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Unlocking the Solar Photovoltaic Value Chain Potential for Enhanced Job Creation in Kenya

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Unlocking the Solar Photovoltaic Value Chain Potential for Enhanced Job Creation in Kenya

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Kenya Institute for Public Policy Research and Analysis

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Abstract

Solar photovoltaic (PV) technologies are emerging as an important factor input in promoting inclusive and sustainable economic development. Particularly, the high job intensity nature of the solar PV industry makes it more feasible for low carbon technologies with a high potential for job creation. This study explores the employment potential of solar PV in Kenya by examining the current growth patterns of the industry, the constraints to growth, the prevailing jobs in the industry, and the skills demand versus the skills supply in the industry in Kenya. The study adopts a mixed method of analysis using value chain analysis methodology, employment elasticity, and employment factor models to estimate the solar PV job creation potential in Kenya. The study identifies that Kenya solar PV is characterized by a short value chain with only two firms engaging in the manufacturing of solar PV systems, while the majority of the firms actively engage in the distribution, installation, operation, and maintenance phases of the value chain. Using employment factor, the study estimates a compounded annual job growth rate of 51 per cent between 2012 and 2018 and 26 per cent between 2018 and 2024, with the jobs increasing to an estimated 48,306 jobs in 2024, which are distributed along the value chain: operation & maintenance (40%) and construction and installation (40%); manufacturing (12%); distribution (5%) and R&D (3%). The skills availability ratio for the certificate and diploma education levels are below the ideal ratio of 10, demonstrating inadequacy of skills. High capital, installation, and maintenance costs; limited financial schemes for solar PV investments; constraining policy and regulatory directions; limited transmission and distribution network in solar energy-rich areas; the low presence of local manufactures; and skills unavailability and inadequacy are the key constraints limiting the industry's growth. The study recommends instituting of policies that promote knowledge and technology accumulation, new business incubation, and promoting industrial clusters that provide incentives that accelerate localization of the portions of the value chain. Further, the study proposes the provision of and sustainable financial incentives and subsidies to solar PV project developers. The study proposes an emphasis on vocational training as opposed to shifting to the universities as the key institutes supporting capacity building.

Abbreviations and Acronyms

EPIA	European Photovoltaic Industry Association
EPRA	Energy and Petroleum Regulatory Authority
FiT	Feed-in Tariff
FTE	Full-Time-Equivalent
GDP	Gross Domestic Product
IEA	International Energy Agency
ILO	International Labour Organization
IPCC	Inter-governmental Panel on Climate Change
IPP	Independent Power Producers
IRENA	International Renewable Energy Association
I-O	Input Output
KIHBS	Kenya Integrated Household and Budget Survey
KNBS	Kenya National Bureau of Statistics
KNOCS	Kenya National Occupational Classification Standard
KPHC	Kenya Population and Housing Census
KNES	Kenya National Electricity Strategy
LCOE	Levelized Cost of Electricity
O&M	Operation and Maintenance
PV	Photovoltaic
R& D	Research and Development
SSA	Sub-Saharan Africa
SHS	Solar Home Systems
SWOT	Strengths Weaknesses Opportunities and Threats
EU	European Union
VAT	Value Added Tax

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1. Introduction

Increasing concerns about global warming and climate change, energy security, and volatility of fossil fuel prices have perpetuated the need for low-carbon renewable technologies. Solar Photovoltaic (PV) is one such pioneering renewable technology (IRENA, 2019a). Solar PV is emerging as an intervention technology to promote improvement of energy self-sufficiency, reduction of greenhouse gas emissions and creation of employment opportunities in both developed and developing countries (Hondo and Moriizumi, 2017).

Consequently, it is an attractive alternative to governments for electricity infrastructure expansion and greening of the electric grid. This is evidenced by the increasing research and development, technological advancements and declining costs of solar PV systems (Choudhary and Srivastava, 2019; Kabir and Kim, 2018; Duan et al., 2013). According to the Intergovernmental Panel on Climate Change - IPCC) (2014), technological progress has enabled a significant reduction in the average price of solar silicon photovoltaic modules, thus substantially declining from US$ 65 per Watt in 1976 to US$ 1.4 per watt in 2010. Between 2010 and 2017, the price of PV modules on a global average dropped by a factor of 79 and over the same period, the efficiency increased from 15 per cent to 25 per cent (Battaglia et al., 2016) due to the technology advancement.

Given triple and inter-connected effects of improved technology, reduction in photovoltaic (PV) module cost, and policy initiatives, solar energy is expected to contribute substantially to the future global energy supply and job creation (Quansah et al., 2016). Currently, solar PV supports 3.5 million jobs globally, accounting for 38 per cent of the total employment by the renewable energy sectors (IRENA, 2019). With increasing developments in technology, and leveraging of low carbon technology transfer policies, increasing job creation and shifting job market of solar PV from advanced economies to developing economies and from low skilled towards skillful work can be anticipated. Extant literature has established that renewable energy technologies entail higher labour intensity relative to fossil energy technologies for similar energy output (Garrett-Peltier, 2017).

The European Photovoltaic Industry Association (EPIA) 2008 estimates that 10 million full-time equivalent (FTE) job opportunities could be generated by solar PV industry across the globe by 2030. The EPIA (2008) estimates 10 jobs per MWp (megawatt peak) at the manufacturing stage, 33 jobs per MWp related to solar PV installation, 3–4 jobs per MWp wholesaling and distribution stage and 1–2 jobs per MWp related to R&D. An analysis of the effects of 100 per cent transition to renewable energy sources including water, wind and solar power by Jacobson et al. (2014) identified 442,200 new construction jobs 190,600 new operation jobs and 413,000 jobs lost due to closure of fossil and nuclear-based industries in California, implying a net 220,000 jobs in 40-year solar PV projects. Similarly, Garrett-Peltier (2017) estimates a net increase of 5 jobs for a 1 million investment shift from fossil fuels and nuclear to renewable energy. Garrett-Peltier (2017) estimates 7.72 FTE jobs in renewables energy compared to 2.65 full-time equivalent (FTE) jobs in fossil fuels for every US$ 1 million investment. A study incorporating both the direct and indirect jobs by Pollin et al. (2009) identified that solar, coal, and oil and gas creates 9.8 jobs, 4.9 jobs, and 3.7 jobs per USD$ 1 million output, respectively.

Although there is a great deal of literature on job creation potential of the solar PV industry, the literature focuses on developed countries such as those in Europe, the USA and China that dominate the manufacturing stage of the solar PV value chain (Zhang et al., 2017). Largely, the extant literature focusses on the technical aspects with minimal focus on the social constructs of deployment of solar PV technology despite the imminent socio-economic benefits (George et al., 2019). In Kenya, extant literature mainly focuses on solar PV policy and development (George et al., 2019; Johannsen et al., 2020; Ondraczek, 2014) with less focus on the employment aspects, a gap that the current study seeks to address with only one study having undertaken a value chain analysis of job creation potential for the renewable energy technologies in Kenya (Shirley et al., 2019). In addition, Jadhav et al. (2017) identify a week foundation and short solar PV chains in economies in Sub-Saharan Africa resulting from failure to master the necessary solar PV technologies. The implication is the absence of a robust solar manufacturing base in the region, hence the high reliance on imports.

Given that solar PV and other renewable technologies are at an early stage of development, low skilled labour shortages are prevalent. Skills gap analysis of the solar PV industry in Kenya was conducted by EPRA (2018), analyzing the skills availability and identified skills unavailability along the solar value chain. The survey results identified that, on average, the skills are inadequate to sustain the optimal operation of the industry. The results imply that there is limited availability of professional solar PV business and technical service providers in the market. Research by the Council for the Development of Social Science Research in Africa - CODESRIA (Lututala, 2012) across five Sub-Saharan Africa countries identified that industry-specific technical skills, cognitive skills (especially critical thinking and numeracy and non-cognitive skills (especially leadership, communication, and decision making) gaps are persistent. In addition, ILO (2010) global report highlights that a majority of developing countries' governments have made limited progress in building skills and capacities to address issues related to climate change, with Technical Vocational Education and Training (TVETs) not adjusting their programmes to respond to the labour market needs of addressing environmental issues. Leveraging of renewable energy in developing countries such as Kenya is not only framed on the energy leapfrog opportunity towards a low emission development path, but also social-economic impacts such as employment effect. Particularly, solar PV exhibits higher backward integration to the economy and strong cross-sectoral linkages, hence providing opportunities for fostering economic growth and development.

Access to reliable electricity is pivotal for the economy in rekindling industrialization, modernizing agriculture and increasing job creation. This would foster economic growth and development. The urgent need to reduce the environmental footprint has yielded the push towards adopting green energy along the value chains. Cost-effective renewable energy, including solar energy, is emerging as an effective solution towards accelerating access to affordable, reliable, and sustainable energy sources. As Kenya grapples with a burgeoning youth population, rising youth unemployment (Omolo, 2018), and the need for inclusive, decent and sustainable jobs, renewable technologies present an opportunity of addressing the paramount unemployment challenge. The Powering Jobs Census by Power for All identified that youths constitute 40 per cent of the workforce in the renewable energy sector, with two-thirds engaged in sales and distribution. As the renewable energy market matures, the nature and scale of the inherent jobs will continue to evolve.

This paper aims to enhance an understanding of the solar PV industry in Kenya and its potential employment effect to guide policy decisions. The contribution of this paper is four-fold. First, we analyze the evolution of the solar PV industry in Kenya using a value chain methodology which enables identification of value activities where Kenya has a competitive advantage along the value chain. Secondly, we analyze the constraints to the growth of the industry, which enables us to make recommendations for areas of policy intervention. Third, we analyze the prevailing jobs in the industry, which enables modelling of the potential job growth. Lastly, we examine the skills requirements, skills demand, and skills supply in the industry, which enables an understanding of the skills level of labour that would enable maximizing the job creation potential of the industry. The study findings are expected to be of use to diverse stakeholders, including the regulators, private investors, training institutions, and development agencies promoting universal access to energy agenda in Kenya.

The rest of the paper is structured as follows. Section two provides a situational analysis of the solar PV industry. Literature review is discussed in section three while methodological framework adopted in the study is discussed in section four. Section five provides an analysis of the findings for the respective research objectives. Conclusions and policy recommendations are highlighted in section six.

2 Situational Analysis of Solar PV Industry

2.1 The Solar PV Policy Frameworks

A meta-theoretical analysis on energy transitions by Cherp et al. (2018) identified technological innovation, economic development, and policy changes as the prominent factors that shape contemporary energy transition. Similarly, Jacobbson and Lauber (2006) identified effective institutions and supporting policies as the fundamental factors that shape the energy transition process.

The Institute of Economic Affairs (IEA) estimates from the top five leading economies in installed solar PV energy highlight that solar PV plays a significant role in the respective economies grid. The statistics demonstrate large scale deployment of solar PV with the following installed capacity: China 176 GW (11% of the grid electricity installed capacity, Germany 45.5 GW (21%) Japan 45.5 GW (17%), Italy 20.1 GW (17%) and the United Kingdom 13 GW (14%)(IEA, 2018). The solar PV industry in the leading markets in Europe and Asia is characterized by several support schemes, including investment subsidies, R&D incentives, investment tax credits, low-interest loans, quotas with green certificates, Fits, net metering, reverse auctions, among others (Honrubia-Escribano et al., 2018; Kumar, 2015).

The Renewable Energy Law in Germany mandates the electric utilities to purchase all the renewable generated electricity in addition to offering government loans and large subsidies to renewable energy producers, resulting to Germany having a rapid rise in PV capacity and one of the biggest capacities of solar PV installed capacities (Kumar, 2015). The adoption of subsidy policy for the residential PV systems in Japan in 2009 resulted in 99% of residential PV systems connected to the grid system. The Investment Tax Credit (ITC) in the USA that issues a 30 per cent tax credit for solar systems reduces the tax liability for the purchase of solar technologies spurred growth in solar energy investments (Kumar, 2015). The Chinese government adopted policies that allowed individual companies to install up to 10MW solar systems and connect to the grid with no connection fee (Kumar, 2015). Such supportive interventions have spurred a robust R&D, manufacturing facilities, and industrial development of solar PV systems in the respective countries which plays a pivotal role in creating solar jobs.

An analysis of Kenya's clean energy transition by Kazimierczuk (2019) identified that the formulation of supportive policies and fiscal incentives have been a key driver in attracting renewable energy investments. Table 1 summarizes policy and regulatory frameworks and points to the gaps and areas of policy intervention.

Table 1: Summary of the policy and regulatory provisions for solar PV systems in Kenya

Policies in Place	Policy Guideline	Respective Regulations for Policy Operationalization	Gaps/Areas for Further Policy Interventions
Sessional Paper No. 4 of 2004 on Energy	The policy identified solar PV as a potential source of energy for lighting, refrigeration, telecommunications, and water pumping in rural and urban slums in Kenya. The policy highlights the need to develop local capacity for manufacturing, installation, maintenance and operation of solar energy technologies	The Energy Act No.12 of 2006 liberalized electricity production in Kenya and set the agenda for renewable energy technologies in Kenya. The Act provided space for private-sector investment, including the participation of Independent Power Producers (IPPs)	There is need to develop robust regulatory and fiscal frameworks to foster an enabling environment to accelerate the development and utilization of solar technology
Feed-in-Tariffs (FiTs) Policy of 2008; Revisions 2010 and 2012	Kenya launched a FiT Policy in 2008 with subsequent revisions in 2010 and 2012. The FiT structure is set out to Independent Power Producers (IPPs) to sell renewable energy generated electricity to an off-taker at a fixed tariff	The Energy Act 2019 provides a legal framework for the operationalization of the FiT.	The Energy Act 2019 does not provide a legal framework for renewable energy auctions to enable competitive bidding of FiT projects as proposed in the National Energy Policy 2018. The construction, upgrading of transmission/distribution lines, and connection costs are borne by the project developer/Investor
National Energy Policy 2019	The policy objective is to expand the installed capacity of solar PV systems to 100MW by 2020. This would be achieved through hybridization of off-grid thermal stations. The policy interventions include provision of incentives to promote local manufacturing and use of efficient solar systems fast-tracking the installation of solar PV systems in public institutions in off-grid areas	Energy Act 2019 provides for electricity consumers with electric power generation facility capacity of exceeding one megawatt to apply for net-metering system Net-metering where the licensed distributor or retailer must make available a net metering service to a consumer upon their request	Energy Act 2019 limits potential domestic net-metered customers from increasing their solar PV system above 1 MW. Implementing solar PV net metering system would imply less investment in solar energy storage battery storage system by the commercial solar PV system, hence an incentive for private sector investment in solar PV geothermal, hydropower, and wind are identified as the cheapest baseload technologies, with gas turbines identified

	Provide a framework for net metering or direct sale of solar energy to the national grid	The Act instituted the Rural Electrification & Renewable Energy Corporation (REREC), mandated to promote rural electrification and renewable energy use	as the peak load sources, implying less incentive for the private sector investment to supply to the grid
Energy (Solar photovoltaics) regulation, 2012; 2019	The Regulations specify the licensing and registration requirements for solar PV system technicians, manufacturers, importers, vendors, and contractors. The regulations also outline the design, installation, repair, and maintenance procedures for solar PV systems.	The regulations are published under the Energy Act, 2019 (Repeal of Energy Act 2006)	A limited number of trained and qualified technicians to be licensed. There were 700 solar PV technicians licensed by 2019. Therefore, need for the government to develop and implement an education framework for human capital development to build knowledge and technical capacity in the energy sectors
Value Added Tax	The VAT Act exempts import duty and VAT for solar cells and modules while PV semiconductor devices are subject to 5 per cent import duty. The VAT Act 2013 and 2014 Amendment Act exempt solar cells and modules from VAT and import duty	VAT Act of 2013 2020 Finance Bill	PV semiconductor devices such as Light-Emitting Diodes (LEDs) and PV cells are subject to 16 per cent VAT and 5 per cent import duty. VAT uncertainty – the 2020 Finance Bill proposes VAT reintroduction for solar equipment, which would be a disincentive for investment in solar PV system manufacturing in Kenya

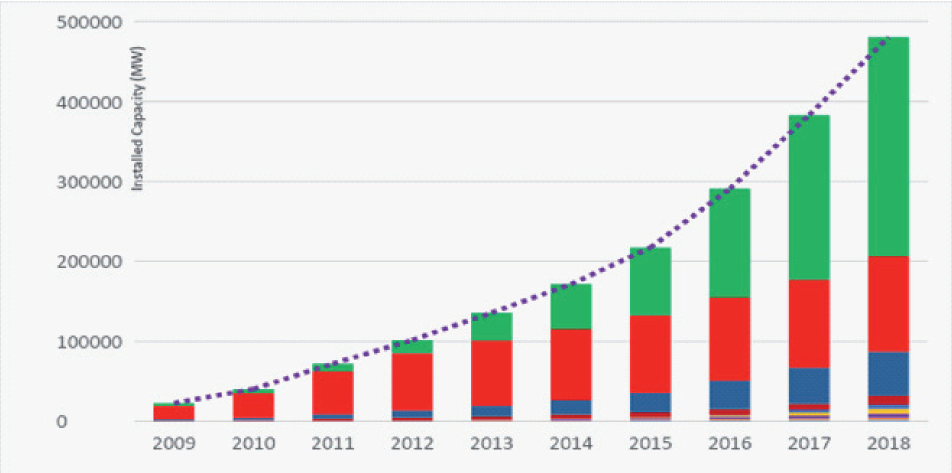
2.2 Growth and Employment in Solar PV

2.2.1 Growth in solar PV generation and Installation

The Institute for Sustainable Futures (ITS) estimates that by 2030, solar PV power generation will supply more than 10 per cent of the world's total electricity supply, and rising to over 20 per cent in 2040. The International Renewable Energy (IRENA) estimates the global cumulative installed capacity of 480 Gigawatts (GW) by 2018, increasing from 22 GW in 2009 (Figure 1) and is estimated to increase to 2,840 GW (13% of global power generation) by 2030 and rising to 8,519 GW (20% of global power generation) by 2050 (IRENA 2019); demonstrating an exponential increase in the solar PV capacity globally. Asia has the highest installed capacity, while Africa accounts for 1 per cent of the global solar PV installed capacity (IRENA, 2019b). According to Lei et al. (2019), Angola implemented a solar PV project at a LOCE of US$ 0.062/kWh while China recorded an exponential decline of LOCE declining to a lowest of US$ 0.077/kWh by 2017.

Given the current global power transformation trajectory, the solar PV industry is estimated to account for the second-largest power generation source and accounting for 25 per cent of the global electricity needs by 2050 (IRENA, 2019; IRENA, 2018).[1]

Figure 1: Global solar PV installed capacity: (IRENA, 2019b)



[1] Photovoltaics (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect (Cleveland and Morris, 2014)

The rapid growth of the installed capacity of solar PV system globally implies that solar PV power will become the mainstay of energy supply in the not too distant future (Atherton and Rutovitz, 2009). Particularly, solar PV home systems are emerging as an effective approach to ensuring access to electricity for developing economies with high off-grid populations prevalent in Sub-Saharan Africa. The International Energy Agency (IEA) estimates that out of 1.1 billion people lacking access to electricity in 2016, Sub-Saharan Africa accounted for 22.5% (or 239 million) (IEA, 2017). The World Energy Outlook 2018 from International Energy Agency (IEA) shows that electricity access is still the primary challenge in Sub-Sahara Africa where 42% of the population is not connected to the grid, and the rural access ratio is only 16% (Choudhary and Srivastava, 2019) and Quansah et al. (2016) posit that the limited electricity access rates and the lack of strong and interconnected electric power grid system, hybrid solar power systems in Africa offer an electric grid leapfrogging opportunity, where the countries adopt decentralized and off-grid electric systems such as solar PV systems.

Affordable, reliable, clean, and sustainable electricity is a key contributing factor in Kenya's realization of an industrialized economy as envisioned by the Kenya Vision 2030. Kenya has effective installed electricity capacity of 2,818.9 MW as at 2019 (KNBS, 2020b), which is projected to increase to 4,244 MW by 2030 (Ministry of Energy, 2018a). To realize the additional installed capacity, the Least Cost Power Development Plans (LCPDP) by the Ministry of Energy identifies a mix of energy sources including geothermal, wind, coal, and solar Individual Power Producer (IPP) projects (Ministry of Energy, 2018b). The LCPD projects growth of the installed solar PV in the grid increasing from 0.66 MW to 110 MW by 2022 and 131 MW by 2024 representing 2 per cent of the total electricity installed capacity by 2024. In addition, the Government is in pursuit of solar hybridization of thermal power plants that currently contribute 696 MW (34% of the total electricity installed capacity) to the national grid presenting an opportunity for the growth of the solar industry in Kenya.

To increase access to the increasing electricity installed capacity, the Government in 2015 launched the Last Mile Connectivity Project (LMCP) that aims to achieve over 70 per cent connectivity by 2017. The project offers a subsidy programme that reduces the connection fee from Ksh 35,000 to Ksh 15,000. The project is planned in three phases, with the first phase targeting to connect 314,200 households within 600 metres of the earmarked transformers to the national grid while the subsequent phases entail grid densification and intensification through extending the low-voltage network and installing new transformers targeting to connect 500,000 households.

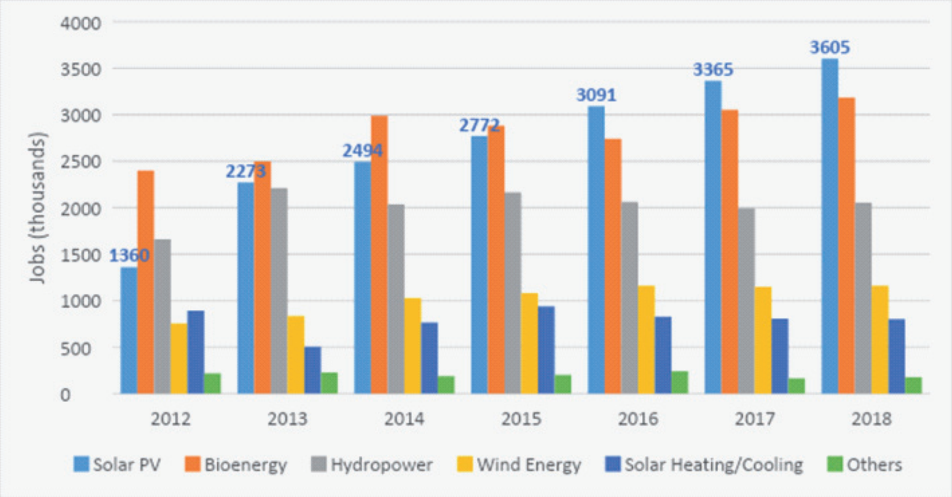
To complement the last mile project in regions that do not have a grid, the Government launched the Kenya Off-grid Solar Access Project (KOSAP) running between 2017 and 2022. The project leverages solar technology to provide electrification to 277,000 households, 1100 public facilitiesand community facilities (health facilities, education facilities, and administrative offices), 380 water pumps and enterprises in 14 underserved counties that collectively account for 20 per cent of the country's population, and 72 per cent of the country's total land area. With an estimated renewable energy generation capacity of 96 MW, the project targets to provide electricity through 120 solar hybrid mini-grids and off-grid standalone solar systems. The KOSAP is part of the Kenya National Electrification Strategy (KNES) that targets to scale up off-grid electricity access by undertaking 35,000 connections through 121 new mini-grids and 1.96 million connections through standalone solar home systems (Ministry of Energy, 2018a).

Given such Government intervention and enabling business environment, Kenya has experienced a large-scale market-driven penetration of small PV systems over the years. The country has also demonstrated a promising model of off-grid electrification fostered by the private sector, with solar companies such as Transmara Solar, Power Gen, and Talek Solar providing electricity to off-grid areas. The increasing market acceptability of the "pay-as-you-go" model in East Africa has created an industry growth and employment growth trigger for the solar PV industry. Start-up companies such as BBOXX, M-KOPA, Azuri, Off-Grid Electric Mobisol that use the pay-as-you-go" model have fostered increasing job creation in the sale, distribution, and installation of decentralized solar panels (IRENA et al., 2018).

2.2.2 Employment in the solar PV industry

With an installed capacity estimated at 482 GW across the globe and estimated to grow at double-digit growth rates into the new decade, solar PV technology has become an increasingly important energy supply option. The IRENA ranks solar industry first in total employment among renewable energy industries amounting to an estimated 3.4 million jobs representing 32.8 per cent of the 11 million direct and indirect jobs in renewable energy globally (Figure 2) (IRENA, 2018). According to the figure below, solar PV employs more people as of 2018 compared to other renewable energy sources. Employment opportunities in solar PV have been on an upward trajectory since 2012, implying that the sector has a greater potential in providing employment opportunities in the future, and hence the more emphasis in enhancing the sector's growth to reduce unemployment rates in most economies, and particularly Kenya.

Figure 2: Global renewable energy employment by technology, 2012-2018 (in thousands)



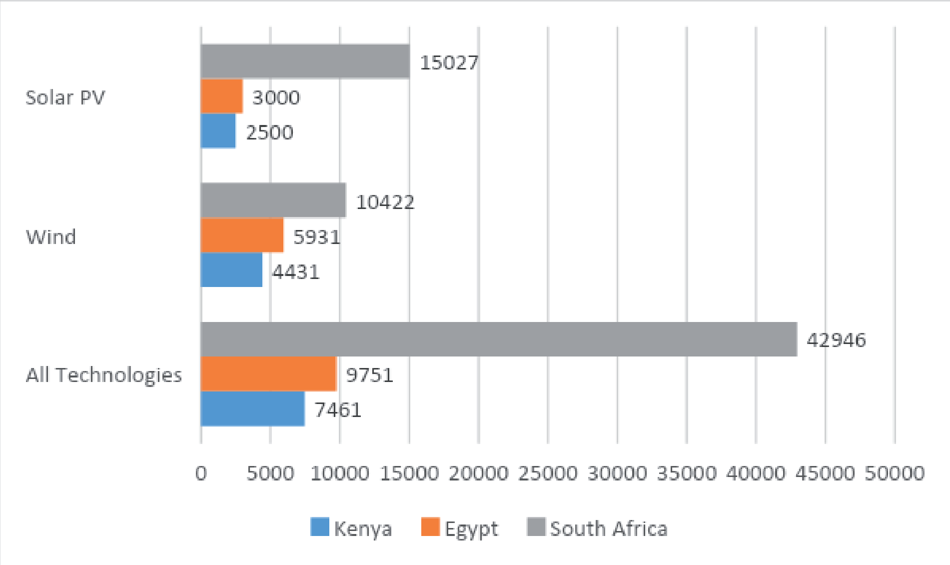
Source: IRENA 2018 (Fragkos and Paroussos, 2018; Çetin and Eĝrican, 2011)

A report by Electric Power Research Institute (EPRI) indicates that 7.14 jobs/MWp from solar energy while the European Renewable Energy Council (EREC) reports that more than 500,000 million will be employed in the solar thermal sector in just a few decades. European Photovoltaic Industry Association (EPIA) estimates 10 million full-time job opportunities will be created in the installation and servicing of PV systems by 2030. The EPIA analysis identifies that the production activities would yield 10 jobs per MWp (megawatt peak) while the installation activities would generate 33 jobs per MWp. The industry analysis by EPIA further estimates 3-4 jobs per MWp in wholesaling and supply activities and 1-2 jobs per MWp in research activities. Jobs in the solar PV value chain are primarily concentrated in installations and operations and maintenance (O&M). For example, 36 per cent of the jobs in the PV value chain are in installation (IRENA, 2019). Similary, Ortega et al. (2015) highlight that the installation operation and maintenance activities entail the use of specialized and local employment. In addition, given that the O&M activities are extended to the project lifetime, the O&M induce permanent jobs, which start the first year the plant operates and end with the lifetime of the plant (Ortega et al., 2015).

The high job intensity nature of the solar PV industry makes it more feasible for low carbon technologies with a high potential for job creation. (Ministry of Energy, 2018b; Fragkos and Paroussos, 2018) highlights that renewable energy technologies are estimated to be on average more labour-intensive and have higher domestic job content relative to fossil fuels. Comparative analysis of renewable technologies by Wei et al. (2009) identify that solar PV has the highest average job multiplier. The solar sector contributes to high skill and lower skills job creation with the design and the manufacturing of solar products generating high skilled jobs while the maintenance of renewable energy systems and operations requiring lower-level knowledge related jobs (Çetin and Eĝrican, 2011). Elliott and Lindley (2017) observe that deployment of renewable energy technologies such as solar PV key in addressing the challenge of high unemployment and subsequently stimulating economic growth. Social-economic benefits such as the potential for new and increased streams of income, enhanced trade balance, and job creation are some of the strategic drivers of deployment of renewables such as solar PV.

IRENA (2019) estimates that renewable technologies contribute to 7,461 direct jobs in Kenya compared to 9,551 jobs in Egypt and 42,946 jobs in South Africa (Figure 3).

Figure 3: Renewable energy employment by technology



IRENA (2019)

Solar PV jobs account for 33.5 per cent (2,500 jobs), 30.7 per cent (3,000) and 35 per cent (15,027) of the total renewable energy jobs in Kenya, Egypt, and South Africa, respectively.

Analysis of employment in the decentralized renewable energy adoption in Kenya by Shirley et al. (2019) identified that DRE contributed to 10,000 direct formal jobs with Pico-Solar and SHS accounting for 7,500 jobs in 2018. The study further estimates 15,000 direct informal jobs and 6,500 productive use jobs for the period 2017-2018, with youths accounting for 41 per cent and women accounting for 23 per cent of the direct jobs in the Direct DRE jobs in Kenya. Shirley et al. (2019) observes that given the high penetration of end-user solar products such as pico-solar appliances and SHS, a large share of the jobs in the value chain are mainly in the sales and distribution part of the chain.

An assessment of the Talek Power Company that entails 40 MWp mini-grid solar revealed the creation of 120 new local jobs, the opening of new shops, and the generation of new productive users in two years period. Powerhive Off-grid solar PV microgrids in Nyamira and Kisii counties with a combined 1 MW of generating capacity has 60,000 and created 100 jobs during construction and 20 direct jobs during operation, while enabling a spring up of business such as chicken hatchery and nursery, woodworking (lathe, saw, drill), hair salon and welding.

2.3 Productive Use of Solar PV Energy in Kenya

Amid the unemployment challenge, there is a significant opportunity for employment by providing access to electricity to people who remain underserved. Literature has identified improved quality of education, access to information, improved quality of life, enhanced health, improved social services, safety, and gender equality as the social positive impact of access to electricity through solar home systems (Khan, 2020; Sharma et al., 2019; Lemaire, 2018; Barman et al., 2017). Literature demonstrates that access to solar energy in rural areas fosters increase in study time (Sharma et al., 2019), social inclusion through access to TV and phones (Lemaire, 2018), reduced the risk of respiratory illnesses due to indoor pollution (Khan, 2020; Lemaire, 2018; Obeng and Evers, 2009).

Access to solar PV among rural households unlocks more work hours and additional income (GOGLA, 2018), enhances household productivity, increases household income, and increases access to employment opportunities (Khan, 2020). Women's access to electricity has been identified to increase the probability of working outside the traditional agriculture sectors and unpaid domestic work, which increases their earnings (Dasso and Fernandez, 2015; Dinkelman, 2011). Access to solar PV home systems contributes to increased household time endowment particularly among women, thus fostering their increased participation on the labour market (Dinkelman, 2011; Spalding-Fecher and Matibe, 2003).

The local production of photovoltaic modules and systems presents a significant effect on the sustainability of the solar PV value chain. Currently, Sub-Saharan Africa imports the largest share of solar PV system components, thus presenting a market niche for a local producer or assembler. Establishing a local manufacturing industry presents multiple potential benefits including cost savings resulting in lower prices, export of domestic manufactured solar products to international markets, local job creation, and accumulating technological capabilities. Locally available raw materials, and lower wages compared to the traditional solar manufacturing markets presents a potential advantage of establishing a solar PV manufacturing base in SSA. Local manufacturing supports a transition away from imported equipment to improve trade balances (IRENA, 2016). Market analysis studies have identified that South Africa and Kenya have a sizeable local manufacturing base for solar PV systems (Elmer and Brix, 2014). Establishing the local PV manufacturing industry in Kenya would imply that manufacturers operate in a dynamic, volatile, and highly competitive global market. Moreover, given the production capacity in Kenya would be comparatively lower, the products would experience significant barriers to entry. The solar PV manufacturing is mostly technical, and requiring a broad spectrum of skills and knowledge, from experience in production line management to chemical materials, hence skilled labourers are inherent (Johnson, 2013).

2.4 Solar Market Trend in Kenya

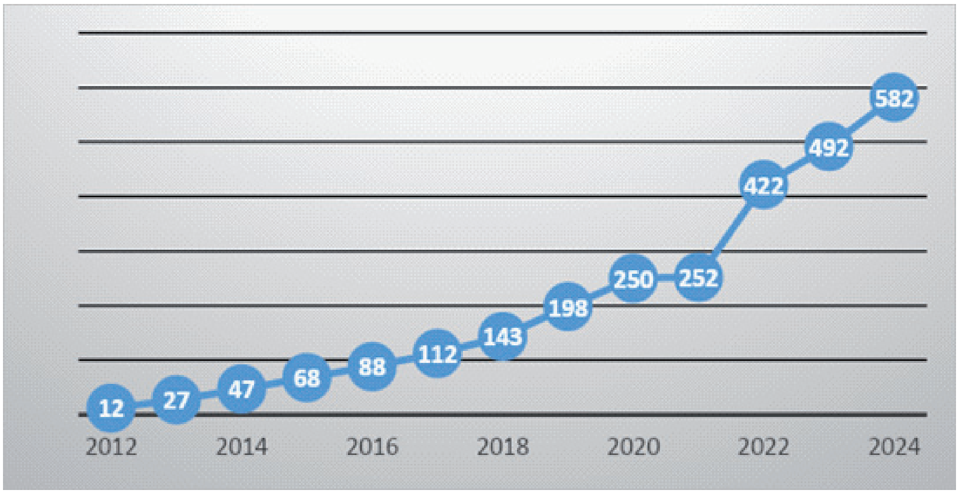
While Kenya is a latecomer in the PV industry, the industry has experienced a dramatic pace of expansion and is experiencing active entry of new PV firms into the market. The market has experienced increasing uptake of solar PV for commercial and industrial applications. The key market segments for solar PV include grid-connected large-scale power plants, grid-connected small scale power plants (solar home systems), grid-connected/stand-alone captive power plants for industry, commerce and institutions such as office parks, telecommunication, flowers, vegetables, tea, fruits farms and tourism, telecommunications, and hospitals (Power Africa, 2019).

An annual estimation of Kenya's PV demand capacity demonstrates a 30 per cent annual growth increasing from approximately 10 MW in 2010 to 50 MW by 2017 (Energy Regulatory Commission , 2019). The Lighting Africa reports estimate that 10 million people rely on off-grid solar products to meet their basic electricity needs. The Lighting Africa observes 200% growth of the solar lantern market between 2009 and 2013, which not only fostered access to lighting but also a vibrant private sector and an innovative PAYGO model. In the last three years alone, GOGLA affiliates reported sales of US$ 3.4 million in products. In recent years, a significant portion of SHS sales has come from on-grid customers looking for backup during blackouts, for those who cannot afford appliances, and those who have found off-grid solutions complementary to grid access.

Using the Kenya Revenue Authority (KRA) importation statistics, a baseline survey by the Energy Regulatory Commission (2018) identified an average annual demand growth of 87% of PV devices importation in Kenya, increasing from 360,370 units in 2010 to 2,561,681 units by 2017. Findings by Ondraczek (2014) suggest that the LCOE off-grid connected PV systems may already be below that of the most expensive conventional power plants, such as medium-speed diesel generators and gas turbines, which account for a large share of Kenya's current power mix. The above statistics demonstrate the viability of the solar value chain in Kenya, which inevitably would contribute to jobs in the Kenyan market.

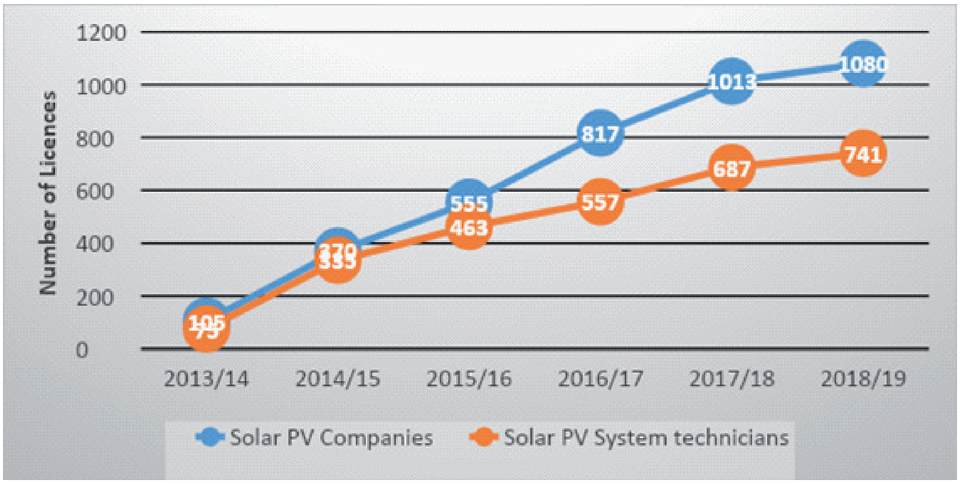
A solar PV Regulatory Impact Assessment (RIA) undertaken by EPRA identified a growth of the installed capacity of solar to approximately 150 MW by 2019 and consists of small pico photovoltaic systems to complex microgrid and grid-connected solar systems, grid-tie and hybrid solar (EPRA, 2019). The study estimates that the installed capacity of both utility-scale solar PV projects and off-grid solar systems would increase to 582 MW by 2025 (Figure 4). Kenya has been exploring policy and deployment schemes for utility-scale solar PV projects. The country currently has two projects connected to the national grid: 50 MW Garissa Power Plant, 600 kW Strathmore Power Plant, and 500 kW UNEP power plant. Other large scale distributed rooftop solar power projects include the 2 MW at Two Rivers Mall, and 860 kW at the Garden City Mall.

Figure 4: Estimated solar PV installed capacity in MW, EPRA



The increase in the installed capacity has been accompanied by an increase in the Solar PV companies and the solar PV systems technicians. EPRA reports that the solar PV companies increased ten-fold from 105 in 2013 to 1,080 companies in 2018 while the number of licensed technicians increased from 75 in 2013 to 741 by 2018 (Figure 5).

Figure 5: Growth in solar PV licenses, EPRA



3. Literature Review

There is considerable debate on the employment effect of the clean energy industry which has elucidated policy interest due to its socio-economic and environmental impact. In this section, we briefly describe three theoretical foundations for the value chain framework adopted in the study. We provide a discussion of the key arguments on the employment creation of the renewables with a specific focus on solar PV. The literature review further covers the solar PV trends in Kenya. Lastly, a detailed analysis of the existing policy framework and the respective regulatory framework is provided, as well as gaps for policy intervention.

3.1 Theoretical Literature

There are divergent methodologies and concepts for value chain analysis that have evolved, including Value Chain (Porter 1985), Global Commodity Chain - GCC (Gereffi, 1994), and the Global Value Chain (Kaplinsky and Morris, 2001). The Porter (1985) value chain concept is premised on the context of competitive advantage and hypothesis, and the need for enterprises to identify activities with higher value addition. Porter's (1985) framework breaks the activities involved in a value chain into inbound logistics, operations, outbound logistics, marketing and sales, post-sale services. As postulated by Porter (1985), the value chain appraisal enables identification of chain nodes where enterprises can develop competitive advantage or countries can develop a comparative advantage. Enterprises could develop a competitive advantage through cost leadership, differentiation, the scope of business which is determined mainly by technological capabilities (Frederick, 2014). The Porter framework, however, centres on activities within an enterprise and does not integrate the downstream and upstream activities beyond an enterprise.

The global commodity chain - GCC (Gereffi, 1994), a derivative of Wallerstein's commodity chain, highlights the presence of dominant actors along a commodity value chain that shape up production and sourcing networks along the value chain. Such dominant actors control the knowledge upgrading and transfers, and the interaction by other actors within the value chain. According to the Global Commodity Chain theory, value chains can be producer-driven or buyer-driven, whereby transnational manufacturers play a pivotal role in the producer-driven chains and the industries in which large retailers or branded marketers play the pivotal roles in the demand-driven value chains.

The Global Value Chain (Kaplinsky and Morris, 2001) integrates concepts of globalization, the rise of regional value chains, new manufacturing hubs and recognizes that business functionalities and production activities are distributed across the globe. The concept posits that the activities involved in a value chain may be carried in different countries, hence value chains involve international production networks. The GVC brings a new paradigm in value chain analysis where countries specialize in functions with established expertise. The concept of GVC demonstrates how it enables latecomer emerging economies to participate in a range of low to very high-tech sectors, and development of local industries which subsequently contribute to employment creation (Taglioni and Winkler, 2016).

Gereffi and Kaplinsky (2001) highlight that value chain analysis enables the identification of activities that create value for an enterprise. For a policy maker, value chain analysis enables identification of opportunities, and constraints that with appropriate policy intervention would yield positive social-economic and environmental impact. A value chain appraisal enables a focus on the nodes in the production and supply processes. Value chain analysis entails exploring the social-economic context of the value chain, demand for the value chain outputs, and analysis of the institutional set-up (FAO, 2013). Frederick (2014) provides a value-chain reference model (VCRM) that identifies research and development, design, production, logistics, marketing, services, and value adding activities as the comprehensive activities involved in a value chain ecosystem.

3.2 Empirical Literature

A multi-tier framework by Dagnachew et al. (2017) analyzing technology mix for promoting universal electricity access in SSA identified that for low-level consumption of electricity, the off-grid solution was more economically viable as opposed to the central grid extension. According to Dagnachew et al. (2017), rural areas are characterized by sparse population distribution, hence high electricity transmission and distribution costs and high cost for each unit of electricity consumed. Similarly, van Ruijven et al. (2012) identifies that the sparse population of SSA and Latin America implies high investment cost for extension of grid-electricity systems to rural areas, hence high potential for off-grid and mini-grid technologies. The findings by Dagnachew et al. (2017) and van Ruijven et al. (2012) are consistent with findings by Zeyringer et al. (2015) whose analysis for Kenya electrification approaches identified decentralized solar PV as the cost-effective electrification option for areas with low demand of electricity. Odhiambo et al. (2020) identify that while the life cycle cost of solar PV system is higher than the grid-connected electricity, the cost of extending the grid to the remote areas and isolated homes is high and uneconomical, implying that solar PV systems are optimal strategies of providing electricity to off-grid areas.

Energy technology leapfrogging, characterized by intensified adoption of renewable energy technologies, is driving economic growth in developing economies, particularly in Sub-Saharan Africa. Cai et al. (2011) identify that energy technology leapfrogging presents an opportunity for addressing labour market challenges, particularly rapidly growing rates of unemployment among the youth. To inform appropriate policies to support the energy technology leapfrogging, there is a need to assess and forecast its associated economic impact, and employment multiplier particularly. Adoption of employment elasticity in modeling sectoral employment potential is one of the popular models among researchers (Bhorat et al., 2020; Deon and Fox, 2013).

Employment elasticity of x implies that a 1 per cent growth in value added yields an x per cent growth in employment but a (1-x) per cent growth in productivity, holding other factors constant (Mishra, 2014; Fox et al., 2013). High employment elasticities are indicative of economic growth that is generating employment. However, it could also be indicative of a low level of productivity growth (Fox et al., 2013). Dongliang (2014) identifies that a transition to the green industry from the traditional smokestack industries would result in a significant increase in labour demand. Dongliang (2014) estimates an employment elasticity of 0.224 for the manufacture of the electrical and machinery equipment in China, which falls within the average employment elasticities of 0.1-0.25 of the sampled manufacturing industries. Mishra (2014) estimates an employment elasticity of 0.53 for the manufacturing of electrical equipment against an aggregate elasticity of 0.41 for the manufacturing industries in India. Fox et al. (2013) emphasize the need for robust private sector in Sub-Saharan Africa to provide wage employment. The study underlies the need for government incentives to attract the private sector investor for Sub-Saharan Africa to absorb the rapidly growing labour force. The study highlights that new technologies and capital is necessary for shifting the structure of employment in SSA to higher productivity sectors.

Studies using employment factors to establish employment in the renewable industries value chain estimate the employment factor as a ratio of the person-years per MW whereby one person-year entails full-time employment for one person for 1 year (Cameron and Van Der Zwaan, 2015). Using a 1998-2001 review period for USA and Europe data, Lambert (2012) identified highest employment factors for solar PV (1.03 jobs/GWh and 4.13 jobs/$ investment) compared to the wind (0.2 jobs/GWh and 2.82 jobs/$ investment) and biomass and 0.21 jobs GWh and 2.75 jobs/$ investment). Sastresa et al. (2010) identified an overall employment factor of 38 jobs/MW in the solar PV industry, with the R&D stage contributing 10.25 jobs/MW, and installation stage contributing 8.12 jobs/MW of installed solar energy. Similarly, an analysis of the Spanish renewable energy development plan for 2005-2010 by Moreno (2008) using the employment factor approach in combination with scenarios identifies that the construction stage of the value chain has the highest job potential yielding 34.6 jobs/MW.

Supply chain analysis of the employment factor of the solar PV industry by Llera et al. (2013) for the period 2001-2010 identified employment factor of 29.46 jobs/MW, with the module assembly and installation stages having the highest employment factor of 9.05 jobs/MW and 6.37 jobs/MW. Llera et al. (2013) observe that more stable jobs are created in the R&D, manufacturing and operation and maintenance phases of the value chain, with the other phases having temporarily jobs. Spreadsheet analysis of PV road map for Turkey by Cetin (2011) estimates 37-46 jobs/MWp of solar PV industry, with the wholesale and retail stage yielding 36 jobs/MW, installation yielding 34.6 jobs/MW, panel production yielding 10 jobs/MW while the operation and maintenance stage yields 2.7 jobs/MW. Adopting employment factors derived from existing literature modelling net employment effects of diffusion of renewable energy technology, we estimate the job creation potential of the solar PV industry in Kenya.

Matsumoto and Bhula-or (2018) highlights that ongoing energy technological progress is increasingly shifting employment towards higher and updated skills, implying a failure to mitigate skills shortage and mismatch in developing countries constrain them from exploiting the opportunities in technological progress. The analysis of Matsumoto and Bhula-or (2018) identifies an oversupply of low-skilled workers and skills shortage for semi-skilled and highly skilled occupations, which is a consequence of under-education. Analyzing the imbalances between skills supplied and skills needed in the labour market, Montt (2015) recommends the need for policy priority to address the qualifications mismatch and skills transferability across sectors. Matsumoto and Bhula-or (2018) recommends addressing the skills gaps and skills mismatch is one of the structural changes necessary to address the productivity gap in developing countries.

According to Tyagi et al. (2017), a rapid expansion of the solar PV industry is associated with skill gaps, and hence recommends the need for policies that support building competencies based on desired skills in solar PV value chain. A skills gap is the disconnect between the skills demanded by the employers and the skills available in the labour force (Bhorat et al., 2020; Tyagi et al., 2017). Bhorat et al. (2020) models two types of skill gaps: occupational skills gap and sectoral skills gap. The sectoral skills gap is the difference between the skills supply and skills demand (requirement) for a particular sector. While the sectoral skills gap model analysis the existence of the skills in the target population, the skills are shared by other sectors, thus a fundamental constraint to the model. To address the limitation, Bhorat et al. (2020) proposes a skills availability ratio, which is a ratio of the skills available in the population against the sectoral skills demand with a ratio of less than 10 indicating skill unavailability. Adopting the sectoral skills gap and the skills availability ratio concept by Bhorat et al. (2020), the current study estimates the skill gap along the solar PV value chain in Kenya.

According to Haas et al. (2018) analysis of constraints in the solar PV industry is usually founded on a combination of systematic review of literature, interaction with stakeholders and analysis of extant projects. Employing semi-structured face-to-face interview, Haas et al. (2018) triagulates the barriers to the solar PV industry in Chile into economic and financier barriers, market barriers, solar technical barriers, system integration barriers, regulatory barriers and information barriers. Kiefer and del Río (2020) undertook a firm level investor survey, expert's consultation and literature review to map the constraints to growth of solar PV in the European Union (EU). Kiefer and del Río (2020) analysis identified high cost of deployment, technology risks, lack of stability of the regulatory framework as the key barriers limiting the deployment of concentrated solar PV in the EU. Baulch et al. (2018) undertook a semi-structured interview with the solar PV value chain stakeholders to analyze the constraints of uptake of solar home systems in Vietnam. The study identified that absence of construction regulations for installing SHS, lack of budgets to finance feed-in-tariff, and limited industry technical capacity as the core constraints to the adoption of SHS in Vietnam.

Lei et al. (2019) uses a Strength Weaknesses Opportunities and Threats (SWOT) analytical framework to examine the solar PV power development in Africa. The study collects data through onsite interviews, literature review and policy analysis. Lei et al. (2019) observe that lack of strong policy incentives limits the solar PV investments. A systematic review of literature by Jadhav et al. (2017) identifies donor dependence for financing, lack of dependable regulatory and policy framework, and lack of solar PV technology research focused institutions as the fundamental challenges to the uptake of solar PV in the Southern African Development Community (SADC) region. The implication is the absence of a robust solar manufacturing base in the region, hence the high reliance on imports. This is evident in Kenya where there are only two manufacturers of solar PV systems and batteries, with other accessories such as inverters imported.

The systematic review of literature by Adenle (2020) identified financial constraints (46%), weak government policy (24%), and technical problems (23%) as the main limiting factors to the uptake of solar PV systems in Kenya. The review identifies that absence of solar research institutes limits research and development programmes that would support the manufacturing of the solar PV components, hence constraining the growth of the solar PV industry (Adenle, 2020). Similarly, a synthesis of the constraints by Johannsen et al. (2020) and Painuly (2001) classify the constraints to adoption of solar PV as economic barriers, technical barriers, and systematic barriers. This study adopts their approach.

3.3 Knowledge Gap

As the globe transitions from brown to a green economy, the trade-off between environmental sustainability and economic growth remains a dilemma for policy makers in developing economies. One stream of literature supporting green policies argues that green growth is associated with high labour-intensive jobs and demand for new skills (White-Walsh, 2008) while critics of green policies caution the risk of job replacement related to fossil technologies (Arias, 2009). Elliott and Lindley (2017) observe that deployment of renewable energy technologies such as solar PV is key in addressing the challenge of high unemployment and subsequently stimulating economic growth. Social-economic benefits such as the potential for new and increased streams of income, enhanced trade balance, and job creation are some of the strategic drivers of deployment of renewables such as solar PV. While there has been extensive empirical literature on the employment potential of the solar PV industry, a more nuanced analysis mapping the employment opportunities while adopting a value chain analysis approach is lacking, thus a research gap. This study capitalizes on such gaps to explore the job creation potential of solar photovoltaic (PV) in Kenya using a value chain analysis. The analysis will incorporate employment elasticities and employment factor models to estimate the employment growth and creation potential relying on data from IRENA and the EPRA. The study also employs the KHIBS 2005/06 data to identify the skills gaps in the industry.

4. Methodology

4.1 Theoretical Framework - Solar PV Value Chain Analysis

Porter (1985) propounded value chain theory in his book “Competitive Advantage”, with the model identifying value chain as an interlinked chain of activities and sub-systems that bring value to the customers while yielding competitive advantage for the enterprise. Kaplinsky and Morris (2001) defines a value chain as a full range of activities undertaken to bring a product or service from conception through different phases of production, delivery to final consumers, and final disposal after use. According to Porter, a value chain consists of two sequences of activities, i.e. primary and support activities. Primary activities include inbound logistics, operations, outbound logistics, marketing and sales, and service. Support activities include firm infrastructure, human resource management, technology, and procurement. The primary activities could be spread within and across countries.

According to ILO, Value Chain Development Framework identifying the job creation potential along the value chains entails an analysis of market dynamics, and the relationship between the different actors in the market (ILO, 2016). Given that enterprise value chains determine their performance and their ability to create jobs, value chain analysis enables identification of opportunities for maximizing enterprise growth and job creation potential (World Bank, 2018).

4.2 Analytical Framework

Given the unavailability of the input/output matrix for Kenya, the spreadsheet-based analytical model, which studies the employment impacts along the industry chain will enable the evaluation of the employment created by Kenya’s solar PV industry. The study will combine data and information from a wide range of sources to give an up-to-date analysis of solar energy development and contribution to employment in Kenya. The current research uses both quantitative and qualitative approaches, whereby a descriptive analysis will be the key analytical tool in establishing the current employment creation, labour skills analysis, and key constraints to the growth of the solar PV industry in Kenya along the sector value chain. The analysis focuses on value chain analysis of the solar PV industry to identify activities that have a greater potential of creating employment for the youth in Kenya.

4.2.1 Forecasting growth of the solar PV industry

Using an analysis of the Global Off-Grid Solar Market Reports, we will establish the growth of the solar off-grid market in Kenya, which presents a proxy for the industry growth. GOGLA and World Bank Group's Lighting Global programme provides a bi-annual market intelligence analysis of the volume of sales of solar off-grid products in multiple developing countries including Kenya.

4.2.2 Constraints to the growth of the solar PV industry in Kenya

To develop a profound understanding of the constraint to growth of the solar PV industry in Kenya, a qualitative primary data collection with market player context is adopted. Specifically, qualitative research provides insights and systematic approach to understand complex behaviours that are key in designing public policies. To comprehensively establish the barriers that constrain the adoption and growth of solar PV industry in Kenya, we relied on extant literature derived from existing case studies and projects. In addition, we developed and administered focus groups and key informant interviews to key industry stakeholders from public organizations, private firms and developers, Non-Governmental Organizations (NGOs) and research institutions, and site visits to relevant locations. This study employed a framework for analysis by Johannsen et al. (2020) and Painuly (2001) who classify the constraints to adoption of solar PV as economic barriers, technical barriers, and systematic barriers.

4.2.3 Employment creation potential

Labour-to-value added ratio

In determining employment creation potential within an economy, it important to evaluate how intensive labour is used in the production process. As a general rule, less developed economies tend to be more labour-intensive. This is because low income means they cannot afford to invest in expensive capital. With low income and low wages, they can remain competitive by employing many workers. The high labour-to-valued added ratio is interpreted as a high labour-intensive industry and low labour-to-value added ratio, capital intensive.

Employment per industry (number of employed individuals in the solar industry) and total output productivity (solar industry contribution to GDP) are the two variables used in the calculation of labour-to-value added ratio in the solar industry. Estimation of the labour-to-value added ratio is preferred due to its capability to model youth employment potential as opposed to general employment.

Employment elasticities

Employment elasticities are widely used by researchers in modelling employment growth potential. This approach can model the impact of increased own-sectoral growth or other sectors' impact on employment growth. Unlike the labour-to-value added ratio, labour elasticities are estimated using time series employment data per sector and GDP contribution per sector (Fox et al., 2013). The following linear regression equation is used to estimate employment elasticities;

$$\Delta ln(E_{it}) = \beta \Delta ln\ (GDP_{it}) + \varepsilon_{it} \qquad (1)$$

where E_{it} is the employment level in the solar PV industry (Kenya) in time t, and GDP_{it} is a solar PV industry contribution to the GDP (Kenya) in time t. Employment elasticity denoted by β is used to determine how employment growth will behave in the solar PV sector, given the GDP contribution growth trajectory of the sector.

Point elasticity of employment creation

This study is limited to applying the above two methods (labour-to-value added ratio and employment elasticities) of estimating the employment creation in the sector due to lack of a long series of both sectoral job and sector contribution to national GDP, since it will lead to a degree of freedom problem. As a result, we modify the employment elasticity method from linear regression stipulated in equation 1, to point and arc elasticity of employment creation (Mishra, 2014). Point elasticity of employment creation method as shown in equation 2 below:

$$Employment\ Elasticity = (\Delta Employment\ Creation\%)/(\Delta Contribution\ to\ GDP\%) \qquad (2)$$

Where the employment elasticity is defined as the ratio of the percentage change in the number of jobs created in the sector to the percentage change in corresponding sectoral contribution to total GDP calculated at a specific time of the year. Since point elasticity of employment is sensitive to large changes in both variables, arc elasticity is used to smoothen the effects, since it takes into perspective averages. The following is the formula used to calculate arc elasticity:

$$Employment\ Elasticity_t = \frac{(Employment_{t+1} - Employment_t)}{\frac{(Employment_{t+1} + Employment_t)}{2}} \div \frac{Contribution\ to\ GDP_{t+1} - Contribution\ to\ GDP_t}{\frac{Contribution\ to\ GDP_{t+1} + Contribution\ to\ GDP_t}{2}} \qquad (3)$$

4.2.4 Employment creation at each point of the value chain

The research will further use the absolute number of jobs created by producing 1 MW of solar energy estimated by IRENA at each node on the solar PV value chain to calculate the total number of jobs created at each node in Kenya. In this way, we will have both employment elasticity and an absolute number of jobs at each note to visualize employment creation in the solar PV sector clearly, since employment elasticity calculation uses the broad electricity sector due to data limitation for solar PV sub-sector in Kenya.

Table 2: Jobs created at each node of the value chain per 1 MWp IRENA estimates

Value Chain Nodes	R&D	Manufacturing	Distribution	Construction & Installation	Operation &Maintenance
Jobs/I MW	2	10	4	33	33

Using installed capacity in MW from EPRA, we calculate the total cumulative job created at each node yearly using the formulae below:

- Total number of jobs created at R&D = Total installed capacity (MW) × Jobs/1MW_R&D
- Total number of jobs created at Manufacturing = Total installed capacity (MW) × Jobs/1MW
- Total number of jobs created at Distribution = Total installed capacity (MW) × Jobs/1MW
- Total number of jobs created at Construction = Total installed capacity (MW) × Jobs/1MW
- Total number of jobs created at O&M = Total installed capacity (MW) × Jobs/1MW

4.2.5 Assessing solar PV industry labour skill requirements and skills gap analysis

In attaining sustainable growth of any sector in the economy, all factors of production (labour, capital, among others) must be fully utilized. In the case that factors of production are not employed fully, the potential growth of the sector/ economy cannot be achieved. In this section, we only focus on labour as the factor of production. In the event there is a disconnect of skills demanded by employers and skills possessed by the labour force, the industry will experience skills gap. The methodology for analysis of skills requirements and skills gap borrows from (Bhorat et al., 2020).

Skills gap

Skills gap is defined as the variance between the skills offered by the workforce and the skills demanded by the employer. Skills gap can be a surplus or deficit, where skills gap surplus implies that skills possessed by the labour force are more than skills required by the industry, and skills deficit is when the skills possessed are fewer than skills demanded/required by the industry. In our skills analysis, we use field of study as a proxy for skills, such that those operating in a certain occupation is given by their field of study (Montt, 2015). For the potential employment to be realized, workers must possess skills required in a particular sector, and hence the importance of evaluating labour skills requirements in the solar PV sector.

For each identified occupational category, we show the number of individuals with varying levels of education. The existing distribution of educational attainment across categories is taken as the skills requirement for the sector in this example. Adding up all of these per education category gives a total skills requirement for that education category. Subtracting the total skills requirement from the skills supply for that education category then gives an indication of the sectoral skills gap (Bhorat et al., 2020). The formula shown below is used to compute the skills gap.

$$\text{Skills Gap} = \text{Skills Supply- Skills Requirement} \qquad (4)$$

Skills availability ratio

Sector skills gap assesses whether the skills exist in the target population (in this case, youth population) as a whole and not electricity sector, and hence we use skills availability ratio, which captures the skills existing in the population against skills required in the sector, for each education level.

The skills availability ratio measures the extent to which the skills required by a specific sector/industry are available in the target population, particularly the youth population. However, if the ratio is considerably smaller, such as less than 10, it may indicate that despite the skills being available in the wider population, there are concerns about whether those skills will be able to be attracted to the electricity sector. Skills availability ratio is computed using the formula by Bhorat et al.,2020:

$$\text{Skills availability ratio} = \text{Skills Supply} \div \text{Skills Requirement} \qquad (5)$$

4.3 Data Sources

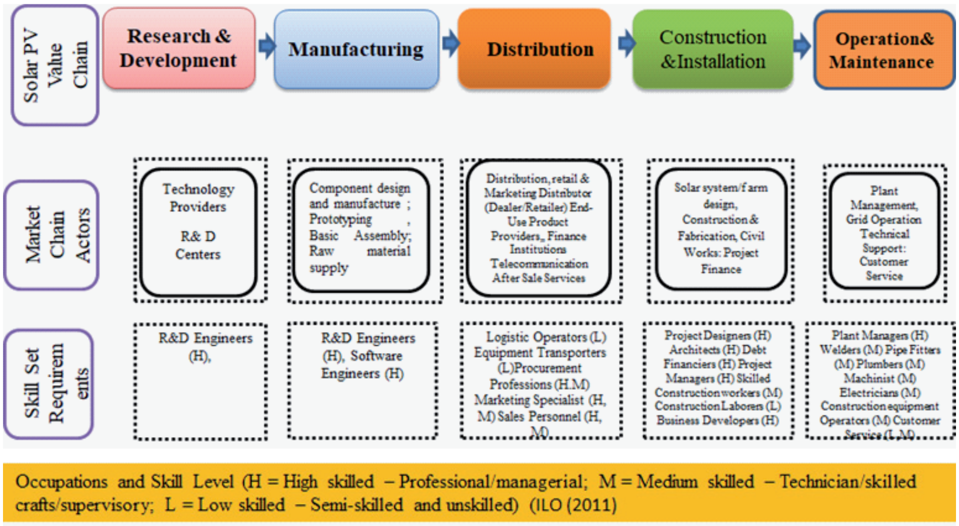
This study makes use of both qualitative and quantitative research approach in synthesizing facts through descriptive analysis of the available data to visualize current and future trends of jobs in the solar energy sector, identification of constraints hindering the growth of solar PV sector, labour skills analysis and mapping of solar PV value chain. We use data from the Kenya Integrated Household Budget Survey 2015/16 (KIHBS 2015/16), which was collected by Kenya National Bureau of Statistics (KNBS) by surveying 66,597 households countrywide, across the 47 counties and various statistical abstracts published by KNBS yearly. We also use KIHBS 2005/6 because of its ability to capture Kenya National Occupational Classification Standard (KNOCS)-2000 codes, which will be used to address the objective of labour skills by mapping occupations in the electricity sector and carrying out a sectoral skills gap analysis. Data sources are further complemented by data from International Renewable Energy Agency and Energy and Petroleum Regulatory Authority to calculate employment factors by estimating the number of jobs created at each node across the entire solar PV value chain. The data obtained from IRENA comes from a variety of sources. Most of the data are official statistics submitted by countries to IRENA using the IRENA renewable energy statistics questionnaire during its annual data collection cycle or taken from official publications. An extensive review of literature will be undertaken in mapping solar PV value chain and also understanding the constraints facing the industry and suggested policy interventions in ensuring continuous inclusive growth, which eventually leads to sustainable jobs especially for the youth.

5. Findings and Discussions

5.1 Value Chain Analysis of the Solar PV Industry

5.1.1 Solar PV value chain

Figure 6: Solar PV value chain



Research & Development

The R&D stage involves developing the basic, general, or specific technologies related to PV technology for both production equipment and process manufacturing. R&D involves the development of solar PV technologies and demonstration of capability in the deployment of industrial solar PV products. The R&D process is knowledge-intensive, unpredictable, and financially risky. Jobs in R&D, design, and even in component manufacturing are often located far from the territory where the renewable installation is set unless a strong industry has been developed in the region (Llera et al., 2013).

Manufacturing of solar PV

This stage includes the manufacturing of solar cells, module components manufacturing, module unit assembly, and balance-of-system technology such as inverters, optimizers, racking, trackers, transformers, and combiner boxes. The manufacturing and deployment of PV are predominantly dominated by Europe, UK, and the US but, with increasing globalization, the market has diversified with new players such as China, Taiwan, South Korea leapfrogging the global PV value chain with the Asia-Pacific region accounting for 76 per cent of the solar PV modules installed globally. Although building a domestic manufacturing capacity for solar has the potential to increase income and employment, Kenya has not realized significant manufacturing, with only two manufacturing firms and the rest of the solar products imported. Solinc Limited, which is the manufacturing company's current manufacturing capacity is 140,000 solar panels per year while Chloride Exide (K) Ltd manufactures batteries that are part of a solar PV system.

Global Value Chain and innovation literature suggest that establishing a robust manufacturing hub is determined by a country’s technology capabilities, technology absorptive capacity and intentional technological and learning efforts, which could be realized through Foreign Direct Investments (FDI), trade-in equipment, licensing agreements, joint ventures, labour mobility and R&D cooperation (Gallagher, 2014). Maximizing value creation from the development of a domestic PV industry relies on leveraging capacities in other industries, such as glass, aluminium, silicon, and semiconductors to provide expertise, raw materials, and intermediary products for the manufacturing of components. Manufacturing the main components of solar systems requires specialized equipment and other machinery It also requires equipment that is commonly used in other industries such as machines for cutting, welding, washing, bending, melting and joining. Electronic and information technology tools are also extensively used in manufacturing for monitoring and control of machinery. In addition, IRENA (2017) highlights that establishing local manufacturing should consider several factors including the future market demand (domestic, regional, and international) and the level of competitiveness of other leading countries.

Sooriyaarachchi et al. (2015) highlights that the production of the above solar-related activities results in the creation of jobs. The European Photovoltaic Industry Association (EPIA) estimates 3-7 direct jobs per PV module manufacturing. The types of human resources required in the manufacturing of PV systems include factory workers and technicians, industrial engineers, administrative personnel, marketing and sales personnel, logistics experts; chemical engineer’s quality control experts; health and safety experts, and regulation and standardization experts (IRENA, 2017).

Distribution

Applying the ‘Smile Curve’ hypothesis, Shin et al. (2012) highlights that the downstream activities in a value chain, which includes distribution, marketing, and brand management are associated with the highest added value, hence the distribution stage presents a leverage opportunity for Kenya to exploit the solar PV industry.

Kenya has a substantial supplier network of PV systems adopting innovative market systems that have seen high penetration of solar home systems. The distribution network in Kenya for the small SHS and pico-solar systems entails the use of Pay-As-You-Go (PAYG) model that is technology-driven payment scheme enabling customers to pay for the lease amount of the system or service while using it, thus enabling the customer to gradually own the system (GOGLA, 2017). In Kenya, the PAYG model has been leveraged by innovative enterprises that sell the SHS to un-electrified households on an affordable M-Pesa payment plan and has been identified as PAYG making solar units affordable (Rolffs et al., 2014). The market leaders in the distribution of decentralized Solar Home Systems (SHSs) include M-Kopa, Mobisol, BBOXX, and Off-Grid Electric. The PAYG companies have a robust distribution network and employ sales agents, technical staff for remote monitoring of systems, and customer helplines, and operators. Currently, M-Kopa which has the largest footprint currently and with 500,000 PAYG units sold in Kenya employs 1,000 full-time staff and 2,100 active direct sales representatives in East Africa (Plantwise, 2013).

Installation

This stage consists of project and construction management, construction labour, mounting and piling equipment, electrical work, and commissioning and testing. The activities in the installation and commissioning stage vary significantly between rooftop and ground-mount applications. The solar pico-PV systems on the other hand are designed as an entire unit, hence entails limited installation and commissioning activities. The European Photovoltaic Industry Association (EPIA) estimates 12-20 indirect jobs per MWp installed

Installation of Solar PV Systems requires human resources such as construction workers and technical personnel, civil engineers and foremen, health and safety experts, electrical and mechanical engineers, environmental experts, and quality-control experts. According to Ortega et al. (2015), the installation activities entail the use of specialized and local employment. However, the stage is associated with employment instability.

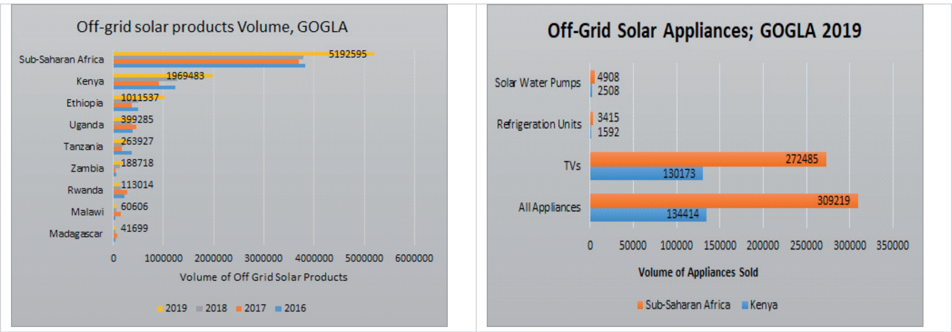
Operation and maintenance

The operation and maintenance entail activities that cover the solar system's lifetime. This stage includes metering and communications, insurance, warranty, aggregation of output and sales and maintenance activities such as breakdown management, cleaning solar glass, and repair works. The activities require skills involving construction workers, safety experts, industrial, electrical and telecommunication engineers, operators, technical personnel, administrative and accountant personnel, lawyers, and experts in energy regulation. Ortega et al. (2015) observe that jobs created at the operation and maintenance stage are stable, entail significant local component, and have an intermediate level of specialization. In addition, given that the O&M activities are extended to the project lifetime, the O&M induce permanent jobs which start the first year the plant operates and end with the lifetime of the plant (Ortega et al., 2015).

5.1.2 Solar PV products volume of business

The application of solar PV power generation takes three forms: distributed solar PV power generation systems, large-scale grid-connected solar PV power plants, and micro-grid power generation systems complemented by multiple energies. While large-scale ground-based solar PV power plants account for the largest share of the total installed capacity in mainstream markets in Europe, China, and the US, small-scale distributed solar power generation units and standalone home systems account for the largest share of the solar systems in latecomer markets such as Kenya.

Figure 7: Authors' analysis from GOGLA global off-grid solar market report



According to GOGLA global off-grid solar market report, Kenya dominates the market for off-grid solar products in Sub-Saharan Africa. Analysis of the 2019 market report indicates that Kenya accounted for 38 per cent of the total sales of off-grid solar lighting products and 43.4 per cent of solar appliances in Sub-Saharan Africa (GOGLA, 2018). The off-grid solar lighting products include portable lanterns, multi-lighting and charging systems, solar home systems while the solar appliances include TVs, refrigerators fans, and solar water pumps.

5.2 Employment Creation Potential along the Solar PV Value Chains

5.2.1 Employment elasticity

We start our analysis by computing employment elasticities as shown in Table 3 below. Employment elasticity measures the percentage changes in employment induced by changes in GDP, and hence it seeks to capture the responsiveness of the labour market with changes in GDP.

Table 3: Employment elasticities

Year	Employment	Contribution to GDP	Employment Elasticity (Point)	Employment Elasticity (Arc)
2012	14,253	48,194	N/A	N/A
2013	14,569	53,901	0.1872	0.1961
2014	15,280	55,190	2.0407	2.0159
2015	16,925	89,358	0.1739	0.2161
2016	17,306	131,617	0.0476	0.0582
2017	18,934	145,693	0.8796	0.8850
2018	19,112	159,217	0.1013	0.1055

Source: Authors computations using data from KNBS Statistical abstracts

The results tabled above shows outputs of both point and arc elasticities since we did not have a long series to carryout OLS estimates. We have data for only seven years (2012-2018), which implies only six employment elasticities can be computed. According to the computed employment elasticities listed in Table 3, it is possible to infer that average employment elasticity for the electricity sector is 0.57 using point elasticity and 0.58 using arc elasticity estimation method. It is important to note that 2014 had employment elasticity over unity (2.0407), which implies that one per cent growth in electricity sector GDP leads to more than one per cent growth in employment in the sector. High employment elasticity in 2014 could be explained by the upswing expansion of infrastructure led by the Jubilee coalition administration, as outlined in the manifesto in alignment with the Kenya Vision 2030. Using the average employment elasticity of 0.57/0.58, it is safe to infer that a one per cent growth in the electricity sector GDP leads to less than one per cent growth in employment in the sector. To be precise, one per cent growth in the electricity sector GDP leads to 0.6 per cent growth in employment in the sector. Due to lack of data on Solar PV, the electricity sector will be used as a proxy sector since Solar PV is a sub-sector of the electricity sector.

Lack of disaggregated data for the solar PV sector is one of the major limitations of this study in computing employment elasticities for solar PV instead of the electricity sector. In the future, KNBS could purpose to capture disaggregated data pertaining to the solar PV sector in both KIHBS and statistical abstracts. It is important to capture employment under the Solar PV sector and sector contribution to national GDP. Capturing different occupations under Solar PV will go a long way in domesticating solar PV value chain and computation of sectoral labour skills analysis.

5.2.2 Employment creation at each point of the Value Chain

Table 4: Employment creation at each point of the value chain

Year	Installed Capacity (MW)	R&D	Manufacturing	Distribution	Installation	O&M	Total
2012	12	24	120	48	396	396	996
2013	27	54	270	108	891	891	2,241
2014	47	94	470	188	1,551	1,551	3,901
2015	68	136	680	272	2,244	2,244	5,644
2016	88	176	880	352	2,904	2,904	7,304
2017	112	224	1,120	448	3,696	3,696	9,296
2018	143	286	1,430	572	4,719	4,719	11,869
2019	198	396	1,980	792	6,534	6,534	16,434
2020	250	500	2,500	1,000	8,250	8,250	20,750
2021	252	504	2,520	1,008	8,316	8,316	20,916
2022	422	844	4,220	1,688	13,926	13,926	35,026
2023	492	984	4,920	1,968	16,236	16,236	40,836
2024	582	1,164	5,820	2,328	19,206	19,206	48,306

Source: Authors computations using data from EPRA and IRENA

Since employment elasticities were calculated using the electricity sector other than the solar PV sub-sector, having a look at the absolute numbers of employment creation in solar PV will be informative. In this section, we use information obtained from IRENA, which estimates the number of jobs created per MW installed at each node of the solar PV value chain. The other variable other than jobs created per MW installed is the cumulative installed capacity of solar PV in Kenya as provided by EPRA. Using the approach explained under the methodology section, Table 4 represents the output indicating the cumulative number of jobs created at each node. According to the output, operation and maintenance and construction and installation indicates the nodes where more jobs are created, with manufacturing and distribution taking the third and fourth positions, respectively. Research and Development (R&D) creates the least number of jobs in the whole solar PV value chain, being ranked number five and the last in terms of job creation. Statistically, R&D, manufacturing, distribution, installation, and operation and maintenance contribute 2%, 12%, 5%, 40%, and 40% of the total jobs created along the value chain, respectively.

In general, job creation in the solar PV value chain has been increasing over time since 2012, where total jobs created across the value chain was 996 and 11,869 total jobs across the value chain in 2018. Using cumulative jobs created across the value chain between 2012 and 2018, the compounded annual growth rate over the period is estimated to be 51%. According to the projections of installed capacity by EPRA, solar PV employment numbers will be around 48,306 in 2024. We estimate the compounded annual growth rate for the forecasted period (2018 to 2024) to be 26%. This is a clear indication that if solar PV is given the right amount of focus as one of the main sources of energy in Kenya, it is could create many jobs for the youth and hence help in reducing youth unemployment rate.

5.3 Labour Skills Requirements of the Solar PV Chains

Table 5 gives a snap check view of the whole electricity sector skills gap analysis due to missing data on the solar PV sub-sector. This analysis is intended to give a bird's-view analysis of the whole electricity industry, which will be used to inform solar PV potential employment in the long run. The occupations identified are informed by the Kenya National Occupation Standards (KNOCs) and ISIC. Placing the number of people employed at each occupation is informed by the required qualifications of each occupation, which we use education level-years of schooling as a proxy.

Table 5: Skills gap analysis

	No Education	Primary Education	Post-Pry Education	Secondary Education	Certificate Education	Diploma Education	Degree Education	Post-Degree Education	Total
Skills supply	2,696,202	2,600,476	23,204	149,225	18,632	25,631	23,144	5,650	5,542,164
Skills requirement				3,221	439	39,374	15,618		58,652
Electrical, electronics and telecommunication							3,832		3,832
Electrical engineering technicians						23,151			23,151
Electronics and telecommunications engineers							11,786		11,786
Electrical linesmen and cable jointers				3,221					3,221
Electrical equipment fitters and installers						3,347			3,347
Electrical equipment fitters and service						6,872			6,872
Power generating plant operators					439				439
Electrical and electronic machinery assemblers						6,004			6004
Skills gap (skills supply-skills requirement)	2,696,202	2,600,476	23,204	146,004	18,193	-13,743	7,526	5,650	5,483,512
Skill availability ratio (skills supply/skills requirement)	x	x	x	46.33	42.44	0.65	1.48	x	94.49

Source: Authors computations using KIHBS 2005/6 data

As per the analysis populated in Table 5, the skills gap analysis was based on secondary, certificate, diploma and degree education levels for which skills requirement data was available for analysis. All the education categories analyzed, other than diploma education level, have skills surpluses; that is, skills supplied to the sector exceed skills required by the sector, implying that for these education levels other than diploma, skills required in the sector exist in the youth population (target group). Diploma education level depicts the presence of skills gap, which implies that skills required by the sector exceed the skills supplied by the target group (youth population). This means that most of the employees required in the electricity sector need to possess specialization offered at the diploma level. If the youth do not supply skills required by the sector, this gap is filled by the non-youth population, which results in more youth being unemployed due to lack of required skills. A limitation of skills gap is that it only informs whether the skills exist in the youth population as a whole. Since it reports the skills of the whole population, it does not take into account that not all the youth will be employed in the electricity sector, because the skills will be absorbed by other sectors in the economy.

In mitigating the limitation of skills gaps analysis, skills availability ratio as an alternative measure is used. Skills availability ratio measures skills available in the youth population against skills required by the sector, and it is calculated by dividing skills supply by skills requirement((skills supply (youth))/(Skills requirement))

When the skills availability ratio is large, it instills confidence that skills required by the sector will be accessed by the specific sector and when the ratio is small, there is concern whether the skills available in the youth population will be attracted by a specific sector. According to the literature, skills availability ratio greater than 10 is considered sufficient enough for the sector to attract the skills needed.

Looking at the analysis in Table 5, the skills availability ratio depicts that unemployed youth population with secondary and certificate education have the potential of supplying the required skills to the solar PV sub-sector in Kenya, since the ratios are more than 10, while diploma and degree holders raise concern whether solar PV sub-sector will be able to attract diploma and degree skills need.

5.4 Constraints to the Growth of the Solar PV Value Chain

A focused group key informant interview with a total of 6 respondents was undertaken that informed the challenges impending the solar PV investment in Kenya (Table 6).

Table 6: Systematic analysis of Constraints to Growth of Solar PV Industry

Economic Barriers	Economic barriers entail issues on affordability and user returns and financing and bankability. The identified economic barriers include: • High capital, installation, and maintenance costs • The long payback period for investment in solar PV project • Liquidity and credit constraints. Energy efficiency projects such as the solar PV projects perceived as a high-risk investment • Lack of appropriate financial schemes for low-income markets • Weak after-sales services in rural areas; can lead to disuse of installed systems

Systematic Barriers	The systematic barriers entail government policies, goals, and strategies that influence technology diffusion. The identified systematic barriers include: • Constraining policy and regulatory directions. The Energy Act 2019 limits potential domestic net-metered customers from increasing their solar PV system above 1 MW and caps the Feed-In-Tariff power generation companies at 100 MW • Solar energy-related equipment are still subject to taxation, which increases the cost of solar PV products and decreases solar energy market opportunities • Tax concession on fossil fuels under the Petroleum Act implies government continued pursuit of non-renewable energy sources remains a disincentive to invest in renewable energy technologies such as solar • The lack of transmission and distribution network in areas that are endowed with solar resources in Kenya
Technical Barriers	Economic barriers entail issues on affordability and user returns and financing and bankability. The identified technical barriers include: • Low-quality standards for PV systems in the market, and rising counterfeits and pirated products. • Lack of knowledge and capacity for implementing solar PV system; architects and planners have insufficient knowledge about PV systems and do not offer them to potential adopters • Limited installation space in urban areas • Low presence of local manufacturers • Low conversion efficiencies of the solar PV modules • Shorter battery operating life relative to the modules • Lack of engineers and local technicians with relevant skills built and solar infrastructure • Lack of flexible system capacity (as per user's requirement) • Inadequate spare parts availability towards the repair

6. Conclusion and Policy Implications

6.1 Conclusion

While the contribution of solar PV technology to energy security and mitigation of climate change is significant in both developed and developing countries, research on the employment potential of the solar PV industry remains under-explored particularly in developing countries such as Kenya. Empirical literature and trend analysis indicate that solar energy technologies create more than twice the number of jobs per unit of electricity compared to fossils fuels (UKER, 2014) and the solar PV industry is the leading source of job creation compared to other renewable energy sources (IRENA, 2019). Given the accelerated growth of the solar PV industry in Kenya, the potential for direct and indirect jobs and productive use is robust. Therefore, a value chain analysis of the solar PV industry that the current study adopts enables the evaluation of the job potential of the industry in Kenya. The major key findings from the study include:

The leverage point along the value chain

The solar PV industry in Kenya has limited localized manufacturing and assembly with only two firms engaging in the manufacture of solar panels and batteries, implying that the country does not have a robust R&D and manufacturing base for solar PV systems. This implies that employment creation is mainly in the other stages of the value chain: distribution, installation, and operation and maintenance. To maximize the opportunity presented by the accelerated growth of the industry, there is need to leverage local content by localizing assembly and manufacturing of the solar PV systems, which will not only contribute to decline in the prices of the solar systems but would also contribute to the government increasing share of manufacturing in the Gross Domestic Product (GDP). This would imply the need for building in the technological capacity of enterprises through business incubation incentives and the provision of supportive infrastructure that promotes industrial clusters.

Constraints that hamper the industry growth

The systematic review of the literature provides an analysis of the inherent constraints to the growth of the solar PV industry. High capital, installation, and maintenance costs; limited financial schemes for solar PV investments; constraining policy and regulatory directions; limited transmission and distribution network in solar energy-rich areas; the low presence of local manufactures; skills unavailability and inadequacy are the key constraints limiting the industry growth.

Job creation potential

The estimated employment factors for the solar PV industry in Kenya demonstrates a positive contribution to the labour market by creating jobs across the Solar PV value chain. Statistically, R&D, manufacturing, distribution, installation, and operation & maintenance contribute 2, 12, 5, 40, and 40 per cent of the total jobs created along the value chain, respectively. The employment factors for solar PV recorded compounded annual growth rate of 51 per cent between 2012 and 2018 and 26 per cent for the forecasted period between 2018 and 2024.

Skills requirement

The diversity of the activities along the value chain implies that the industry requires a wide diversity of skills, ranging from an electrician and chemical engineers, technicians, plumbers, construction workers to planners, administrators, marketers, legal experts, financial specialist, all with diversified specializations. Using education level as a proxy for skills, all the education categories other than diploma education level have skills surpluses. The skills availability ratio depicts that unemployed youth population with secondary and certificate education have the potential of supplying required skills to the solar PV sub-sector in Kenya, while diploma and degree holders raise concern whether solar PV sub-sector will be able to attract diploma and degree skills needs of this sector.

6.2. Policy Implications

The literature demonstrates that the stability of the policy framework has been a fundamental prerequisite of the successful development of the solar PV industry in front runner economies. It is imperative, therefore, that Kenya adopts the right policy instrument to ensure the development of the solar PV industry. The study findings are particularly imperative for policy makers when framing the case for the deployment of solar PV systems in Kenya.

1. Establishing a robust solar PV industry requires needs strong policies to incentivize private sector investments and change from fossil-fuel dominated energy framework. Kenya could draw lessons from China that adopted solar PV deployment as an intervention tool for poverty alleviation where policy permitted individuals and enterprises in poverty-stricken rural areas to set up PV power stations and supply power to the grid.
2. Improve the implementation of the existing solar PV policies. There is need to provide a legal framework for renewable energy auctions to enable competitive

bidding of FiT projects as proposed in the National Energy Policy 2018. Energy auctions would create competition among developers and investors to offer lower prices, which would translate to lower prices for consumers.

3. Financial support for solar PV project developers: The current regulatory and policy framework outlines that the construction, upgrading of transmission/ distribution lines are undertaken at the cost of the developer, and upfront payment of the connection cost by the developer as opposed to the recovery of the cost through the supply of electricity, which limits the private investment in large scale solar projects.
4. There exists uneven data on renewable energy technologies, particularly labour market data, underscoring the significance of maintaining a systematic database at sufficiently disaggregated levels.
5. To stimulate employer demand for solar PV skills, there is need to provide incentives that accelerate localization of the portions of the value chain, particularly the manufacturing of solar PV systems by leveraging the domestic content. To realize this, there is need to adopt policies that promote knowledge and technology accumulation, new business incubation, promoting industrial clusters, and provision of supportive infrastructure.
6. Given the rapid growth of the large renewable energy sector, there is need to enhance skills-building efforts that could be realized through coordination between the Technical and Vocational Education Training (TVET) and the renewable energy sector. The coordination is imperative in ensuring that renewable energy modules and apprenticeships are integrated into vocational training courses.
7. Given that renewable technologies particularly solar PV are off-grid and decentralized, they offer tremendous opportunities for women involvement in the solar PV value chain. It is therefore important that social and economic policies address legal and social barriers that gender-specific barriers including limited access to finance, inequity in ownership of assets, insufficient skills, and training opportunities that would limit the participation of women in the solar PV value chain.

6.3. Limitations and Areas for Further Research

This study is not without limitations and reservations. Given that renewable energy is not included in the national statistics classification systems, estimating employment in the solar PV is limited without primary data collection studies. The study does not eliminate the effect of renewable subsidization policies such as zero-taxation that ideally reduces the prices of the solar PV products, which if not provided could result in negative employment effect, lower employment factors. In addition, the effect of a shift from the importation of the solar home systems to domestic manufacturing would result in an employment shift, a factor that the current study does not control for. Therefore, we recommend further systematic research accounting for the effect of policy intervention or market intervention to provide more information for comprehensive conclusion and validation for the current research results. In addition, undertaking field surveys, and collecting firm's up-to-date employment figures along the value chain phases would enrich employment intensity data available to support policy interventions when framing cases for the solar PV industry.

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