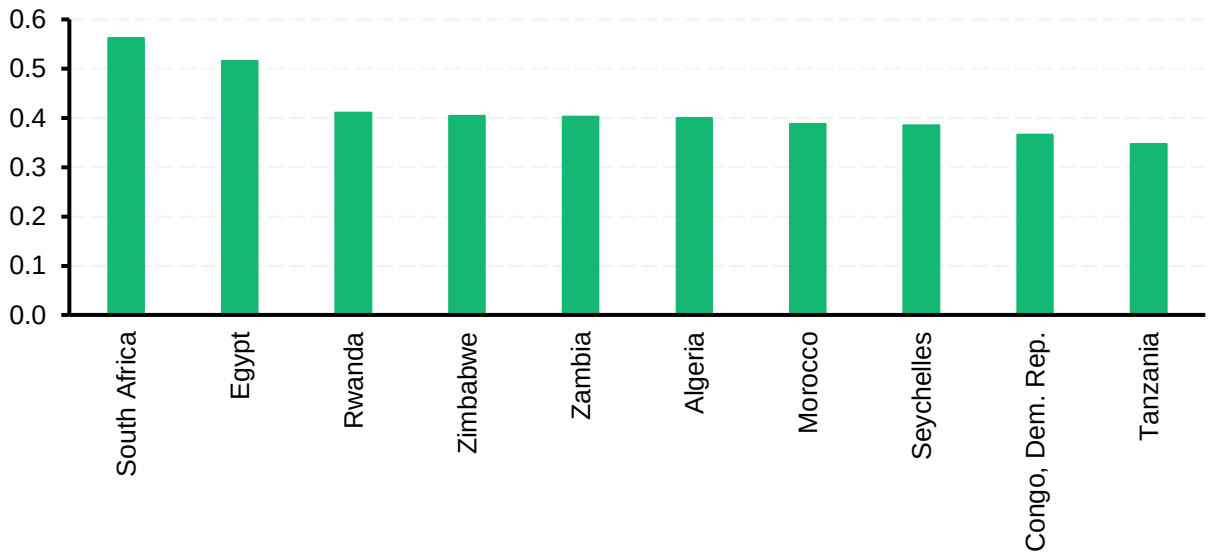
Criterion	Selection Rationale
Manufacturing sector as a share of GDP	This criterion measures the readiness and ability of a county's infrastructure sector to accommodate the manufacturing part of the solar PV value chain. The higher the proportion of the manufacturing sector as a % of GDP, the higher the ability of that country to undertake the manufacturing of solar PV. A weight of 20% is applied to this criterion.
Chinese FDI stock to GDP	This criterion measures a country's track record in attracting and maintaining Chinese investments in their domestic market but most importantly indicates the relationship of a particular African country with China. This is of great importance when exploring how China can relocate its PV manufacturing to Africa and how it can help localise the PV solar value chain. A weight of 30% is applied to this criterion.
Strength of regulatory framework for renewable energy	This criterion indicates a country's effort towards fostering an enabling environment for investments in the renewable energy sector. A weight of 15% is applied to this criterion.

Criterion	Selection Rationale
Solar potential	This criterion measures a country's ability to generate solar power based on the hours of sunlight it gets on average on a daily basis. A weight of 10% is applied to this criterion.
Quality of infrastructure	This criterion measures the quality of a country's infrastructure (such as roads, ports etc.) and indicates whether this country would be able to sustain a domestic and even cross-border value chain. A weight of 25% is applied to this criterion.

Note: In Annex 1, we provide more details on the criteria used to select the 10 countries. The dataset with all the above data can also be made available upon request.

After collecting data for each of the mentioned criteria and completing a normalization process, we pinpointed the top 10 countries with the highest scores (see Figure 3). Nonetheless, due to the large number of countries within the continent and given the scope of this paper, we will concentrate our deep dive analysis on the top three performers namely: South Africa, Egypt and Rwanda.

Figure 3: Top 10 most suitable African countries for Chinese PV investments

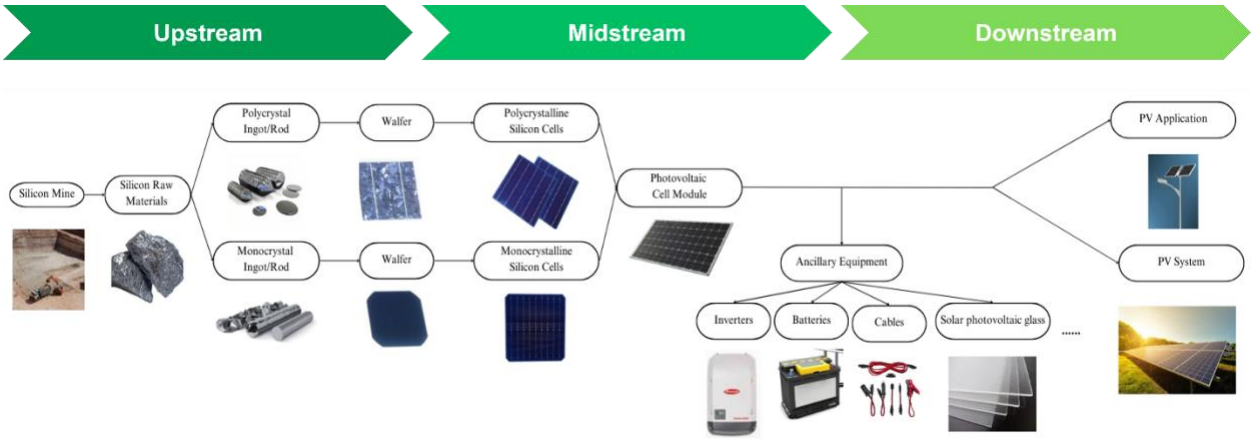


The main reasons why South Africa and Egypt are high performers is due to the fact that both countries have a strong manufacturing sector of the economy, they both provide a strong regulatory framework for investments in renewable energy resources and also have a strong solar PV potential. On top of that, both countries are two of the largest economies in the Africa (in GDP terms) which means that the underlying market opportunity for Chinese stakeholders would be significant. On the other hand, Rwanda (which has comparable scores with other countries like Zimbabwe, Zambia and Algeria and Morocco and could easily all fall under the 3rd most suitable country) has scored third as it is the country with a very strong regulatory environment to attract renewable energy investments and also has a high quality of infrastructure. More information on the actual data and sources used can be provided upon request.

4 OVERVIEW OF THE PV VALUE CHAIN

The solar PV value chain represents the entire journey of solar energy production, from the raw materials to the final application of PV systems. It's divided into three main stages: Upstream, Midstream, and Downstream (see Figure 4). While there are two types of PV technologies, crystalline-silicon (c-Si) PV and thin-film PV, c-Si PV is the dominant player, accounting for over 95% of the market share.[10] Hence, this section primarily focuses on the c-Si PV value chain.

Figure 4: The three stages within the PV value chain



In the Upstream stage, the process begins with the extraction and refinement of raw materials, primarily silicon, to produce high-purity polysilicon. This is achieved through methods like the Siemens process or the fluidized bed reactor method, where impurities are removed to ensure the silicon's quality. Once purified, the silicon is melted and solidified into large ingots, which are then sliced into thin wafers using precise cutting techniques.

China hosts major production facilities in the upstream stage as silicon is extracted from quartz sand which is available in abundant deposits within China. Polysilicon production is largely self-sufficient, with additional auxiliary products like doping agents, metal contacts, and anti-reflective coatings produced domestically by specialized chemical and material companies. Key Chinese companies operating in this stage include Tongwei, TBEA, Hoshine and East Hope (see Table 3). These firms are predominantly located in regions rich in raw materials and energy supply, such as Xinjiang, Inner Mongolia, and Sichuan provinces.

Table 3: Chinese leading polysilicon producers

Company Name	Location	Polysilicon Production in 2023 (thousand tones)
Tongwei	Sichuan	420
GCL	Shanghai(HQ), 60+ production base	400
Daqo	Zhejiang(HQ) ; Xinjiang(Production)	305
TBEA	Xinjiang	300

[10] IEA. “Solar PV Overview”. https://www.iea.org/energy-system/renewables/solar-pv#

Company Name	Location	Polysilicon Production in 2023 (thousand tones)
East Hope	Xinjiang	255
Hoshine	Zhejiang (HQ); Xinjiang, Sichuan (Production)	200

Data source: ASKCI

Moving on to the Midstream stage, these silicon wafers undergo various processes to transform them into functional solar cells. This includes cleaning the surface, applying anti-reflective coatings, doping to create positive and negative layers, and adding metal contacts to collect electricity. The individual cell clusters are then “joined” together to form a solar module, typically encapsulated with protective materials to withstand environmental factors and ensure longevity. This process is mainly known as the PV module assembly stage. The PV module is the cornerstone of the solar energy technology as it includes the solar cell which transforms sunlight into electricity and other components such as aluminum frame, glass, encapsulant, back sheet and junction box (see Figure 5) – all falling under the Midstream stage.

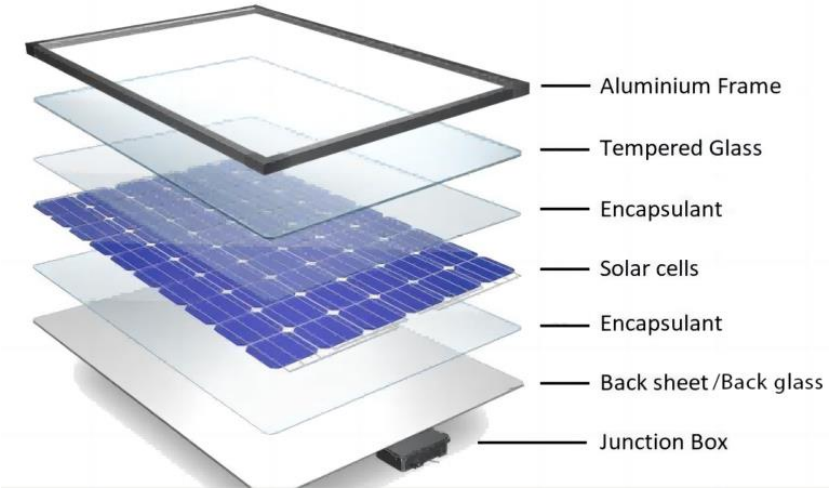
In China, major players in this stage include LONGi, JA Solar, and JinkoSolar. These companies are mainly based in industrial hubs such as Jiangsu and Zhejiang provinces, benefiting from the well-established industrial ecosystem and infrastructure. The auxiliary products like anti-reflective coatings, doping materials, and metal contacts are often sourced from specialized chemical and material companies located in the same or nearby regions. Furthermore, a number of Chinese companies lead in utilising PV technology (see Table 4), achieving significant breakthroughs in producing high-efficiency solar cells compared to the current mainstream PERC cells.

Table 4: PV technology breakthroughs

Technology	Leading Companies	Key Features	Efficiency
TOPCon (Tunnel Oxide Passivated Contact)	Longi, Jinko Solar	Based on N-type silicon wafers	Higher potential efficiency than PERC
HJT (Heterojunction with Intrinsic Thin Layer)	Risen Energy, Tongwei Co.	Based on N-type silicon wafers	Higher potential efficiency than PERC
BC (Back Contact) Solar Cells	Trina Solar, JA Solar	High front-side efficiency, aesthetically pleasing	High efficiency
Perovskite Solar Cells	GCL-Poly	High efficiency limit, high power generation capability, rich appearance, accessible raw materials	Laboratory conversion efficiency reached 25.7% within a decade from 3.8%

Finally, in the Downstream stage, solar modules are integrated into PV power systems or used in various PV application products. PV power systems can range from residential rooftop installations to large-scale utility projects while PV application products range from solar-powered streetlights to portable chargers. The solar PV system consists of the PV module and other ancillary equipment such as inverters, mounting systems, trackers, and cables which fall under the Downstream stage as they are required for the installation of solar PV systems.

Figure 5: Components of PV module



Source: Maysun Solar

Companies like Trina Solar and JinkoSolar are prominent players in this stage. These companies have extensive manufacturing bases in Jiangsu, Anhui, and Zhejiang provinces. For the production of solar modules, auxiliary products such as encapsulants, back sheets, and junction boxes are sourced both domestically and from international suppliers to ensure high quality and reliability.

Beyond China, there are Chinese companies operating in the PV industry that have established a significant presence in Africa too (see Table 5). The domain business model includes working with local distributors to deliver solar products, offer financing options, and provide after-sales support and maintenance. In particular, JA Solar has built a head office in Johannesburg and hired an African CEO. According to a source off record, the local sales team has also hired 20 African staff from different regions to maintain the distributors' relationships. Moreover, since 2014, pioneers like Jinko Solar revolved around the establishment of manufacturing facilities in, for example, South Africa to cater to the growing demand in the region[11] while at present (2024), it is said that Jinko Solar is pushing the boundaries of solar power in the country particularly after they announced the launch of a revolutionary N-type 66-cell solar panel in 2024 with a groundbreaking power output of 600W and an efficiency rate of 22.72%.[12]

[11] JinkoSolar Opens Solar Module Factory in Cape Town, South Africa, https://jinkosolar.us/press/jinkosolar-opens-solar-module-factory-in-cape-town-south-africa/
[12] JinkoSolar: Revolutionizing Solar Technology in Africa (2024). Available from: https://www.afsiasolar.com/jinkosolar-revolutionizing-solar-technology-in-africa/

Table 5: The presence of top Chinese PV producers in the African region

Company	Major Countries Operating	Local Team Capacity	Non-profit Actions
LONGi	Utility PV Projects in South Africa (300+MW), Egypt (600+MW), Tunisia (120 MW), Burkina Faso (100+ MW), Togo (20M W) Uganda (19 MW)	Africa Representative Office in South Africa	Donate PV modules to unpowered facilities in 16 African countries through the Lightening Africa program
Jinko Solar	South Africa, Egypt, Kenya, Nigeria, Zimbabwe Partnership with Palette for 50 MWh solar storage distribute	Solar module factory in Cape Town (120 MW capacity)	Contribute into initiatives aimed at promoting sustainable energy in Africa. No specific exposure
Trina Solar	South Africa, Morocco, Egypt, Kenya, Ghana	Through local distributors for trade and service	No specific exposure
JA Solar	South Africa, Egypt, Nigeria, Algeria, Tanzania	Head Office in South Africa	Rural communities and school solar installations

5 COUNTRY DEEP DIVES: SOUTH AFRICA, EGYPT, RWANDA

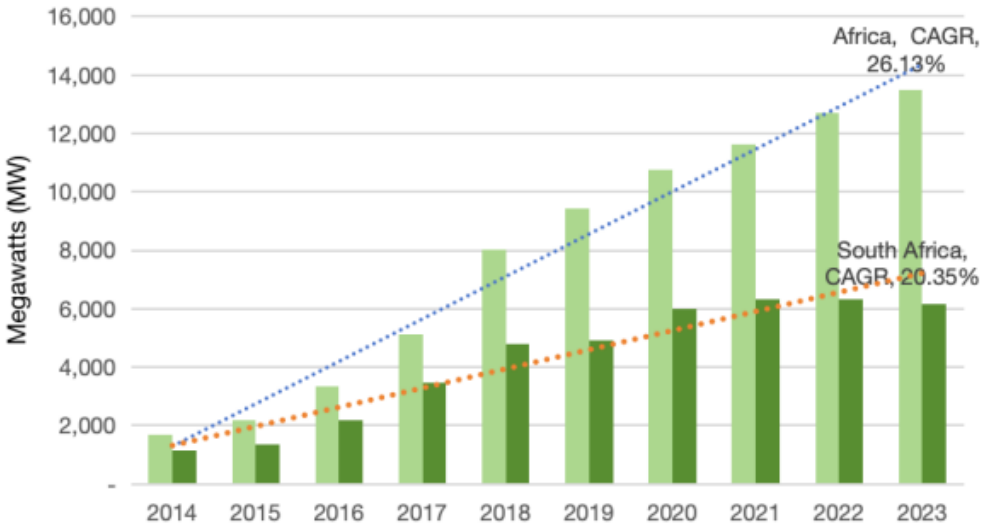
As mentioned above, to provide more specific and valuable insights, the following section conducts an analysis of the top three African countries that scored highest in our evaluation matrix, namely South Africa, Egypt and Rwanda. This analysis focuses on current state of these countries across the three stages of the PV value chain, their existing gaps (and hence needs) and challenges as well as the key actions required to move forward and bridge these gaps effectively. The ultimate goal is to shed the spotlight on what are these countries' needs and how can Chinese stakeholders support them in localizing their PV value chain and therefore achieving solar PV autonomy.

5.1 South Africa (1st Ranked Country)

South Africa is the largest solar energy producer in Africa, contributing nearly half of the continent's solar energy capacity (see Figure 6). It covers about 1.22 million square kilometers, a land area comparable to China's Xinjiang Uyghur Autonomous Region (approximately 1.66 million square kilometers) or Ukraine in Europe (approximately 603,500 square kilometers). The country benefits from an ideal climate for solar energy, with most areas averaging more than 2,500 hours of sunshine per year and solar radiation levels ranging between 4.5 and 6.5 kWh/m2 in a single day.[13]

[13] Department of Mineral Resources and Energy, Government of South Africa. https://www.energy.gov.za/files/esources/renewables/r_solar.html

Figure 6: Evolution of South Africa's and Africa's solar energy capacity



Source: IRENA: Renewable Energy Capacity Statistics

Currently, coal represents about 70% of South Africa's electricity capacity, with the share of renewables catching up gradually. Solar energy is the largest renewable source in the country, contributing over half of the total renewable capacity. It's contribution to the nation's electricity capacity also climbed from a 2.5% share in 2014 to 9.9% in 2023. This expansion encompasses both solar PV and concentrated solar power (CSP) technologies (5,664 MW of solar PV and 500 MW of CSP as of 2023).[14] To meet the carbon reduction goals outlined in South Africa's Nationally Determined Contributions, approximately 70 GW of renewables must be connected to the grid by 2030.[15] Solar energy not only plays a pivotal role in South Africa's carbon emissions reduction efforts, but it also enhances energy security, and drives economic growth. Therefore, the development of a localized PV value chain within the country is essential. By fostering domestic manufacturing capabilities for solar PV production, South Africa can foster a more resilient and stable renewable energy supply chain while simultaneously bolstering its economy through job creation, investment attraction, and technological advancement.

5.1.1 CURRENT STATE OF SOUTH AFRICA'S SOLAR INDUSTRY AND GOVERNMENT POLICIES

Moving towards reducing the carbon footprint of the energy sector while addressing growing energy demand and ensuring a just transition, the South African government has set out a long-term plan for diversification of the power mix. Captured within the Integrated Resource Plan, which estimates energy demand and identifies the requisite investment in the electricity sector, South Africa has committed to incorporate 3,615 MW of new solar PV capacity by 2030, and an additional 9,000 MW by 2040.[16] South Africa has implemented various initiatives to incentivize

[14] IRENA. Renewable Capacity Statistics 2024.
[15] GOV.UK. "South Africa's Just Energy Transition is progressing". https://www.gov.uk/government/news/south-africas-just-energy-transition-is-progressing
[16] Government of South Africa. Draft Integrated Resource Plan 2023. https://www.gov.za/sites/default/files/gcis_document/202401/49974gon4238.pdf

solar energy development and deployment, including feed-in-tariff, competitive bidding, net metering and tax incentives.[17] Notably, the government launched the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) initiative in 2011 aimed at increasing electricity capacity through private sector investment in solar PV and concentrated solar, onshore wind power, small hydro, landfill gas, biomass, and biogas. As of 2023, and through introducing a competitive bidding system, the programme awarded a total of 123 projects to the private sector which added approximately 9,910 MW of electricity generation capacity while in 2024 the programme seeks to add an additional 1,800 MW.[18] The government of South Africa is also committed to enhance the industrialization of the PV value chain. The South African Renewable Energy Masterplan (SAREM), with objectives to grow the industrial capacity in renewable energy value chain, presented South Africa's vision and opportunity for localizing PV value chain and other renewables.[19]

5.1.2 CURRENT STATE AND GAPS IN THE UPSTREAM STAGE OF THE PV VALUE CHAIN

South Africa is a significant player in the production of the core raw material for PV modules, namely silicon. In 2023, the country exported silicon worth USD 53.8 million to various international markets, including Germany, Malaysia, China, and Japan, among others.[20] However, the country lacks the capacity to convert silicon into polysilicon, which is a key raw material for PV cells, due to the high technological and financial barriers involved. There are three core technologies derived for polysilicon production, which are currently housed in a handful of enterprises in the United States, Germany, Japan, China, and Malaysia. This technology gap, coupled with high investment risks and cost-efficiency concerns, hinders the development of the upstream PV value chain in South Africa. Despite these challenges, targeting major Chinese integrated PV firms that possess the necessary technologies and expertise could facilitate the gradual relocation of the upstream PV supply chain to South Africa.

5.1.3 CURRENT STATE AND GAPS IN THE MIDSTREAM STAGE OF THE PV VALUE CHAIN

The midstream stage of the PV value chain includes both PV cell and module production as well as the production of ancillary equipment. PV cell production has a high geographical concentration, with the Asia Pacific region manufacturing over 95% of the PV cell supply. Currently, there are no local or foreign cell manufacturing activities in South Africa while PV module assembly is more diversified but still depends on China and other parts of the Asia-Pacific for key inputs. In particular, there are currently only a few local factories involved in PV module assembly, namely, ArtSolar, Seraphim, EGA as well as the Chinese-owned JinkoSolar which built the first Chinese solar module factory in Africa (see Figure 7).[21] Regarding the production of ancillary equipment for PVs, there are certain local suppliers that produce inverters, cables, mounting structures, and trackers, however, imports still dominate the market. Local manufacturers also produce module components like lamination, aluminum frames, and junction

[17] Africa Solar Industry Association. "Annual Solar Outlook 2024".
[18] IPP Renewables. https://www.ipp-renewables.co.za
[19] Government of South Africa. South African Renewable Energy Masterplan (SAREM). Draft version for review July 2023.
[20] UN COMTRADE.
[21] LSF. "Manufacturing Localisation Potential in Renewable Energy Value Chains". November 2023.

boxes.[22] South Africa could offer support in the forms of grants, tax incentives and concessional funding to encourage firms moving to PV cell manufacturing. In the meantime, it is imperative to establish testing and certification laboratories for locally manufactured PV panels.

Case Study: The first Chinese Solar Module Factory in Africa

JinkoSolar Holding Co., Ltd. (JinkoSolar hereafter) is one of the top ten solar module manufacturers globally. Headquartered in Shanghai, China, it is the first company to establish a 'vertically integrated' production capacity from silicon material processing to wafer, cell and module production in the industry. It has a total of 14 global production bases in China, the United States, Malaysia and Vietnam. In 2014, JinkoSolar invested USD 7.5 million in a solar module manufacturing factory in Cape Town, which was the first Chinese solar module factory in Africa. It covers an area of 5000 square meters and can produce 120 MW of solar modules every year.

5.1.4 CURRENT STATE AND GAPS IN THE DOWNSTREAM STAGE OF THE PV VALUE CHAIN

In South Africa's PV value chain, the focus predominantly lies on the downstream stage—PV solutions and applications. According to the ENF website, 926 companies are involved in solar panel installation in South Africa.[23] The high demand for both utility-scale PV systems and Small-Scale Embedded Generation[24], driven by the REIPPPP and persistent load-shedding challenges, has significantly fueled the growth of this sector. However, it is important to note that this stage does not involve manufacturing and relies heavily on imported components and modules, highlighting the need for a more integrated local PV supply chain. In solar energy application and storage, it is essential to develop an Implementation Plan for infrastructure, i.e. transmission and distribution networks, along with clear grid access regulations, to enable efficient solar energy resource deployment.

5.1.5 CHALLENGES AND WAY FORWARD

The current inadequacy of domestic PV value chain manufacturing in South Africa is attributed to several challenges. These include a shortage of technological expertise in PV manufacturing processes and technologies, which hamper growth and innovation. Financing constraints also pose a significant barrier as establishing PV manufacturing facilities requires substantial upfront investments in infrastructure, equipment, and research and development, while borrowing costs are high in South Africa. Additionally, policy and regulatory barriers exist, as current government incentives primarily focus on the installation of solar systems rather than supporting PV manufacturers, which undermines investor confidence.

To address these issues and fully realize the potential of the PV industry, South Africa needs to create a supportive trade and industrial policy environment that targets localisation objectives. The SAREM provides a good starting point. It is crucial to incentivize investments in PV

[22] LSF. "Manufacturing Localisation Potential in Renewable Energy Value Chains". November 2023.
[23] ENF Solar. Solar System Installers in South Africa. https://www.enfsolar.com/directory/installer/South%20Africa
[24] Small-Scale Embedded Generation (SSEG) refers to electricity generation systems, typically using renewable energy sources like solar PV, that are connected to the local distribution network on the consumer's side of the meter. These systems are generally smaller in scale and are used to generate power primarily for on-site use, with the possibility of feeding excess energy back into the grid.

manufacturing facilities through subsidies, tax exemptions, and financing schemes. Essential steps include setting up realistic localization requirements for public procurement programs like REIPPPP to promote the use of locally sourced modules, reducing incentives for PV module imports, and providing concessional financial support for firms' investment needs.

In accordance with the SAREM, the industrial development roadmap for the PV value chain identifies that the highest potential for localisation lies in the PV module assembly and the production of ancillary equipment for PV systems, such as mounting structures, trackers, and cables. Cell manufacturing is seen as a short-to-medium-term opportunity, while the production of ingots and wafers is recognized as the next frontier for manufacturing in South Africa. Given China's dominance in the global PV value chain, Chinese FDI will be crucial in unlocking South Africa's PV manufacturing potential.

Table 6: Key Activities Required to Further Develop South Africa's PV Value Chain

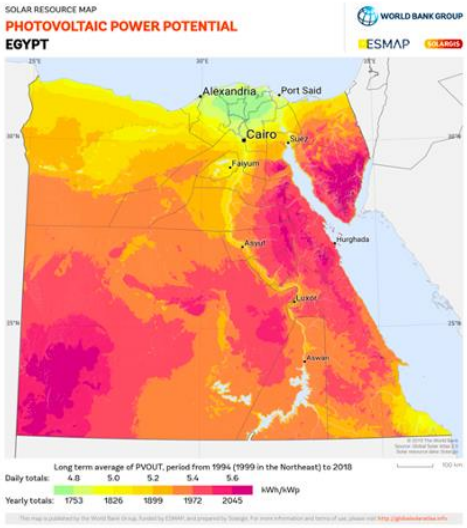
Focus Area of the PV Value Chain	Recommended Activities
Upstream	• Leverage the country's maturity in producing silicon and provide Chinese integrated PV enterprises incentives to initiate the production of polysilicon • Develop local expertise through training and knowledge exchange initiatives with Chinese PV technology institutions.
Midstream	• Expand PV module assembly facilities and manufacturing of additional ancillary equipment such as junction boxes and PV glasses by incentivizing investors and streamlining regulatory processes. • Develop and expand the existing SEZs with dedicated facilities and infrastructure for PV manufacturing. • Establish testing and certification laboratories for locally manufactured PV panels.
Downstream	• Attract manufacturers of PV applications such as solar lamps to the dedicated renewable energy industrial zones • Develop an Implementation Plan for infrastructure, i.e. transmission and distribution networks, along with clear grid access regulations. • Enhance market access and awareness to increase demand for PV solar energy, by conducting nationwide campaigns to raise awareness on the benefits of solar energy and PV systems among households and businesses. • Design and implement concessional financing mechanisms for disadvantaged households, small and medium-sized businesses to procure PV systems

5.2 Egypt (2nd Ranked Country)

Egypt is located in the North of Africa and covers an area of 1.00 million square kilometres which can be comparable to China's Tibet Autonomous Region (approximately 1.2 million square kilometres) and the country of Ukraine in Europe (approximately 603,500 square kilometers).

The current landscape of renewable energy in Egypt is distributed as follows: 80% thermal, 12% wind, 6% hydro, and 2% solar. [25] Although solar energy comprises a small share of Egypt's total production and consumption, Egypt is one of the world's richest countries in solar PV power potential as it is located in the world solar belt region (see Figure 8). In particular, it has considerable global horizontal irradiance at 2,450 (kWh/m2/year) and direct normal radiation at 2,800 kWh/m2/year.[26] It also enjoys high solar intensity with an annual direct normal intensity of 1,970-3,200 kWh/m2 and a total radiation intensity varying between 2,000 and 3 200 kWh/m2 /year.[27] All these natural factors contribute towards making Egypt an ideal destination for PV investment. [28] In addition to that, the vast land available within the country that could be used for solar yields, make PV investments an attractive option compared to other sources of energy.

Figure 7: Egypt's PV Power Potential

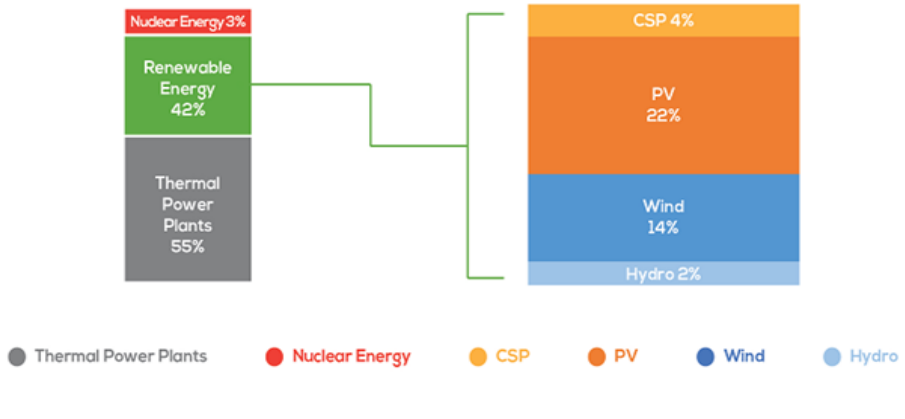


Source: Global Solar Atlas

5.2.1 CURRENT STATE OF EGYPT'S SOLAR INDUSTRY AND GOVERNMENT POLICIES

The Egyptian government has set ambitious goals to promote domestic solar energy production and transition towards renewable energy. As seen in Figure 8, by 2035, the government plans to achieve 42% renewable energy in the overall energy mix with 22% sourced from solar power. To meet this objective, an estimated 31 GW of solar energy capacity is still required.

Figure 8: Electricity Production Goal by 2035



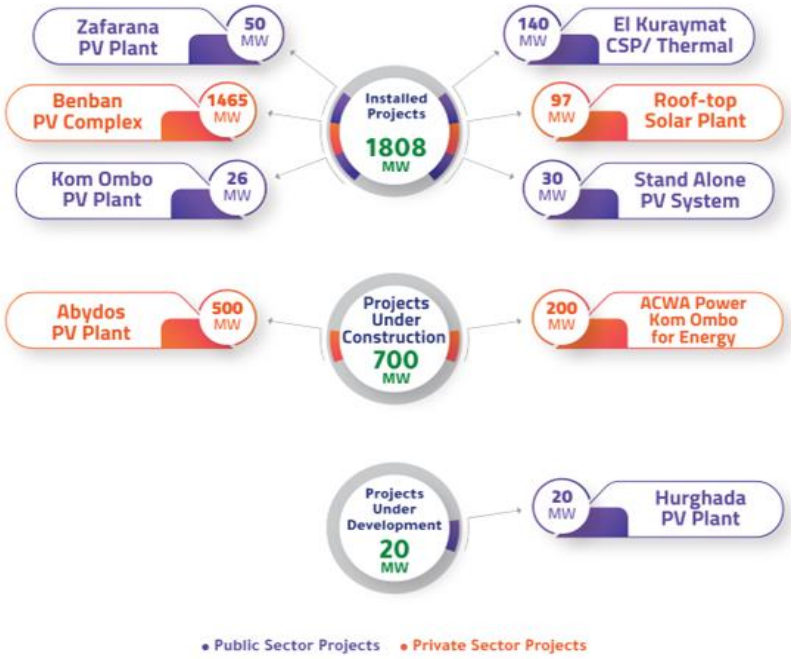
Source: Ministry of Electricity and Renewable Energy

[25] BP (2022), "BP Statistical Review of World Energy (71st editoin)", BP
[26] Davies, M., Elmatbouly, S., El-Mazghouny, D., Schellekens, G., & Ahmad, S. (2015). Developing Renewable Energy Projects – A Guide to Achieving Success in the Middle East: Egypt, Eversheds, PwC.
[27] IRENA (2018). "Renewable Energy Outlook: Egypt", International Renewable Energy Agency, Abu Dhabi, 120.
[28] World Bank (2023), "Egypt- Solar Irradiation and PV Power Potential Map, https://datacatalog.worldbank.org/search/dataset/0041086

Additionally, to achieve the 42% target, the government has adopted a top-down approach, implementing a series of policies and reforms and providing special investment incentives. For example, Egypt's Investment Law, published in 2017[29] and further amended in 2023[30], refers to a 30% deduction of net taxable profits for the first seven years of the renewable energy project (subject to specific conditions) and a substantial tax reduction for projects funded by foreign currency. Additionally, it provides a reduced (2%) unified customs duty rate on all imported equipment and machinery required for the project. The government has also agreed to provide land that is free of charge if the project's activities are considered of strategic interest or in other cases provide exemptions or reductions on land use fees for up to ten years. Finally, the establishment of a "golden license" which allows investors to bypass multiple governmental approvals, is yet another incentive provided by the Government of Egypt to enhance the overall attractiveness and feasibility of renewable energy investments in Egypt.

So far, solar energy in Egypt is one of the most successful projects nowadays given the rapid technological advancement in solar energy projects in the country. By the end of 2022 and as seen in Figure 9, Egypt already had 6 installed projects (with a total of 1808 MW), 2 projects under construction (799 MW) and 1 project under development (20 MW). The majority was contributed by the Benban solar project, with the commissioning of its initial photovoltaic plant which is acknowledged as one of the largest PV sites worldwide.[31]

Figure 9: Egypt Solar Energy Projects in 2022



Source: Ministry of Electricity and Renewable Energy

[29] GAFI, Egypt (2017). Law No. 72 of 2017. Available from: https://www.gafi.gov.eg/english/startabusiness/laws-and-regulations/publishingimages/pages/businesslaws/investment%20law%20english%20ban.pdf
[30] GAFI, Egypt (2023). 2023 INLAND. Available from: https://www.gafi.gov.eg/English/StartaBusiness/InvestmentZones/Pages/Inland.aspx and from: https://riad-riad.com/egypt-amendment-to-the-investment-law/
[31] Alternative Policy Solutions, "Renewable Energy Policies in Egypt: An Overview and Analysis", https://aps.aucegypt.edu/en/articles/807/renewable-energy-policies-in-egypt-an-overview-and-analysis

5.2.2 CURRENT STATE AND GAPS IN THE UPSTREAM STAGE OF THE PV VALUE CHAIN

Egypt is endowed with abundant silica ores, including extensive high-quality quartz deposits in the Eastern Desert along the Red Sea coast, as well as significant white sand reserves in Sinai, the northern part of the Eastern Desert, and the Western Desert, which provide ideal silicon raw material for the production of PV modules.[32] Despite the abundance of silicon resources, local investments in mining silica are limited and predominantly managed by small and medium-sized private companies. Additionally, there is a significant shortfall in silicon processing and refining capacity in the country. Only 30% of mined silica sand is used domestically, while the remaining 70% is exported without undergoing any refinement or processing[33]. However, Egypt has a very robust local glass industry, which Egypt can take advantage of and use for establishing a localized silicon manufacturing line. For instance, the three international float glass companies—Saint Gobain, Sphinx, and Guardian—possess production facilities that can manufacture high-purity silica sand suitable for PV module production.

Additionally, the actions for scaling up local mining of silicon only started in recent years. The most successful examples have been those where the government collaborated with foreign consultancy and formed joint ventures. For instance, the Ministry of Military Production's collaborated with PSE German Alliance in 2017 to conduct a feasibility study on a USD 2 billion project which involves the construction of a solar power plant and a factory with annual capacity of 1 GW to make solar panels by using local silica sand. The government received a number of proposals from international actors which are still under review. Also, the same Ministry signed an MoU with China's GCL Group in 2018, making the company fully responsible for using sand from local mines throughout its operations. Additionally, in 2019, the Egyptian government launched plans to build a specialized free zone in the southwest of New Aswan City, in which PV cells will be produced using local silica sand. The most recent initiative however is the government's plan to construct the silicon factory in New Alamein (see below).

Case Study: Egypt's New Silicon Factory in New Alamein

In 2023, to maximize the value added from natural resources and reduce dependence on imported high-value products, the Egyptian government initiated the construction of a silicon factory in New Alamein under a public and private partnership. During the first phase, an annual production capacity of 45,000 silicon tons will be produced while during the third phase an initial production capacity of 10,000 polysilicon tons of polysilicon will be achieved. This project, which is expected to significantly boost the country's revenue marks one of the initial steps toward localizing Egypt's PV production chain and opening significant opportunities for foreign companies, including Chinese to get involved.

[32] Ezz-El Din, M et al., "Mineral Industry in Egypt-Part II Non-Metallic Commodities-Silica Ores", Journal of Mining World Express (MWE) 5, (2016):9-27.

[33] AmCham (2022): Built on a grain of sand. Available from: https://www.amcham.org.eg/publications/business-monthly/issues/313/January-2022/4130/built-on-a-grain-of-sand

5.2.3 CURRENT STATE AND GAPS IN THE MIDSTREAM STAGE OF THE PV VALUE CHAIN

As per the midstream stage, Egypt still relies on the import of solar cells. In 2020, Egypt imported USD 62 million in solar cells, with 93% of these imports coming from China.[34] Research reveals that, apart from the new installation of a 60MW PV module manufacturing line in Cairo, by Mondragon Assembly[35], there hasn't been another integrated facility for manufacturing solar cells as local manufacturing mostly focuses on system integration due to mainly the lack of technical expertise.[36] Egypt has approximately 256 companies operating in the field of solar cells systems, primarily engaged in their design, operation, and maintenance.[37]

Another important element within the midstream stage of the PV value chain is the production of ancillary equipment, of which Egypt has not yet fully unleashed its potential. So far, the costs of the balance of system (BoS), which include wiring, switches, mounting structures, solar inverters, battery bank, and charger, represent the major cost component of solar projects in Egypt. It is estimated that only 30% of the cost of PV production is actually attributed to the PV modules (and 10% to inverters), while the remaining 60% of the cost is tied to the balance of system (i.e., cables, mounting structures etc.).

This emphasizes the importance of localising the PV value chain as a way to reduce the significant costs and promote efficiencies.[38] Estimates indicated that the complete transfer of the solar cell industry to Egypt can lead to a 9.6% cost reduction in the solar cell industry and a 3.8% cost reduction in the module industry.[39] In addition to costs. the heavy reliance on imports leaves the PV industry vulnerable to significant price disruptions, particularly during and after events like the COVID-19 pandemic. To fill this gap, Egypt, which is considered an industrial leader in the Middle East and African markets, must leverage its mature steel, glass and cable industries as well as its skilled workforce to produce solar components locally.

5.2.4 CURRENT STATE AND GAPS IN THE DOWNSTREAM STAGE OF THE PV VALUE CHAIN

In 2024, Egypt has made a revolutionary step forward in facilitating the distribution and installation of solar panels. The Egyptian Ministry of Electricity and Renewable Energy has unveiled the "Egypt Solar Energy Platform," a pioneering initiative to track, manage and provide guidance on solar energy installations for both individuals and businesses. Currently, a total of 122 installation companies are registered on the platform, overseeing 1,835 implemented solar power plants. The platform categorizes these companies into platinum, gold, silver, and bronze tiers based on their installation capacity.[40] This initiative aims to make it easier for individuals and businesses to access reliable information and resources for adopting solar energy solutions. The platform's prospects include expanding its reach by encouraging more companies to register and providing

[34] General Authority for Investment and Free Zones, "Preliminary Feasibility Study on the Solar Cells Industry", https://www.investinegypt.gov.eg/docs/Solar%20Cells%20Industry%20-%20Ismaillia.pdf
[35] https://www.enfsolar.com/news/15403/mondragon-assembly-installs-60mw-pv-production-line-in-egypt
[36] Solar systems integration involves developing technologies and tools that allow solar energy onto the electricity grid, while maintaining grid reliability, security and efficiency.
[37] GAFI, Preliminary Feasibility Study on the Solar Cells Industry, https://www.investinegypt.gov.eg/docs/Solar%20Cells%20Industry%20-%20Ismaillia.pdf
[38] IRENA, Renewable Energy Outllook Egypt, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_Outlook_Egypt_2018_En.pdf
[39] Osama Tobail, "Potential of Photovoltaic Industry in Egypt", Journal of Energy and Power Engineering 7, (2013):1844-185.
[40] Egypt PV Hub Platform, https://pv-hub.org/?page_id=8731&lang=en

more mature and comprehensive guidance on solar panel installation, and also consider expanding its scope to other stages of the PV value chain.

5.2.5 CHALLENGES AND WAY FORWARD

Despite the Egyptian government's efforts to establish favourable policy conditions for the PV industry and the country's substantial high-quality solar energy potential, the sector continues to face challenges. One of the primary obstacles to localizing the industry is the lack of expertise in the design and manufacturing of PV cells and modules. However, Egypt's well-developed automotive and glass industry offers great opportunities for potential synergies with the concentrated solar power (CSP) industry as a way to start the localisation of the PV value chain.

Moreover, accessibility to project financing is also a major obstacle while the fluctuating economic conditions and currency instability in Egypt, deter potential investors who are concerned about the financial viability and return on investment of solar projects. This highlights the need for more robust financial incentives and risk mitigation mechanisms to encourage both domestic and foreign investors. Finally, another challenge that Egypt is facing is the long existence of electricity subsidies, which keep electricity prices artificially low. This policy, while beneficial for consumers in the short term, poses a challenge for the PV industry as low electricity prices reduce the financial attractiveness of investing in alternative energy sources like solar power. To localize and grow the PV industry, Egyptian electricity regulators need to address the barriers created by the existing subsidy structure. For example, they can gradually reduce subsidies while implementing measures to protect and support the most vulnerable consumers. Moreover, on the demand side, the Egyptian government must implement more mechanisms and instruments to stimulate demand for solar energy for example by providing incentives and subsidies for PV installation and prioritising energy security over price, especially in light of recent shifts in global energy dynamics.

Table 7: Key Activities Required to Further Develop Egypt's PV Value Chain

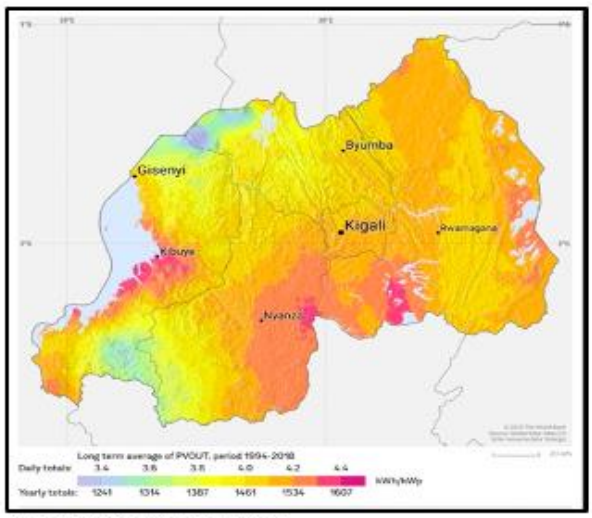
Focus Area of the PV Value Chain	Recommended Activities
Upstream	• Leverage local companies and foreign business operating in the glass and automobile industries and provide them with incentives that will help them to get involved in the processing and refining of silica raw materials. • Continue to mandate the use of locally sourced silicon sand to other companies operating in the country as a way to encourage such practices and increase the chance of spillover effects. • Facilitate investment in the research and development of silica purification and processing through cooperation with leading silicon processing companies to ensure an environmental-friendly and cost-effective silicon mining industry. • Continue to attract investors for the establishment of more silicon factories similar to the one in New Alamein

Focus Area of the PV Value Chain	Recommended Activities
Midstream	• Incentivise local companies already involved in the production of steel, glass and cables to further expand their production lines towards PV specific ancillary equipment such as cablings, inverters, heat exchangers, pumps, storage tanks, and condensers. • Form joint ventures with Chinese companies for technology transfer and knowledge sharing in manufacturing PV cells and module assembly. • Develop and expand the existing SEZs such as the Suez Canal Economic Zone and the newly developed New Alamain City with dedicated facilities and infrastructure for PV manufacturing, providing incentives and streamlining regulatory processes.
Downstream	• Collaborate with Chinese companies with expertise to provide more mature and comprehensive guidance and best practice on solar panel installation • In collaboration with Chinese companies, develop and support training programs for solar installers, technicians, and maintenance personnel to ensure that there will be a skilled workforce capable of supporting the growing demands for PV installation. • Provide subsidies or tax incentives for the installation of solar PV systems for residential, commercial, and industrial users.

5.3 Rwanda (3rd Ranked Country)

Rwanda, which is strategically located in East-Central Africa and borders with Uganda to the north, Tanzania to the east, Burundi to the south, and the Democratic Republic of Congo (DRC) to the west, covers an area of 26,338 square kilometres which can be compared to China's Hainan Island (approximately 33,920 square kilometres) and the country of Albania in Europe (approximately 28,748 square kilometres). Based on the most recent available data from IRENA, in 2021, 58% of Rwanda's electricity generation was based on renewable energy resources and 4% of Rwanda's total electricity was generated from solar PVs.[41] Therefore, despite the small share of solar energy as a proportion of Rwanda's total energy mix, the fact that 58% of the country's electricity generation is sourced from renewable energy resources (mostly hydropower energy) proves the country's commitment in bolstering a clean energy mix and investments into its local energy market. More specifically, in relation to solar energy, Rwanda is located near the Equator and is endowed with a solar radiation intensity of 5 kWh per m^2 per day and has approximately five

Figure 10: Rwanda's PV Power Potential



Source: Global Solar Atlas

[41] IRENA, (2022). "*Rwanda Energy Profile*". Available here.

peak sun hours per day (see Figure 11). Despite its modest solar potential, Rwanda has the highest score in the entire African continent in terms of its enabling environment for investments into renewable energy resources based on RISE.[42] The only countries that rank higher than Rwanda globally are the United Kingdom, Denmark and Germany which are among the global pioneers in renewable energy solutions.

Moreover, due to its location, Rwanda can also strategically position itself as a pivotal hub for solar manufacturing in Africa. Situated at the crossroads of East Africa and neighbouring the resource-rich Democratic Republic of Congo (DRC), Rwanda can have abundant access to key raw materials that are essential for the production of PV panels, ensuring thus a sustainable supply chain and enhancing operational efficiencies for PV manufacturers looking to capitalise on regional resources. In addition, Rwanda can also serve as an ideal gateway to burgeoning markets in East Africa, encompassing over 190 million consumers across countries like Kenya, Uganda, Tanzania, and Burundi.[43] Its strategic proximity to the DRC can also further support Rwanda in tapping into the vast potential of the Central African market too and its infrastructure development needs.

With this in mind and considering Rwanda's resource and market access potential but also its stable political climate, robust governance, and investor-friendly policies, Rwanda can be a low-risk destination for Chinese investors seeking reliable operational environments in the African PV manufacturing industry as well as local market opportunities and regional growth prospects.

5.3.1 CURRENT STATE OF RWANDA'S SOLAR INDUSTRY AND GOVERNMENT POLICIES

As at the end of 2022, Rwanda had 25 MW of installed solar capacity although no new investments were made since 2019.[44] There are currently two major solar farms in operation in the country. The first, is a solar installation located in Rwinkwavu with an installed generating capacity of 10 MW which was completed in 2017.[45] The second solar installation is located in the Asyv region and can generate 8.5 MW per annum - enough to power 16,000 households on an annual basis.[46] In 2022, the Government of Rwanda announced its target to achieve universal electricity access by 2024 as part of its ambition to become a middle-income country in the coming years. The government aims to achieve this, *inter alia*, by connecting 70% of households to the grid and 30% to off-grid solar PV systems.[47] Rwanda is actively seeking to involve the private sector to accelerate its progress towards achieving its off grid- electricity access. To attract foreign investments in its energy sector, Rwanda has implemented several investor friendly policies that include tax exemption of VAT on importation of equipment, investment allowance up to 50%, free repatriation of profits, 100% written-off development and research costs, preferential corporate income tax of 15% and corporate income tax holiday of up to seven years for energy projects.[48] The main challenge that hinder Rwanda's progress towards green energy electrification and PV manufacturing are the high initial setup costs and the limited capacity and knowledge-how in the country. Notwithstanding that, Rwanda has already developed policies to encourage local manufacturing and attract FDI investments in solar products and LED light -assembly. The

[42] RISE (2023): Rwanda country profile. Available from: https://rise.esmap.org/country/rwanda
[43] According to countries' latest census
[44] PV magazine, (2024). "*Renewable energy adoption taking off in Rwanda*". Available here.
[45] Gesto, (2024). "Rwanda 10 MW Solar PV Development". Available here.
[46] Scatec, (2024). "Asyv, Rwanda, 8.5 MV". Available here.
[47] Commonwealth scholarships, (2022). "*The green way to power up Rwanda*". Available here.
[48] Rwanda Development Board, (2024). "*Incentives to private developers in the power sector*". Available here.

question becomes how Chinese stakeholders can assist Rwanda develop its PV value chain and harness the strong regulatory environment that exists in the country in relation to energy resources?

5.3.2 CURRENT STATE AND GAPS IN THE UPSTREAM STAGE OF THE PV VALUE CHAIN

Rwanda possesses a variety of materials such as good quality silicon sand that is the main raw material used in the manufacturing of PV panels. However, despite Rwanda's vision is to become a local mining hub in the East Africa region, the Rwandan government identifies the absence of mining equipment and services as the main gap and limiting factor to the development of the local manufacturing sector.[49] The manufacturing of specialised mining equipment in the domestic market will require several years to complete however, given China's extensive experience and involvement in this field, Chinese investors can facilitate the importation of expertise and mining equipment to the country as a way to support Rwanda localise its operations in the upstream stage of the PV value chain. In any case, the mining of silica sand can be obtained via open pit or quarry mines using standard mining equipment. As the process usually begins with sand mining, it's relatively easy and cost-effective to extract silica from the soil.[50] That means that Rwanda can rump-up its silica mining capabilities rapidly with the provision of mining equipment and mining know-how- from Chinese stakeholders.

5.3.3 CURRENT STATE AND GAPS IN THE MIDSTREAM 3RD STAGE OF THE PV VALUE CHAIN

According to research, there is currently no activity taking place in Rwanda at the Midstream stage of the PV value chain, implying a lack of PV cell manufacturing and PV module assembly activities in the country. However, Rwanda currently has large scale Special Economic Zones (SEZs) in Kigali[51], which can act as a promising platform to develop and localise PV manufacturing operations within the country. The well-established and fully operational SEZ in Kigali[52] can provide favourable conditions and incentives to Chinese companies seeking to relocating their PV manufacturing operations to Rwanda. These incentives can span from tax exemptions, to streamlined regulatory processes, and "golden visas" to reduce bureaucracy and ease the operations of investors.

5.3.4 CURRENT STATE AND GAPS IN THE DOWNSTREAM STAGE OF THE PV VALUE CHAIN

When it comes to the Downstream stage of the PV value chain, namely the distribution and installation of the solar PV panels, there are currently around 18 companies based in Rwanda undertaking solar panel installation, including rooftop and standalone solar systems, of which 17 provide smaller installations while only 1 (the Afritech Energy[53]) focuses on installations of more than 1 MWp. Additionally, from the 18 companies in total, 14 also have battery storage

[49] Rwanda Mines, Petroleum and Gas Board. "*Mining Investment Opportunities*". Available here
[50] Mosimtec. "*The Lifecycle of Silica Mining Towards Electronics*". Available here.
[51] RBD (2023): Rwanda Special Economic Zones. Available from: https://rdb.rw/wp-content/uploads/2020/09/SEZAR-Catalogue.pdf
[52] Rwanda Development Board, (2024). "*Special Economic Zone and Exports*". Available here.
[53] Afritech Energy. http://www.afritechenergy.com/

capabilities[54]. Regarding the other equipment that are used in the PV value chain (i.e., cables, inverters, batteries and more), there are only a few country-based companies involved in their production such as Sai Office[55] and Great Lakes Energy[56]. This gap underscores not only the need for the establishment of more country-based companies in this sector but also the opportunity for those Chinese manufactures who are seeking to relocate their operations from China to countries like Rwanda.

5.3.5 CHALLENGES AND WAY FORWARD

Rwanda is lagging vis-a-vis South Africa and Egypt with regards to the condition of its local PV value chain. As we explained above, Rwanda does not currently mine silicon and the installed PV capacity in the country is limited. This comes us a result of several factors such as the: (i) condition of the mining sector in the country and the lack of the necessary equipment to sustain the local mining sector; (ii) shortage of technological expertise in PV manufacturing processes and technologies, which hamper growth and innovation; and (iii) reduced interest in solar technologies given the importance of hydropower as a form of renewable energy resource in the country. Further, financing constraints also pose a significant barrier, as establishing PV manufacturing facilities requires substantial upfront investment in infrastructure, equipment, and research and development while borrowing costs are high in the Global South. Nonetheless, the attractive regulatory environment currently in place in Rwanda indicates that the Government is keen to attract investors that will help the country develop its PV industry and this should be taken into account by Chinese PV manufacturers – particularly by those that are being squeezed on profits due to the oversupply in China.

Focus Area of the PV Value Chain	Recommended Activities
Upstream	• Provide financial incentives to attract investors operating in the mining industry and enable the importation of mining equipment needed for the extraction of the raw materials. • Form strategic partnerships with Chinese companies already producing silicon to ensure a steady and cost-effective supply of the raw materials.
Midstream	• Make Rwanda's SEZ in Kigali a PV manufacturing hub. Attract investment from Chinese PV manufacturers to set up local PV manufacturing and PV assembly plants within the SEZs by provide strong incentives (e.g., significant tax reduction or exemptions on income, import duties, streamlined process etc.). • Implement fast-track permitting and licensing procedures specifically tailored for PV manufacturing companies of the SEZ – "golden visas". • Provide support for technology transfer and training programs, enabling local manufacturers to upgrade their skills and capabilities with expertise from Chinese partners.

[54] ENF Solar. "Company Directory". https://www.enfsolar.com/directory/installer/Rwanda
[55] Sai Office. https://www.sai-office.com/rwanda/products_services/solar/
[56] Great Lake Energy. Our Story. https://gle.solar/our-story/

Focus Area of the PV Value Chain	Recommended Activities
Downstream	• Incentivise local manufacturing companies to expand their production lines towards PV specific ancillary equipment such as inverters, heat exchangers, pumps, storage tanks, and condensers. • Further increase the production of such ancillary equipment by attracting foreign Chinese investors. Facilitate partnerships or offer incentives for joint ventures. • Enhance market access and awareness to increase demand. Conduct nationwide campaigns to raise the awareness of Rwanda's citizens about the benefits of solar energy and PV systems among households and businesses. This will drive demand and adoption and therefore will enhance PV deployment. • Provide subsidies or tax incentives for the installation of solar PV systems for residential, commercial, and industrial users as a way to increase demand.

6 BENEFITS FOR BOTH CHINA AND AFRICA

China's investment in Africa's PV industry holds substantial promise for both parties as it offers a pathway for economic growth, sustainable development, and enhanced bilateral relations between the two.

With regards to the benefits for Chinese stakeholders and as aforementioned, in the last few years Chinese companies operating in the solar manufacturing industry have rapidly expanded their production capacities to meet growing global demand for solar panels. However, this increase has sometimes led to production exceeding global market demand, resulting therefore in an oversupply of solar panels. This oversupply has put pressure on profit margins for Chinese manufacturers, making it thus difficult for them to maintain profitability.[57] In light of this situation, Africa presents a great opportunity for Chinese stakeholders to invest and focus on and this is based on a plethora of reasons. Firstly, Africa is a vast and relatively untapped market for solar energy and thus investing in Africa's PV industry allows Chinese companies to take the first mover advantage, expand their market reach, and drive their sales and growth. Moreover, investing in overseas markets like Africa helps Chinese companies diversify their investments, reducing therefore their reliance on domestic and other international markets which could be saturated or could face regulatory changes. Most importantly however, by investing in Africa's solar PV industry, Chinese counterparts can help drive Africa's renewable energy transition and accelerate its green energy future – all in line with the Chinese government's "going out strategy" and South-South cooperation ambitions.

On the other hand, working alongside Chinese companies to further develop and localize the PV value chain can help African countries deal with the significant energy shortages that many countries are still facing. Investments in the solar PV industry can help provide reliable and sustainable electricity, fostering thus economic development and improving the quality of life of hundreds of citizens living in the African continent. Additionally, several studies have shown that Africa is one of the most vulnerable continents in the world to the impacts of climate change

[57] Tan Huileng. 2024. "China flooded the market with so many solar panels that people are using them as garden fencing." *Business Insider*. https://www.businessinsider.com/china-flood-solar-panel-cell-market-garden-fence-overcapacity-yellen-2024-4

despite its low contribution to greenhouse gas emissions.[58] However, supporting African countries utilise and develop further their renewable energy sources such as solar power can help countries reduce the overall global emissions and their dependence to fossil fuels and therefore mitigate the effects of climate change. What is more, drawing from China's own experience[59], the development of the PV industry can create numerous jobs in the whole continent in a variety of areas such as manufacturing, installation, maintenance and other sectors boosting therefore local economies and leading to long term economic growth. Within the same context, often Chinese investments come with the development of other, supporting infrastructure such as roads, power grids and more which can have broader economic benefits beyond the PV industry. Finally, conducting partnerships and joint ventures with Chinese companies can also lead to technology and know-how transfers as well as capacity building. Chinese counterparts can bring their advanced PV technology and expertise to local companies and local workers developing therefore their skills and knowledge in cutting-edge solar technologies. This can ultimately foster innovation and promote the growth of not only the PV industry but of the economy as a whole.

From the above, it becomes clear that working together to further develop Africa's PV value chain and overall PV industry can have tangible benefits for both African and Chinese stakeholders. Section 7 below provides detailed and robust recommendations for both Chinese and African stakeholders on the most effective steps moving forward.

7 RECOMMENDATIONS

The following recommendations have been drafted based on research as well as on consultations with key Chinese stakeholders operating in the PV industry. These insights provide a comprehensive understanding of the factors necessary to catalyse investment in Africa's PV manufacturing sector, ensuring sustainable growth and mutual benefits for both African economies and Chinese investors.

7.1 For African Stakeholders

To utilise their vast potential in the solar energy sector and boost their solar capacity, governments of Africa should explore a variety of measures to provide the clear "signal" to investors, covering many areas such as regulatory, financial and even infrastructure. More specifically:

1. Develop a Favourable Enabling Environment: To boost and further promote the solar industry, governments should first establish clear objective and goals in their national plans. Without such compressive documents, governments may find it challenging to communicate to both internal and external stakeholders the nation's overall ambitions. It is therefore vital for governments to create and implement detailed national renewable energy strategies that specify targets, timelines, and regulatory frameworks to support solar energy projects. These strategies should be aligned with broader energy and economic goals to ensure cohesive development. To implement this measure, African officials can have consultations with Chinese government stakeholders as China has extensive experience in developing and executing similar national plans. In addition to that and in order for African governments to demonstrate their own commitment to solar energy, they should also take steps and initiative public projects such as the Noor

[58] African Development Bank. "Climate Change in Africa." https://www.afdb.org/en/cop25/climate-change-africa
[59] Gao L, Tianchang C, Xin S, Yasir AS (2023): Examining and prioritizing the effect of sustainable energy on the job market to advance China's green workforce, Heliyon, Volume 9, Issue 12,https://www.sciencedirect.com/science/article/pii/S2405844023099188

Ouarzazate Solar Complex in Morocco[60], one of the world's largest concentrated solar power plants.

2. Establish Incentives for Investors: To attract investors, African governments should seriously consider establishing a combination of financial incentives that will aim to last for at least 10 years. A few examples could be the following:

    a) Introduce continuous feed-in tariff schemes to guarantee a fixed payment rate for the electricity that solar energy investors will produce. This will guarantee them a fixed income and will ultimately make investments more attractive. Kenya's feed-in tariff policy could be taken as an example as it has already encouraged private sector investment in renewable energy projects;[61]

    b) Provide several tax incentives for both local and international investors in the solar industry. For example, (i) provide tax exceptions to solar energy investors for 5-10 years allowing them to reinvest their profits into expanding operations, (ii) reduce corporate tax rates specifically for solar PV companies, (iii) implement low or zero tariffs on the import of raw materials, components and other equipment needed for solar PV manufacturing which can make it more cost-effective for companies to source materials locally rather than importing finished products;

    c) Provide subsidies to reduce the capital expenditure for setting up solar PV plants or offer grants and low-interest loans for the development of solar PV projects to reduce the financial burden on local and international investors;

    d) Implement fast-track approval processes for solar PV projects, reducing bureaucracy and making it easier and quicker for Chinese investors to start projects;

    e) Offer long-term energy purchase agreements (EPAs) at attractive rates, guaranteeing a market for the electricity produced by solar PV projects;

    f) Encourage attractive Public and Private Partnerships where the government shares most of risk and cost of large-scale solar PV projects with Chinese investors to provide additional security and financial support; and

    g) Provide land at reduced rates or even free of charge for solar PV installations as a way to significantly lower the cost of establishing solar farms.

3. Develop a Strong Local Supply Chain: For Chinese investors to transfer their PV industries to Africa, it is important to first strengthen countries' local supply chain as a way to reduce the complexities and costs associated with importing everything that is required from abroad. For that reason, governments should leverage existing local manufacturing sites and provide local companies with incentives to further expand their operations towards the PV industry. In addition, given that many African countries already have numerous industrial zones, governments should aim to leverage these and convert some of them into PV manufacturing hubs where various components of

[60] ESFC Investment Group. "Noor Ouarzazate: the world's largest concentrated solar power plan built in Morocco." https://esfccompany.com/en/articles/solar-energy/noor-ouarzazate-the-world-s-largest-concentrated-solar-power-plant-csp-built-in-morocco/

[61] The Government of Kenya. Ministry of Energy. "Feed-in-tariffs policy on Renewable Energy Resource Generated Electricity." https://communications.bowmanslaw.com/REACTION/emsdocuments/fitPolicy.pdf

the solar PV value chain can coexist. These zones can house Chinese and local manufacturers of PV modules, inverters, batteries, and other related products, fostering collaboration and reducing logistics costs. All of the aforementioned initiatives however should be guided by a national regulation that would require all foreign investors to employ local stuff in the manufacturing industries as a way to generate jobs in the local communities and hence support in the growth of the economy.

4. Create a Skilled Labour Force: One of the difficulties in developing the PV industry in African countries further is the lack of a skilled labour force. African governments should partner with Chinese PV companies to establish training and knowledge sharing centres specifically focused on solar PV technology and related fields. In addition, they should establish formal partnerships with academic institutions and with the Chinese government to create a framework for exchange programs where the African workforce can get hands-on experience at Chinese PV manufacturing sites.

5. Invest in Infrastructure: Developing robust infrastructure that supports manufacturing, logistics, and operational efficiency is another key enabler for Chinese PV investors looking to transfer their PV manufacturing operations to Africa. Governments of Africa should attract local and foreign investors and seek their support in the development of the country's infrastructure in order to make their countries an attractive option for solar PV investments. Improving the port, road and rail network, upgrading the national grid, creating electricity storage systems to store energy produced from PV and establishing SEZs dedicated to PV manufacturing are only a few examples that could help not only with creating a conducive environment for the transfer of PV manufacturing's operations from China but also with building a sustainable and self-sufficient solar PV industry in Africa as a whole.

7.2 For Chinese Stakeholders (Chinese PV Investors, Chinese Banks, Chinese Government)

1. Active Engagement with African Governments: Chinese PV investors should engage directly with local and national government officials to understand in more depth the regulatory and policy environment, the market potential as well as the incentives offered for solar energy projects – particularly with top 10 countries that have been ranked in Section 3 as the most attractive destinations for Chinese investments. Where this is required, Chinese private actors should work closely and advise the government on alternative incentives that will help them take the decision to investment.

2. Close Engagement with the Local Community and Establish Local Partnerships: Chinese investors should identify local companies operating in the PV manufacturing industry or in relevant sectors such as the production of glass, cables etc. and aim to establish joint ventures or partnerships with them. Chinese investors should ensure environmental, social and governance (ESG) requirements, as well as the benefits and participation of local communities, when developing their business strategies and doing business in the country. Utilising the local supply chain will help reduce dependency on imports, thereby lowering costs and ensuring quicker, more efficient and less costly logistics and distribution. Most importantly however, it will support the development of local industries in African countries, helping thus to avoid establishing dependencies. This is also a key goal of China's south-south cooperation ambitions.

3. Project Financing: Chinese banks have a pivotal opportunity to propel the growth of the solar manufacturing industry by adopting innovative project financing strategies that capitalize on both financial returns and sustainability. One upfront action is China could offer development finance as part of the financing package, to incentivize Chinese companies to invest in and relocate to Africa, thereby supporting the development of the continent's manufacturing capacity. Another promising approach is the implementation of green bonds as per the example of Evolt in Mauritius[62] which are specifically created to fund environmentally friendly projects. By issuing green bonds dedicated to the solar industry, Chinese banks can attract a broad spectrum of investors who are keen on sustainable investments. Banks could also consider the establishment of solar investment funds that pool resources from multiple investors to fund large-scale solar projects, spreading risk and increasing the potential for substantial returns. The Sustainable Energy Fund for Africa could be seen as an example in this case – although the funders are national governments.[63] Chinese banks could also seek to establish PPPs in which they will collaborate with government entities to finance large solar projects, benefiting from government guarantees or subsidies that will reduce their financial risks.

[62] FSD Africa. (2023). "Envolt launches pioneering MUR 2.0 billion green bond programme for major solar energy projects in Mauritius, supported by MCB Capital Markets and FSD Africa."https://fsdafrica.org/press-release/envolt-launches-pioneering-mur-2-0-billion-green-bond-programme-for-major-solar-energy-projects-in-mauritius-supported-by-mcb-capital-markets-and-fsd-africa/
[63] Sustainable Energy for All. "Sustainable Energy Fund for Africa." https://www.se4all-africa.org/seforall-in-africa/financing-opportunities/sustainable-energy-fund-for-africa/

About Development Reimagined

Development Reimagined (DR) is a pioneering, African-led, women-led, Africa-first and award-winning international development consultancy, with headquarters in Beijing and offices in the UK and Kenya. DR was created in response to the complexities of global poverty and sustainable development – which requires new ideas, and new solutions. DR - and the clients we work with - invest in thoughtful insights backed by cutting-edge analytics and deep relationships.

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