POWER FOR ALL

Schneider Electric Foundation

The Rockefeller Foundation

Powering Jobs Census 2019: The Energy Access Workforce

Contents

Foreword

Many of us working in energy access know from first-hand experience that solving energy poverty is no longer a technological issue. We have seen what happens when people who, by necessity, rely on kerosene or diesel for light and power, gain access to a clean energy alternative like a solar home system. Customers demonstrate with millions of off-grid purchases that they want to create sustainable energy access for themselves, their families, and their communities.

Just as importantly, hundreds of decentralized renewable energy (DRE) companies around the world have shown how mini-grids or rooftop solar systems can deliver clean energy access at pace and scale while also creating meaningful job opportunities for the energy poor. The impact of organizations like Solar Sisters and Barefoot College, or companies like Mlinda, d.light, Claro, and Powerhive, demonstrate the symbiotic relationship between achieving Sustainable Development Goal (SDG) 7, defined as access to affordable, reliable, sustainable, and modern energy for all, and SDG 8, defined as inclusive and sustainable economic growth, employment, and decent work for all. The impact potential is enormous: today, there are an estimated 370,000 jobs in the off-grid lighting sector in Asia alone. By 2030, the entire DRE value chain, including sales, installation, service, appliances, and operations and maintenance—is projected to create 4.5 million jobs globally.

However, there are challenges that limit the DRE sector's ability to accelerate adoption of clean technology and deliver energy access: last mile delivery, adoption at scale, leveling the playing field, and financing. Solving these requires creativity, ingenuity, and tenacity. In short, it is the collective skills, knowledge, and intangible assets of humanity that will make or break SDG 7. Despite the importance of human capital to the spread of DRE technology, there has yet to be a coordinated global effort to develop a DRE-specific human capital pipeline to meet the needs of this rapidly growing sector.

Together, with our research partners the Council on Energy, Environment and Water in India and Strathmore University in Kenya, Power for All is pleased to present the first annual Powering Jobs Census. Generously supported by lead sponsors Schneider Electric Foundation and The Rockefeller Foundation, Powering Jobs offers a comprehensive job census for the DRE sector. This census is the first of its kind, bottom-up count of employment in the DRE sector for emerging economies, capturing a full year of employment data from 2017–18. Nearly 150 companies in India, Kenya and Nigeria were surveyed across the DRE technology spectrum, including solar lanterns, solar home systems, solar irrigation, commercial and industrial solar systems, and mini-grids, representing the largest dataset on DRE jobs in emerging markets known today.

Scaling this sector, now widely acknowledged as a critical part of rural electrification and universal energy access, requires a skilled, engaged workforce. But until our sector can prove that DRE technologies deliver sustainable energy and real jobs, the potential speed of access will be hampered by a lack of compelling, defensible benefits. With this study, Power for All hopes to provide a baseline that better enables the entire energy access ecosystem, from traditional utilities to civil society organizations, to make informed decisions about both electrification strategies and the associated development impacts on job creation. This study shows that while the potential for direct DRE jobs is large, the potential for informal and productive use jobs may be far larger. As such, while our initial findings from these first three countries are important, we need more information across an expanding range of countries, companies, and energy types to understand the development outcomes of DRE sector jobs worldwide.

With just over 10 years to go, the global community is facing a critical deadline: in order to have the workforce of 2030 delivering energy at scale, we must immediately begin developing the skills required and expose a growing young workforce to this expanding sector. The results from the Powering Jobs census are just the beginning of exploring the linkages between SDG 7 and SDG 8 and understanding the potential for the DRE workforce to become one of the major job engines of emerging economies.

Kristina Skierka
CEO, Power for All

Executive Summary

This report presents the results of the first annual jobs census for the decentralized renewable energy (DRE) sector, which includes a range of solutions that allow for generation and distribution of clean electricity at or near end-user communities. Scaling this sector, now widely acknowledged as a critical part of rural electrification and universal energy access [1], requires a skilled, engaged workforce. With adequate policy and financial support, the DRE sector could contribute directly to ameliorating high unemployment in emerging economies and least developed countries (LDCs). However, little data exists to support such targeted policy. Power for All thus conducted an inaugural jobs census in 2018, which captures DRE employment data from 2017, to establish a baseline that explores the linkage between clean, universal energy access, Sustainable Development Goal (SDG) 7, and decent work, SDG 8, with a particular focus on the role of DRE technologies. Based on survey findings, this report explains the current DRE workforce landscape, from employment estimates to skills needs, and lays the groundwork for raising awareness about the available jobs in energy access, and the need to build a strong workforce that has access to decent work and social protection.

The survey explores companies working across a wide range of DRE technologies in three low energy access countries: India, Kenya, and Nigeria. Together, they represent different sizes and stages of DRE market development. The DRE technologies covered in scope include pico-solar appliances, solar home systems (SHS), standalone and grid-tied commercial and industrial systems, mini-grids, and productive use systems such as solar water pumps. The survey covered DRE companies working in off-grid and weak-grid contexts. By surveying companies directly working with DRE technologies, the resulting analysis draws clear, quantitative insights into employment in the DRE sector, including the quality of compensation, women and youth representation, and key skills demands. Key stakeholders across India, Kenya, and Nigeria also participated in focus groups to discuss their experiences and develop recommendations based on the data. Below, we highlight our four key research findings and recommendations. See Appendix A for all relevant definitions.

1. The DRE sector has emerged as a significant employer in emerging markets. Although nascent and just beginning to scale, it has already grown a workforce comparative to traditional utility-scale power sectors, and is expected to more than double by 2022–23, according to our early estimates.

» In 2017–18, the DRE sector in India provided 95,000 direct jobs as compared to 92,400 jobs from the on-grid solar sector. In Kenya, the sector accounted for 10,000 direct jobs as compared to 11,000 by Kenya Power and Lighting Company. In Nigeria, the sector accounted for 4,000 direct jobs, as compared to 10,000 jobs in the electricity, gas, steam, and air conditioning sector, according to official statistics [2]–[4].

» By 2022–23, the DRE sector could provide as many as 190,000 direct, formal, full-time equivalent jobs in India under a high mini-grid penetration scenario, 17,000 in Kenya, and more than 52,000 in Nigeria. This would represent a 100% and 70% increase over 2017–18 in India and Kenya respectively, and more than a tenfold increase in Nigeria.

» Our study projections show that the DRE sector is on track to provide more than 260,000 direct, formal jobs in just three countries by 2022–23, and the worldwide number is even larger given that many other emerging economies have now established DRE targets.

2. Compared to direct, formal employment, the DRE sector employs twice as many workers through informal jobs and five times as many through productive use jobs, both critical as informal work is the largest source of employment for most LDCs.

» These are difficult job sectors to accurately assess, but early estimates suggest that in 2017, the DRE sector accounted for 210,000 direct, informal jobs in India, 15,000 in Kenya, and 9,000 in Nigeria—almost double the sector's direct, formal workforce.

» By 2022–23 the sector could provide as many as 210,000 direct, informal jobs in India, 30,000 in Kenya, and 24,000 in Nigeria.

» Rough estimates of productive use jobs stimulated through new or improved electricity access in 2017 are 470,000 in India, 65,000 in Kenya, and 15,000 in Nigeria—five times the size of the DRE sector's direct, formal workforce.

» People working at informal jobs tend to be employed for less than a third of the time compared to formal jobs, and are paid as little as one-tenth the wages of a formal job.

» Potential job displacement caused by fuel switching and/or other losses is not estimated. Stronger data on informal work and productive use job creation is critically needed by the sector.

Executive Summary

3. Pico-solar appliance and SHS companies are currently the job engine of the DRE sector, though employment from mini-grids is likely to grow, match and potentially exceed standalone solar in some regions.

- Pico-solar appliances and SHS accounted for 97% of India's total direct, formal DRE employment in 2017–18. The equivalent numbers for Kenya and Nigeria are 75% and 25% respectively. Many of these were associated with government initiatives.
- As more national electrification strategies put focus on mini-grids and productive use applications, such as solar water pumps, the nature of employment in the sector may evolve.
- For instance, ambitious mini-grid plans in Nigeria mean that by 2022–23, mini-grids could account for 96% of the 52,000 anticipated direct, formal DRE jobs.
- These estimates are speculative and depend on the actual growth rate of the various DRE technology markets, but show the nature of the DRE workforce and how it could shift over time.

4. The DRE sector requires a highly skilled workforce. Sales and distribution skills are important to sustain the sector, while management skills represent a critical gap for unlocking further sectoral growth.

- More than two-thirds of the DRE workforce is skilled, compared to 50% of the global utility-scale solar sector workforce [5].
- Pico-solar appliance and SHS companies depend heavily on large, informal workforces for product sales through distributed networks. Sales and distribution is the largest DRE job category in India and Kenya, while Nigeria relies less on sales and distribution.
- In Nigeria, demand is strong for people with project operations and management skills, especially as mini-grids are projected to create more than half of total DRE jobs by 2022–23. This requires a very different skill portfolio from the SHS sector.
- Across all countries surveyed, management and business positions only comprise a fifth of the sector's direct, formal jobs. Unfortunately, this is reported as the most critical and difficult skill set to recruit, representing a significant skills gap.
- Employee retention for direct, formal jobs in the DRE sector averages more than 30 months for all three countries. This is longer than the jobs created by the utility-scale renewable sector. Thus, direct, formal DRE sector jobs are predominantly skilled and long term.

5. Women's participation in the formal DRE workforce is low while youth participation is high. However, women's participation in the informal DRE workforce is high.

- On average, women make up about a quarter of the direct, formal workforce, though this is comparable with the broader global renewable energy sector, in which women account for 32% of the workforce [6].
- The percentage of women taking up leadership roles is even lower: less than one-fourth of senior managers in DRE companies are women.
- Conversely, the percentage of women engaged in informal work is high. In India, women account for as much as 60% of informal jobs. This may be due to the recognized importance of women in rural sales and distribution networks.
- In India and Kenya, more than 40% of the workforce are youth, compared to more than 28% in Nigeria.
- DRE companies agree there is more opportunity for participation of women and youth in the workforce if the challenges of business culture, recruitment, and skill development can be overcome.

These insights highlight the job creation potential of the DRE sector, its impact on gender and youth, and its skills needs, leading to a series of key recommendations, discussed in Chapter 5.

About

Coordinated and led by Power for All, Powering Jobs and the job census are made possible with the generous support and encouragement of Schneider Electric Foundation and The Rockefeller Foundation.

Power for All

Power for All is a stakeholder coalition campaigning to rapidly scale the deployment of decentralized renewable energy in order to achieve universal electricity access before 2030. Decentralized renewables, specifically solar appliances and systems designed for households, businesses, and productive use, offer the fastest, most affordable, and cleanest path to electricity access for all. Power for All brings together more than 250 business, finance, research, and civil society organizations to achieve that goal.
powerforall.org

Schneider Electric Foundation

In a world where social and environmental challenges are more widespread and more urgent than ever, the Schneider Electric Foundation supports innovative and forward-looking initiatives to give as many people as possible the energy they need to succeed. It is this pioneering spirit that the Schneider Electric Foundation is seeking to advance. We see our role as a catalyst for technological, social and entrepreneurial innovation helping to close the energy gap and striving for a more equitable energy transition around the world. Ever optimistic, the Schneider Electric Foundation's aim is to help build a fairer, lower-carbon society to give future generations the keys to transform our world.
schneider-electric.com/en/about-us/sustainability/foundation/

The Rockefeller Foundation

The Rockefeller Foundation advances new frontiers of science, data, policy and innovation to solve global challenges related to health, food, power and economic mobility. As a science-driven philanthropy focused on building collaborative relationships with partners and grantees, the Foundation seeks to inspire and foster large-scale human impact that promotes the well-being of humanity throughout the world by identifying and accelerating breakthrough solutions, ideas and conversations.
rockefellerfoundation.org

Acknowledgments

Our Powering Jobs partners contributed to data collection, analysis, interpretation of results, and feedback on the report. Steering committees and peer reviewers provided expert guidance.

Local Research Partners
Council on Energy, Environment and Water
Strathmore Energy Research Centre

Global Steering Committee
Africa Mini-Grid Developers Association
Alliance for Rural Electrification
CLASP
International Energy Agency
International Labour Organization
International Renewable Energy Agency
International Solar Alliance
International Solar Energy Society
Schneider Electric
Skill Council for Green Jobs
United Nations Women
World Bank ESMAP
Youth in Energy

Country Steering Committees
AnthroPower
Centre for Petroleum Energy Economics and Law
Clean Energy Access Network
Council on Energy, Environment and Water
Don Bosco Tech Africa
Don Bosco Tech Society
UNEP DTU Partnership
Fuzu
GIZ
HR Madam
IFC Lighting Asia
IRADe
Kenya Renewable Energy Association
LEDsafari
Kenya Ministry of Agriculture, Livestock, Fisheries and Irrigation
Nigeria National Board for Technical Education
National Power Training Institute of Nigeria
Natural Resource Defense Council
Nigerian Climate Innovation Centre
One Campaign
The Osasu Show Network
Practical Action
Renewable Energy Association of Nigeria
Renewable Energy Technical Training Institute
Rise Network
Schneider Electric
SELCO Foundation
Strategy and Innovation for Development Initiative
Strathmore Energy Research Centre
Tech Her
ToolKit Institute
University of Ibadan
United Nations Energy Programme
UN Women
WRI India

Peer Reviewers
- Jessica Stephens, Africa Mini-Grid Developers Association
- Tapera Jeffery Muzira, African Development Bank
- Jens Jaeger, Alliance for Rural Electrification
- Pritisha Uttamchandani, CDC Group
- Akachukwu Okafor, Change Partners International
- Yasemin Erboy Ruff, CLASP
- Susanne Hounsell, East Africa Energy Analytics
- Mercy Rose, Energy 4 Impact
- Julie Cammell, GOGLA
- Susie Wheeldon, GOGLA
- Maimuna Kabatesi, Hivos
- Anjali Garg, IFC Lighting Asia
- Balasubramanian Viswanathan, International Institute for Sustainable Development
- Marek Harsdoff, International Labour Organization
- Celia García-Baños, International Renewable Energy Agency
- Thomas Andre, REN21
- Clare Boland Ross, The Rockefeller Foundation
- Emilienne Lepoutre, Schneider Electric Foundation
- Tanmay Bishnoi, Skill Council for Green Jobs
- Seemin Qayum, UN Women
- Dana Rysankova, World Bank
- Pamli Deka, WRI India

We also thank the survey respondents and focus group participants for providing invaluable data and insights.

1. Introduction: Energy Access and Decent Work

1.1. Motivation and Research Objectives

With the growing adoption of artificial intelligence and dramatic changes in global population demographics, the future of work is a source of major uncertainty, particularly in emerging economies.

The growing impact of climate change on precipitation patterns, heat stress, water availability, and extreme weather severely impacts productivity in Africa's largely rain-fed agricultural sector, deepening its food crisis. But this also affects the predictability and availability of work for millions in farming, which employs over 65% of the continent's labor force [7]. This is compounded by an increase in automation and mechanization, which reduces farm costs but jeopardizes traditional agricultural job opportunities. Meanwhile, as jobs grow scarce, recent improvements in healthcare access have lead to a youth explosion. Countries across sub-Saharan Africa, South Asia, and Southeast Asia are experiencing a youth bulge, defined as a situation where more than 20% of a country's population is between the ages of 15 and 24 [8].

While a young population can be a major boon to the local economy and a positive force for growth, if the capacity to create new jobs is not cultivated in tandem with the population increase, it will lead to massive unemployment, increasing dependency on the existing working population, and persistent poverty. Employment data suggests that women and youth are the hardest impacted by the dearth of employment opportunities, particularly those in rural communities [9]. Rural women, who make up the majority of agricultural and mining labor, are often unable to diversify away from these sectors even as employment opportunities decline, due to lack of education, traditional perceptions of gender roles, and a host of other sociocultural factors.

Thus, the scale of the challenge is enormous, as the latest statistics make clear: young men and women between the ages of 15 to 24 comprise 25% of the working-age population in India and over 34% in sub-Saharan Africa [10]. In fact, Africa's youth population is projected to double by 2050 to 840 million [11]. The youth unemployment rate is more than 10% in India, and almost 20% in both Kenya and Nigeria. This explains why the World Bank, in its *Jobless Growth* report, warns that India needs 8 million jobs per year to satisfy the number of young people looking for work [12], while over 10 million jobless youth are looking for work every year in Africa [13].

Amid this challenge, there is a major opportunity for employment through delivering energy access to almost 1 billion people [14]. Many low energy access countries are in the midst of an energy transition as solar, wind, and electricity storage displace fossil fuel, and rural electrification receives growing attention [15]. Decentralized renewable energy (DRE) solutions, including solar lanterns, solar home systems (SHS), standalone and grid-tied commercial and industrial (C&I) solar systems, solar water pumps and heaters, and mini-grids, are at the center of that transition. Experts suggest that DRE technologies can create a large number of direct jobs because of their growing market and distributed nature. A potential of 4.5 million off-grid, renewable energy, direct jobs could be created globally by 2030, which would account for more than one-sixth of the global renewable energy workforce, estimated to be 24 million by 2030 [16]. Importantly, in addition to direct jobs, there are clear signs that access to electricity is also creating productive use jobs within the communities gaining that access. Agriculture, the sector which still dominates emerging economies, is likely best poised to benefit from the potential of clean energy access to mitigate climate change, unlock productivity, and thereby boost near-term economic growth and local job creation. Energy access, food security, and livelihoods are inherently connected [17]. Thus, DRE technologies are not only a key part of the solution for achieving universal energy access, Sustainable Development Goal (SDG) 7, but are a direct solution to decent work and job creation, SDG 8.

According to a recent World Economic Forum report, human capital, which encompasses digital, technical, and vocational skills, is the area that is least prepared for the energy transition in emerging economies. In other words, the energy workforce of the future lacks the necessary skills to fully realize the transition [18]. National decision makers and their donors in sub-Saharan Africa, developing Asia, and other energy-poor regions have a unique opportunity to invest in the necessary resources to train the needed entrepreneurial, technical, financial, and managerial talent to deliver universal energy access and create millions of jobs. Otherwise, the lack of a skilled DRE workforce in emerging markets may hinder the achievement of government electrification targets, slow down the building of a more resilient energy infrastructure, and limit the potential of the energy sector to unlock major employment benefits. In the countries most vulnerable to climate change, the time to act is now.

However, a key barrier to informed decision making remains: the lack of quality data. There are few studies to date that provide an accurate job count for the DRE sector, and there is little quantitative data on the specific skills gaps that hinder sectoral growth. In late 2018, Power for All and a coalition of partners launched the Powering Jobs campaign with two goals: commissioning an annual jobs census for the entire DRE sector to understand its employment potential and using that data to create policy which centers around improving energy access and the needed skills training.

This job census is the first of its kind, bottom-up count of employment in the DRE sector for emerging economies. The survey captures DRE company employment data for 2017–18. Nearly 150 companies in India, Kenya, and Nigeria were surveyed across the DRE technology spectrum, including solar lanterns, SHS, solar irrigation, C&I solar systems, and mini-grids. It also covers the supply chain, from manufacturing and wholesale imports to sales, installation, and operations. This included DRE companies working in off-grid, weak-grid, or on-grid contexts. It is the most comprehensive job survey known to date, creating a baseline for future data collection and a profound understanding of DRE employment potential. The annual survey will expand its geographic scope each year. This report outlines the research undertaken and its key findings.

1.2. Report Structure

This report delivers an in-depth study on the current employment and skills needs of the DRE sector in three low energy access countries: India, Kenya, and Nigeria. They represent different market scales and levels of development. We use our findings to make recommendations for relevant stakeholders: governments, donors, the private sector, and civil society organizations. The report is structured as follows:

» **Chapter 1** provides a review of past and current literature related to DRE job creation and introduces the methodology, sample set, and key output metrics.
» **Chapter 2** details the findings from the analysis regarding the size of the current DRE workforce across the target countries.
» **Chapter 3** delivers deeper insights into the characteristics of the DRE workforce, exploring gender and youth balance, skills needs breakdown, recruitment challenges, and other topics.
» **Chapter 4** presents projections of future workforce size in the target countries based on survey findings, expected DRE market growth, and national policy goals.
» **Chapter 5** concludes with key insights and recommendations, while outlining the study's limitations and future research plans.

1.3. Literature Review: Past Studies on DRE Employment

To date there is little literature available on the relationship between energy access and job creation in low energy access countries. The Powering Jobs report aims to fill the data gap for DRE jobs by covering a wide range of DRE technologies and activities.

1. Introduction: Energy Access and Decent Work

Renewable Energy Jobs and Access by the International Renewable Energy Agency (IRENA) in 2012 was one of the first reports on DRE jobs. The IRENA study mapped employment factors from India on to the International Energy Agency's DRE scenarios and estimated global, off-grid, renewable, direct employment at roughly 4.5 million by 2030 [19]. Nevertheless, this estimate is limited by the generalizability of Indian DRE employment trends. Later IRENA studies on global renewable energy and jobs placed limited focus on DRE technologies.

The first major data collection effort on DRE jobs was in 2014, when Mills conducted the first job survey with a focus on LED lanterns, and their job displacement impact on kerosene lamps in Malawi and Kenya [20]. Starting in late 2018, Global Off-Grid Lighting Association (GOGLA) began publication of a three-part brief series on jobs. In 2018, GOGLA's first job brief estimated the off-grid solar sector can create 1.3 million jobs globally by 2022 [21]. In a more recent job brief, GOGLA estimated that of the 1.3 million jobs, 510,000 are medium and high skilled, while 800,000 are low skilled [22]. However, GOGLA's study is based on a survey of 40 companies, limiting even regional generalization. Another study by The Council on Energy, Environment and Water (CEEW) and Natural Resource Defense Council concluded that, in India, roughly 25 job-years are created for every MW of rooftop solar systems developed and installed [23]. With reference to mini-grids, the Energy and Environment Partnership Africa 2018 survey of its mini-grid portfolio found that 36 direct jobs were created per mini-grid, but did not specify how many of these were short or long term [24].

Productive use of electricity is defined as agricultural, commercial and industrial activity involving electricity as a direct input to the production of goods or provision of services [25]. Research into new jobs stimulated by productive use of electricity is even more scarce in the literature, although some studies have been done on income generation. According to Practical Action's review of past studies, only 24% of the literature studying the impact of productive use of energy found that employment increased from improved energy access, though most of these studies focused only on India and did not explore direct causal links [26]. On the contrary, both GOGLA in its *Powering Opportunities* report in 2016 and Acumen in its *Energy Impact Report* in 2017, concluded positive impact on income from newly acquired or enhanced energy access [27], [28]. Acumen's recent *Lean Data* study found that 18% of rural businesses surveyed had grown their workforce since purchasing a DRE product or service between 2016 and 2018. While such studies do not yet explicitly explore job creation, they indicate a positive linkage and highlight the need for deeper customer-oriented research [29].

Thus few studies to date directly explore job creation from the comprehensive range of technologies serving off-grid and weak-grid areas and across employment categories. Power for All's annual job census thus adds significantly to the DRE literature by providing the largest bottom-up study on jobs focused on DRE technologies in emerging markets and their local value chain. Below is a brief overview of the study scope and the three country markets included in this initial census.

FIGURE 1. TECHNOLOGY SCOPE

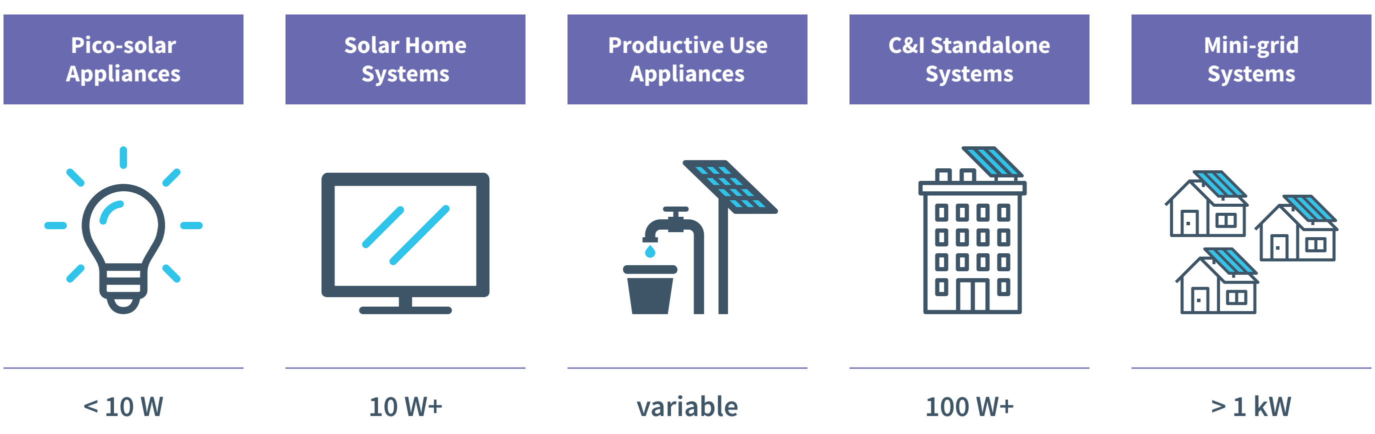
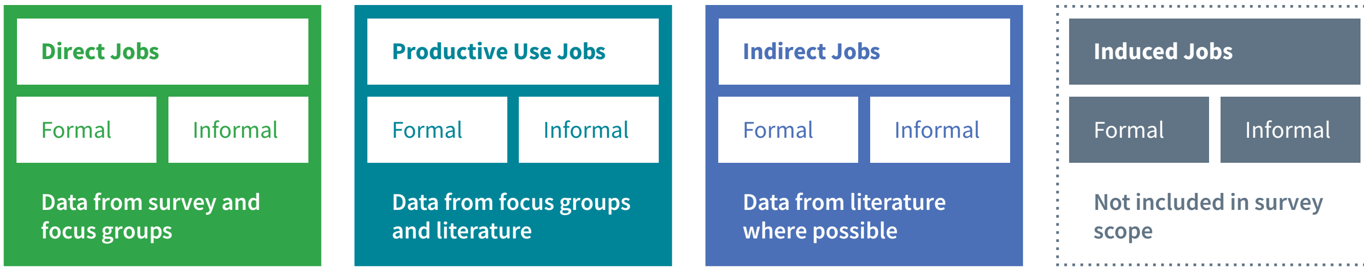


FIGURE 2. JOB CATEGORY SCOPE



1.4. Survey Scope and Key Definitions

To create a comprehensive baseline of employment generated by the DRE sector, Power for All and its local research partners, including Strathmore Energy Research Centre and CEEW, jointly conducted a survey of practitioners directly engaged in the DRE sector or servicing the sector. The survey was designed with specific scope criteria, which can be characterized as follows:

» **Country scope:** For the first year of the Powering Jobs campaign, the survey was conducted in India, Kenya, and Nigeria. As the largest DRE market in the world with 36% of global market potential [30], India is a key country to study. The survey covers companies across India, and does not target or disaggregate by state. Kenya's DRE market is one of the most mature in sub-Saharan Africa and has the highest product penetration of solar lanterns and SHS in the world, with more than 50% market penetration [30]. Nigeria has the largest potential DRE market in sub-Saharan Africa, complete with the most ambitious mini-grid program, yet has very low, but rapidly expanding, DRE market penetration [30]. These characteristics provide unique insights into the job and skill trends of DRE markets of different sizes and stages of growth, thus serving as an instructive starting point. See Table 1 for a summary of each country's key electrification and workforce metrics.

» **Technology scope:** The survey covers the breadth of DRE technologies, including small pico-solar products of less than 10 W that power a few bulbs and a phone charging station, SHS of roughly up to 200 W that power basic appliances such as TVs and refrigerators, standalone or grid-tied C&I systems that range from a few hundred W to multiple kW, solar water pumps, and mini-grid systems that can be a few kW up to 10 MW. The survey does not yet cover clean cooking technologies.

» **Value chain scope:** The survey covers the entire local DRE value chain, including manufacturing and assembly (where applicable, such as in-house manufacturing or customization activity of a SHS company), import, wholesale, sales and distribution, project development and installation, operations and maintenance (O&M), and other DRE services such as finance, software, and technical support. The scope excludes out-of-country operations, such as when manufacturing and assembly takes place primarily in countries like China and Germany. It also excludes end-of-life waste management, regardless of where it occurs.

» **Employment type scope:** The survey explores direct employment in the DRE sector, both formally and informally, as well as job creation stimulated through electricity access from DRE technologies. Productive use data is drawn from the literature and focus groups. Data on indirect jobs is drawn from literature where possible, whereas induced jobs are outside the current survey scope. See Figure 2 for job categories covered in the study and their data source.

The study uses survey data as its major input, alongside market estimates and other data from the literature, to estimate direct, formal, informal, and productive use jobs. For key employment terms used throughout the report, see Appendix A:

» **Direct, formal jobs** are those created through contractual engagement with an incorporated company in the DRE sector. For example, an IT professional or a project manager who is employed by a DRE company. The term "job" as used in this study is agnostic to the socioeconomic benefits that may accompany a full-time job, such as insurance.

» **The informal sector,** according to the International Labour Organization (ILO), comprises all work for unincorporated enterprises, and for which no complete accounts are available that would permit a financial separation of the production activities of the enterprise from other activities of its owner(s). Informal jobs can extend to include non-remunerative work of contributing family members, and can be difficult to bound definitively.

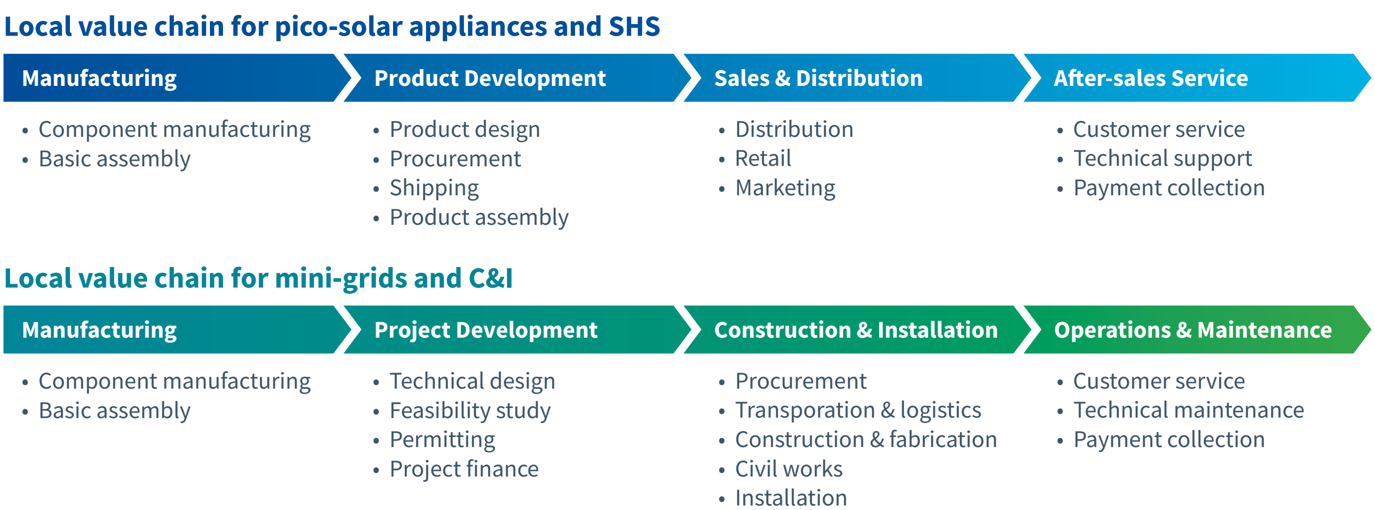
- **Direct, informal jobs** are informal jobs created through contractual or non-contractual engagement with an incorporated company in the DRE sector. Informal employment in the sector takes on various forms, from long-term arrangements with companies, like product retail, to commissioned sales, like a home business owner who works as the village sales representative.
- **Indirect jobs** are the formal and informal jobs created by vendors and suppliers who serve the DRE sector upstream or provide services for day-to-day operations either with or without a contract. For example, the jobs created by an inverter manufacturer or an importer who supplies DRE companies are indirect. Literature on indirect jobs is cited where available.
- **Productive use jobs** are those created by the DRE end users themselves as a result of newly acquired or enhanced electricity access. For the purpose of this study, productive use is defined as any income-generating application of a DRE product or service. An example would be the new jobs created by the purchase of a solar milling plant. Productive use jobs are estimated through insights from focus groups and literature, as most surveyed respondents did not readily have data on jobs created by their product or service at the customer level.
- **Induced jobs** are those created through forward linkages as workers in the DRE sector spend salaries on goods and services throughout the larger economy. For example, during the construction of a mini-grid plant, induced jobs are created for food vendors and water fetchers at the construction site. The study does not explore the macroeconomic effects of spending on the economy and further jobs this creates. Induced jobs are thus excluded from the analysis and this report.
- **A full-time equivalent (FTE) job** is equal to one employee working full time over the course of a year, where full-time work is defined in accordance with the country context. Part-time and contract work are converted to FTE based on hours worked or length of contract. Estimates of direct, formal jobs are presented in FTE job terms. References to jobs outside of direct, formal employment do not assume full-time equivalency.

1.5. Key Outputs and Analyses Conducted

Based on the sample set, this study provides employment estimates at the national level for each country. Full analytical methods are found in Appendix B. The three key outputs are:

1. A country-level estimate of gross DRE employment in 2017–18, including direct, formal, informal, and productive use jobs. This is achieved by multiplying an employment factor from the survey data and recent market estimates from existing literature.
2. By 2023, DRE employment, including direct, formal and direct, informal jobs, is estimated by applying the employment factors to projected market estimates based on official electrification strategies and unofficial energy access deployment projects.
3. DRE workforce trends, broken down by job function, gender

FIGURE 3. LOCAL VALUE CHAIN SCOPE



and youth representation, retention, and level of compensation. These analyses provide a high resolution view into the composition of the DRE workforce and shed light on needed skills.

This report provides an initial baseline and early estimate of DRE employment based on one year of company survey data and the available literature. Beyond the scope of this study, socioeconomic and macroeconomic exploration of local labor markets are required to fully understand potential job displacement, as well as induced, indirect, informal, and productive use jobs. Findings from this study should not be generalized. A thorough discussion of the study limitations is found in section 5.3.

1.6. Data Collection Methods

For each country, the respective partner research organizations determined the local DRE market size by sales, installed capacity, geographical representation, and the total number of companies. Contact information was sourced for as many DRE companies as possible to create a comprehensive database for each country. The target sample size was then determined to ensure a statistically relevant representation of the total market. See total company and sample size estimates for each country in Table 2.

To achieve a confidence level of 90% and a confidence interval of 10%, the target was 57 respondents in India, and 50 each in Kenya and Nigeria. Over the course of three months, the local partner research organizations contacted companies directly, being careful to ensure fair representation across company types and geography. A total of 139 organizations completed the survey: 36 in India, 52 in Kenya, and 51 in Nigeria. Due to the survey's timing, the difficulty of working across multiple states, and industry "survey fatigue," the response rate was lowest for India. While India's respondents included many major companies, results should be interpreted with caution. Effort will be made to improve the response rate and representation across company types and geography in future iterations.

TABLE 1. KEY ELECTRIFICATION AND WORKFORCE METRICS FOR INDIA, KENYA, AND NIGERIA

Description		India	Kenya	Nigeria
National household electrification goals		100% by 2019 [31]	100% by 2022 [32]	90% by 2030 [33]
2018 official national electrification rate, including on-grid and off-grid connections		99%[A] [34]	75%[B] [32]	60%[C] [1], [35]
2017 Global Tracking Framework national household electrification rate [36]		93%	64%	54%
2018 market penetration of solar lanterns and SHS (see definition in Appendix A) [30]		20%	50%	4%
2018 labor force participation rate (persons aged 15+ as percentage of total population) [10]		52%	66%	55%
2018 unemployment rate (unemployed persons as percentage of total labor force) [10]		3%	10%	6%
2018 youth unemployment rate (unemployed youth as percentage of total labor force)[10]		10%	18%	20%
2018 female unemployment rate (unemployed women as a percentage of total labor force) [10]		4%	9%	6%
Employment by sector in 2018:	Service	31%	35%	52%
	Industry	25%	8%	12%
	Agriculture	44%	57%	36%

[A] *Households unelectrified due to unwillingness or inability to pay are not considered.*
[B] *The electrification rate includes both on-grid and off-grid connections.*
[C] *However, among on-grid consumers, 43–45% get less than 4 hours of electricity per day.*

1. Introduction: Energy Access and Decent Work

That said, this sample is the largest dataset on DRE jobs known at the time of publication. Based on the response rates the resultant data set is statistically significant in Africa. However, these results cannot necessarily be generalized to other countries or regions.

To help contextualize findings of the quantitative survey data, qualitative focus groups were also held in India, Kenya, and Nigeria in December 2018. The convened focus groups comprised industry leaders, financiers, training institutes, and policymakers to validate findings and to discuss the most pressing workforce challenges faced by the DRE sector. A total of 13 representatives in India, 14 in Kenya, and 17 in Nigeria participated and provided expert opinion.

The focus groups discussed issues such as gender balance, youth engagement, technical and vocational education and training (TVET), productive use jobs, and interpretation of data findings. All survey implementation, focus group moderation, data analysis, and interpretation was conducted in partnership with local research partners and sector experts in each country.

1.7. Practitioner Groupings and Description of Resultant Sample Set

From the responses, most companies work across different types of DRE technologies and are engaged in multiple parts of the value chain, particularly pico-solar appliance and SHS companies. This makes it difficult to squarely account for jobs according to one technology type such as SHS, because many SHS companies are also engaged in selling pico-solar appliances. Further, employment cannot be solely associated with specific segments of the value chain because a majority of companies work across various parts of the value chain. For instance, some SHS companies work more in product distribution while others are also heavily engaged in project development and installation. Likewise, employees tend to cover a broad spectrum of functions even within a single company.

As such, survey respondents are broadly categorized into five practitioner groupings according to their business model and the market segments they serve based on their predominantly advertised market service or product offering. There is still overlap between some of these groupings. While this does not greatly affect total employment estimates, results cannot be generalized. The practitioner groupings are defined as follows:

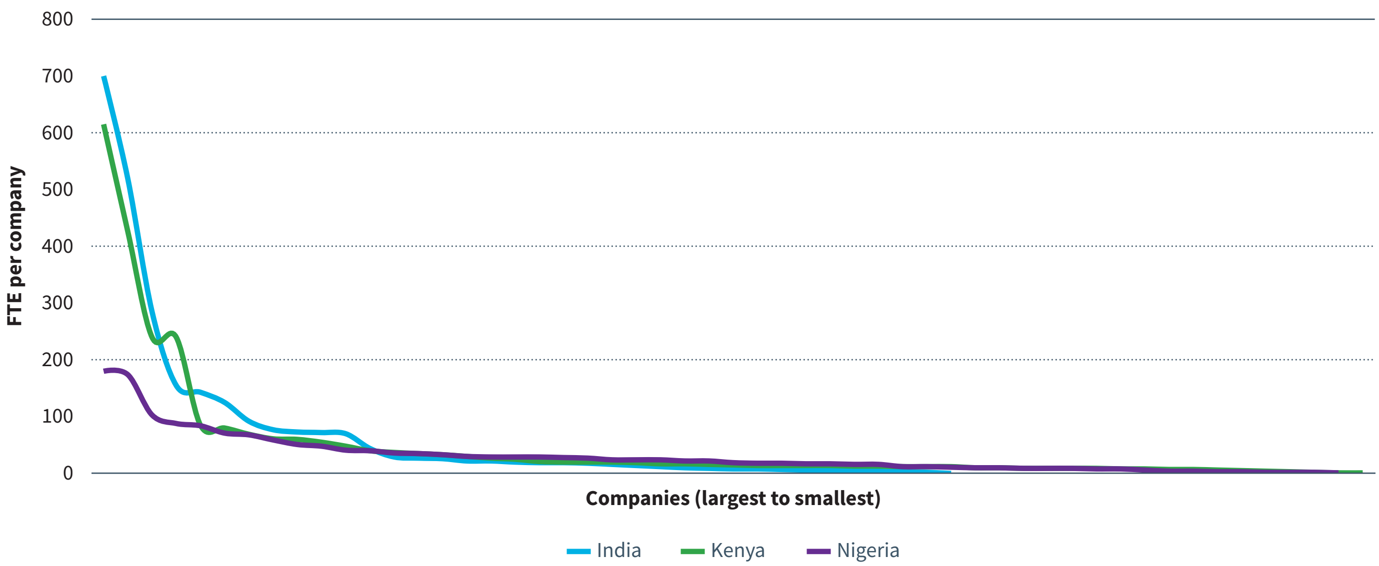
1. **End-user product providers** sell pico-solar appliances, SHS, solar water pumps, and/or other DRE products to end users. This group of companies get their main revenue from product sales, and interface directly with DRE end users.
2. **Project developers and installers'** revenue mainly comes from the development and implementation of projects instead of products. They develop and install C&I systems. They are usually involved in procurement of PV panels and batteries, site feasibility study, system design and development, construction, and installation. Note that the term project development here should not be interpreted as "pre-development," which is legal work, regulatory work, project design, and site development.
3. **Mini-grid operators** are private companies which operate and maintain mini-grid systems and are characterized by sales of electricity as an integrated part of their business model. Many mini-grid operators also design, develop and install projects. Companies which develop and construct mini-grids, but do not operate them, are considered project developers and installers.

TABLE 2. SURVEY SAMPLE SIZE AND STATISTICS

Country	India	Kenya	Nigeria
Estimated total companies*	300–350	150–200	150–200
Desired confidence level	90%	90%	90%
Desired margin of error	10%	10%	10%
Ideal sample size	57	51	51
Total survey responses	36	52	51
Estimated response rate	10%	25%	25%

**Total number of company estimates are based on detailed contacts lists for all companies known to operate in each country, compiled through data provided by country research partners and trade associations.*

FIGURE 4. DISTRIBUTION OF RESPONDENTS BY FTE ESTIMATE



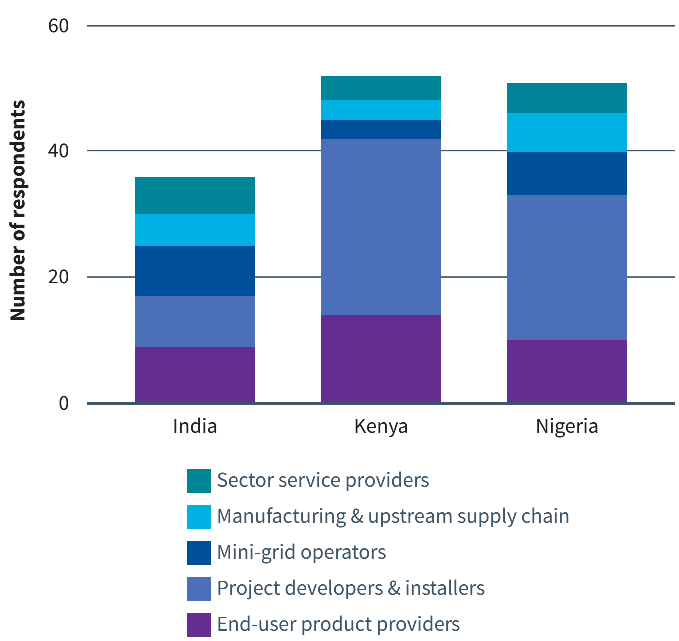
4. **Manufacturing and upstream supply chain** companies are those whose core business is in manufacturing, assembling, importing, and wholesale.
5. **Sector service providers** work closely with the DRE sector to provide services such as microfinancing for energy access, metering and software services, training, human resources, research, and advocacy.

In the survey sample, companies are represented fairly evenly across the different company types in each country, though Kenya and Nigeria had more responses from project developers and installers. In terms of geographical representation, survey respondents in India drew largely from north Indian states. Nevertheless, the study aggregates survey results in India to the national level.

Among the 139 survey respondents, there are outlier companies which employ significantly more workers than other companies, especially in India and Kenya. In Chapter 5, we describe the impact of these large employers. Where possible, we also describe the differences between local and foreign companies. While a large number of survey respondents from Kenya were foreign companies, only a few were in India and Nigeria.

Finally, while we attempted to capture the sector's local, indirect job footprint, only very few manufacturing and upstream supply chain companies and sector service providers responded to the survey. As such, although these two company groups are considered in the analysis of DRE workforce trends (Chapter 3), we cannot accurately estimate or project indirect jobs at the national level. See more explanation of indirect jobs in section 2.4.

FIGURE 5. SURVEY RESPONDENT BREAKDOWN BY COMPANY TYPE



2. Employment Impact

2.1. Total Employment Footprint

This study found that the DRE sector has a major impact across the formal and informal job markets. In 2017–18, the DRE sector accounted for 95,000 direct, formal FTE jobs in India, 10,000 in Kenya, and 4,000 in Nigeria. The DRE sector also relies heavily on informal work, employing twice as many people in the informal sector: 210,000 informal jobs in India, 15,000 in Kenya, and 9,000 in Nigeria. As mentioned earlier, an informal job does not necessarily equate full-time engagement.

Finally, drawing on employment factors from the literature, productive use jobs stimulated by access to electricity may employ more than five times as many people as direct, formal jobs. The scale of productive use job impact in 2017–18 is estimated at 470,000 jobs in India, 65,000 in Kenya, and 15,000 in Nigeria. In the sections below, we expand on these findings and their implications.

2.2. Direct, Formal Jobs

In 2017–18, the DRE sector provided 95,000 direct, formal jobs in India, 10,000 jobs in Kenya and 4,000 jobs in Nigeria. This is equivalent to the total number of jobs within the utility-scale solar sector in India, the traditional power sector in Kenya, and the electricity, gas, steam, and air conditioning sector in Nigeria [2]–[4].

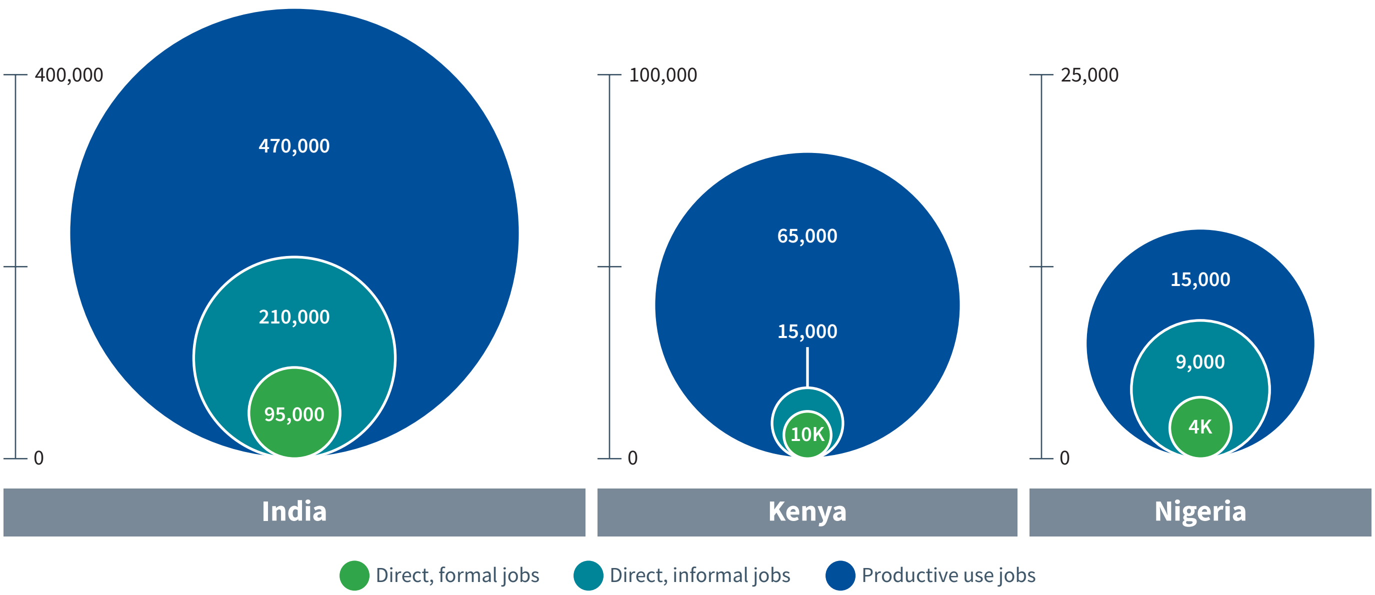
IRENA estimated that employment in solar PV increased by 36% in 2017 to reach 164,400 jobs in India, among which 92,400 are on-grid and 72,000 are off-grid [2]. The estimate considers different segments of the PV industry: manufacturing, project development, installation and construction, and O&M. This is on the same order as our estimate of DRE jobs, indicating that the DRE sector is already a substantial contributor to job creation within the renewable energy sector in India.

In Kenya, total national formal employment in 2018 was about 18 million [10]. Kenya Power and Lighting Company (KPLC) has about 11,000 personnel [3]. So the DRE sector, having provided 10,000 jobs in 2017–18, is already comparable to the jobs created by the distribution and retail segment of the utility-scale power sector.

In Nigeria, a total of 55.5 million people were employed in 2017 [10]. In the country, a total of 370,000 new jobs were created between Q3 2016 to Q3 2017, among which 10,000 jobs were in the electricity, gas, steam, and air conditioning supply sector [4]. Again, if the DRE sector is directly employing 4,000 people, this is on the same order as jobs provided by the utility-scale power sector.

According to the survey, among the 95,000 direct, formal DRE jobs in India, 97% are provided by pico-solar appliances and SHS, 2% by solar water pumps, and less than 1% each by standalone and

FIGURE 6. FORMAL, INFORMAL, AND PRODUCTIVE USE EMPLOYMENT ESTIMATES FOR 2017–18



grid-tied C&I systems and mini-grids. The Kenyan DRE sector provided approximately 10,000 formal jobs in 2017–18 and was also dominated by pico-solar appliance and SHS companies. In fact, 78% of formal Kenyan jobs were in the pico-solar appliances and SHS sector, followed by another 18% in the C&I sector. Mini-grids and solar water pumps accounted for 4% of jobs.

In Nigeria, project developers and installers are the primary job engines for the DRE sector. The DRE market in Nigeria is dominated by C&I projects that serve urban, periurban, and rural consumers from grid-tied backup solar systems or standalone electricity supplies. The survey estimates that in 2017–18, the Nigeria DRE sector provided 4,000 jobs directly, with 71% of the direct DRE jobs provided by the C&I sector, followed by 26% in the pico-solar appliances and SHS sector, and 3% by the mini-grid sector.

These estimates are derived from employment factors based on the survey and market projections from existing literature. For more detailed methods, please refer to Appendix B.

2.3. Direct, Informal Jobs

The informal sector is an important driver for emerging economies like India, Kenya, and Nigeria. Often the major source of employment, in India, 88.2% of the employed population are informal workers, similar to 82.7% in Kenya and 92.9% in Nigeria [37], [38]. Likewise, in the DRE sector, direct, formal employment is just the tip of the iceberg: there are a large number of informal jobs such as field technicians and commissioned sales agents.

According to the survey findings, the DRE sector relies heavily on informal work, employing almost twice as many people informally as it does formally. In 2017–18 the sector was responsible for 210,000 informal jobs in India, 15,000 in Kenya, and 9,000 in Nigeria. A majority of this informal work is attributed to end-user product providers such as pico-solar appliance and SHS companies, which are dependent on a wide network of distributors, retailers, and technicians to serve their customers. Thus, Nigerian DRE companies employ fewer informal workers compared to Kenya and India. In Nigeria, there is high demand for DRE products in both on-grid and off-grid areas because of the poor quality of the national grid [35]. Perhaps, since much of the distribution of DRE products takes place in urban areas, less extensive informal networks are necessary. Further exploration into local, informal supply chains is warranted.

Informal jobs, though greater in number than direct, formal jobs, may involve several different arrangements, from long-term agreements with DRE companies as product retailers, to commissioned sales activities. Focus groups indicated that informal workers often work with several companies and have multiple income streams, so

FIGURE 7. RETENTION OF FORMAL FULL-TIME EMPLOYEES AND INFORMAL WORKERS

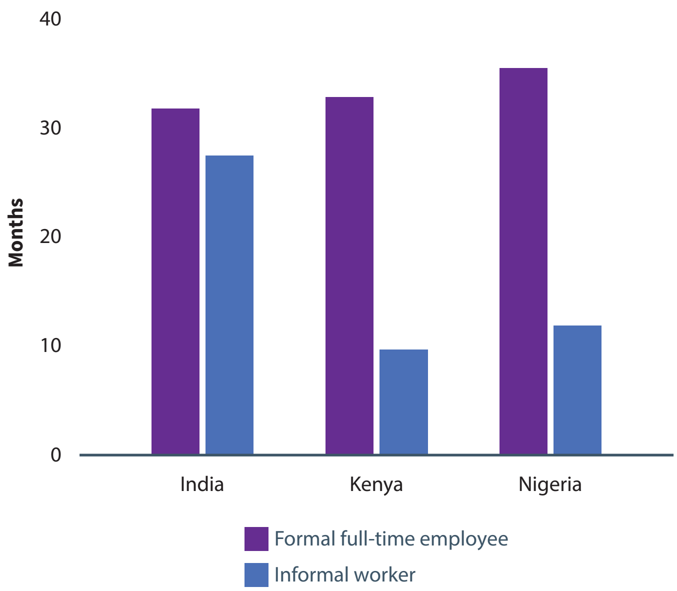
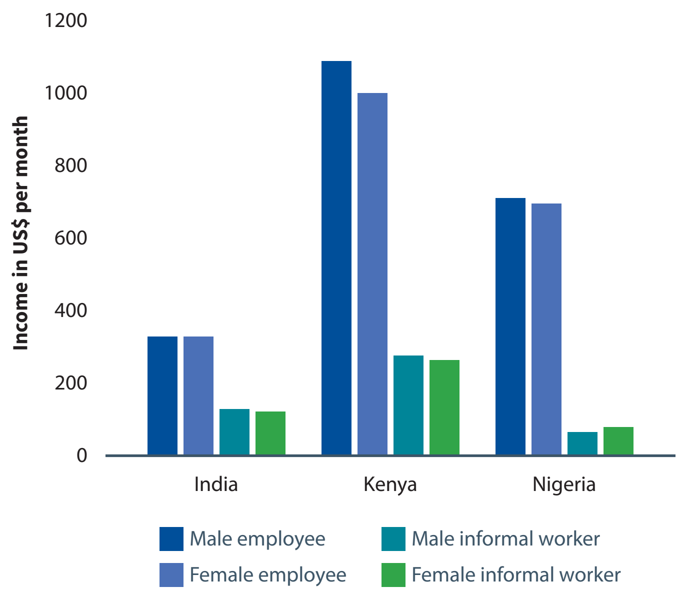


FIGURE 8. EARNINGS PER MONTH BY FULL-TIME NONMANAGERIAL EMPLOYEES AND INFORMAL WORKERS



level of engagement, quality of labor, and level of compensation may vary. Informal workers generally do not have secure employment contracts, benefits, social protection, or representation.

Generally, informal workers are retained for shorter periods than regular, full-time employees, as shown in Figure 7, except in India where retention times seem more comparable. An explanation for the differences in retention time was not captured through the survey, and warrants further analysis as informal sales can range from independent agents to family members of all ages.

In terms of monthly earnings, the survey data does not provide a full picture of an informal worker's total monthly income across various income streams. It is therefore difficult to compare compensation between informal workers and their formal counterparts, or to calculate informal employment as FTE jobs based on survey data. More insights on compensation are discussed in section 3.2. Deeper research into DRE employment characteristics within the informal sector is warranted.

2.4. Indirect Jobs

Alongside direct jobs, there are also microfinance institutions (MFI), educational organizations, and other service providers that account for additional indirect jobs. Given that few companies engaged in indirect activity responded to the survey, any estimate of local, indirect employment by the DRE sector is beyond the study's scope. Furthermore, our study explores employment and job creation within a given country, while indirect jobs are mostly created upstream, in other countries. Thus, understanding indirect job creation, both inside and outside countries, requires in depth information on the contracting and hiring behavior of companies along the full length of the value chain and subsequent macroeconomic input-output analysis. Such data is not readily available for most emerging markets. Further study is clearly required in this area. Nevertheless, the sections below provide qualitative insights on two key types of indirect DRE jobs based on literature review and our limited survey data inputs.

Upstream indirect jobs: The main types of upstream indirect services in the DRE value chain include: 1) raw material extraction, 2) manufacturing of PV panels, batteries, inverters, electrical appliances, and other electrical equipment, 3) import and export of different components, and 4) integration, assembly, or installation of systems. Each of these services requires a workforce that serves the DRE sector indirectly. Understanding these indirect jobs requires in depth knowledge of the resources and import export behavior of the DRE sector, as indirect jobs are often in other countries.

Literature suggests that for India, local, indirect job creation comes mostly from manufacturing activities in India. There are 23 PV manufacturers listed with the India Solar Manufacturers Association [39]. India is also responsible for manufacturing 14% of solar lanterns sold globally, and many large, global, inverter suppliers manufacture their products in India [40]. In 2018, India manufactured more than 2.6 million pico-solar appliances, with approximately 18.3 million units sold globally. The company ABB, for instance, accounts for 22% of the Indian inverter market and manufactures inverters locally in India [41], [42]. In addition, India is also home to manufacturers supplying direct current TVs and fans, and alternating current pumps. Thus, India has a large manufacturing workforce that supplies the DRE sector as well as other power and utility sectors.

In Kenya, local manufacturing capacity is low compared to India. The only local solar cell manufacturer, Solinc, was established in 2011. Solinc employs 130 people, and is expected to hire an additional 30 engineers as major DRE companies begin sourcing solar panels locally. The company M-KOPA, for instance, aims to sell 6.6 MW of Kenyan-made PV panels between 2018 and 2020 [43]. Domestic sourcing incentives could help drive the growth of local manufacturing activities.

Likewise, in Nigeria, most PV and electrical equipment suppliers also rely on products already manufactured outside of the country [44]. According to the survey sample, many of these companies have a small, local staff who handle logistics of the importing and wholesale activities.

For C&I project developers, solar water pump installers, and mini-grid operators, there is considerable indirect job impact during the construction phase of a project. Depending on the strategic focus of the companies, not all of the project developers have in-house engineers for system design or laborers for construction, so support often comes indirectly from engineering, procurement, and construction contractors and/or logistic companies.

Indirect jobs from sector services: Another type of indirect job creation comes from organizations such as MFIs, research and advocacy organizations, software companies, consumer awareness and education organizations, metering companies, and consultancy services that the sector depends on more broadly. For instance, indirect jobs from MFIs are created by the demand for loan and capital provision services, which pico-solar appliance and SHS companies need for their customers. Many large companies integrate pay-as-you-go loans as part of their product offering, while others rely on financial services from MFIs to close the financial gap for rural end users.

As the DRE sector relies heavily on individual product sales, consumer awareness organizations and seller networks are key. The survey results suggest that, in India, for every 1,000 DRE products sold, three related jobs in education and consumer awareness are required. Said differently, for every 1 MW of DRE products or services installed and operated, five jobs are created in advocacy, education and research organizations. However, this estimate is based on a very small set of respondents. It is also difficult to calculate the FTE of jobs to the DRE sector alone as such organizations serve multiple sectors. Fully understanding indirect employment from sector service providers requires an in depth analysis of the demand for different types of sector services and the additional impact on new jobs. Thus, there is not yet enough data from the survey or literature covering the diverse range of indirect jobs serving the DRE sector. More study limitations can be found in section 5.3.

2.5. Productive Use Jobs

The DRE sector has a significant direct employment footprint, but may have an even larger impact among end users. Newly acquired or improved energy access within a community can benefit business performance, increase productivity via mechanization, and enable women to spend less time on fuel collection, thus creating or enhancing many jobs. These productive use impacts are particularly important in rural communities where unemployment is high, job opportunity is low, and where job diversification presents a challenge, especially for the marginalized.

Drawing from employment factors in the literature, productive use jobs in 2017–18 were estimated to be around 470,000 in India, 65,000 in Kenya, and 15,000 in Nigeria. Employment factors from the literature are used in lieu of the survey results as most respondents were unable to confidently provide data on job creation among end users. Given the potential scale of productive use jobs, this is clearly an area for further research. Despite the lack of systematic reporting on productive use jobs as a defined impact metric, 24% of the literature studying the impact of productive use jobs found that energy access increases employment [26].

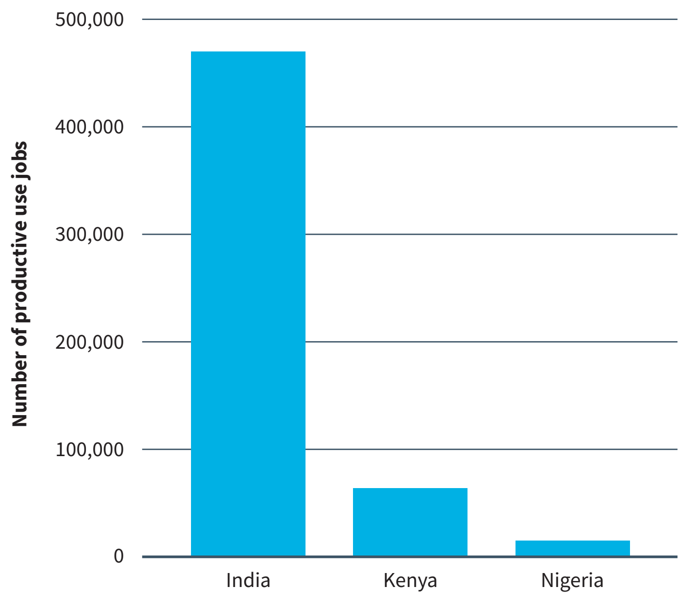
With regard to solar appliances and SHS, GOGLA, in 2018, surveyed more than 2,300 off-grid solar product users in East Africa and found that 7% of the respondents reported using these products enabled a new job [28]. Even greater potential seems to come from mini-grid companies. For instance, Smart Power India reported that, on average, for every new mini-grid system that is commissioned, three new enterprises are created, with each employing three people [46]. See section 5.3 for a discussion on the limitations in estimating productive use jobs.

While not providing specific data on job creation, there are also numerous studies that explore the impact of electricity access through DRE technologies on increased productivity and income generation, For instance, the SELCO Foundation in India conducted a study in 2018 for 1,500 standalone SHS users in 50 livelihood areas, and found positive economic benefits from the use of DRE technology in nine different rural value chains. The additional value created ranged from 20% to 400%, depending on how the energy was put to use. [47].

Similarly, in 2018, GOGLA studied SHS markets in Kenya, Mozambique, Rwanda, Tanzania, and Uganda, finding that 24% of SHS are used in home businesses or income-generating activities. Nearly 60% of the surveyed off-grid solar customers undertook more economic activity within just three months of purchasing a SHS, whether gaining a new job, using their system directly for a business, or working for longer. For more than a third of customers, this access to electricity enabled them to increase their monthly income by US$35 a month, more than half the average monthly GDP per capita in these countries [28]. Finally, in a 2017 study that covers 20 companies in sub-Saharan Africa and South Asia, Acumen concluded that 20% of surveyed DRE customers use energy productively [27]. Acumen also conducted a survey of rural business from 2016–18 and found that 18% saw an increase in their workforce after the acquisition of a DRE product or service [29].

These early indicators suggest that more quantitative research into productive use is needed. Producing a strong quantitative evidence base will require more standard reporting metrics and surveys directed at the DRE end users that focus on different productive use value chains. We plan on continuing to contribute to the growing literature on productive use in future iterations of the Powering Jobs census.

FIGURE 9. PRODUCTIVE USE JOB ESTIMATES IN 2017–18



Spotlight: Induced Jobs in the DRE Sector

Induced job creation is not included in the scope of the survey. Literature and interviews with key stakeholders provides a bit of insight into how the spending from those employed by the DRE sector can have an impact on other sectors of the economy. For instance, the induced job impact is often seen during the initial and short-term phases of project development as food vendors and water fetchers temporarily cluster around a construction site to serve those working for DRE companies [45]. Common examples from Nigeria show that every 50 construction workers might require two food vendors for a short-term (approximately four-month) project like solar street light installation. Another example from Nigeria found a 2.4 kW solar milling project was served by six water-fetchers during its four-month construction phase [45]. To better capture the effect of induced jobs, IRENA recommends the use of input-output models that predict macroeconomic outcomes based on tracing linkages across the entire economy [16].

2. Employment Impact

Spotlight: Jobs in Clean Cooking

Globally, 2.8 billion people do not have access to clean cooking and use fuel sources that present health hazards [1]. Cleaner stoves and fuels include improved biomass cookstoves that use fuel more efficiently and cookstoves that use alternative fuels such as liquefied petroleum gas, biogas, methane, or ethanol. In recent years, attention has also turned to electric cookstoves, or e-cooking, as a promising solution. UK Aid recently launched the Modern Energy Cooking Services program, a five-year research and innovation program designed to facilitate a transition to modern cooking services [48].

The job creation potential of the clean cooking sector is reported in several past studies and there is a strong correlation between improved cookstove jobs and gender. For example, IRENA cited a program in Burkina Faso that disseminated 180,000 cookstoves between 2006–11 and trained 313 metal smiths, 314 masons, and 180 potters, mostly women [19]. A case study in Kenya also reported that the deployment of 251,000 cookstoves resulted in more than 200 jobs in manufacturing, sales, and distribution, 14 full-time jobs, and two part-time jobs [49]. The Developing Energy Enterprises Project East Africa program reported that 42% of its 819 improved cookstove entrepreneurs were women [19]. Similarly, a joint initiative of EnDev and SNV invested US$660,000 in improved cookstoves in East Africa, creating 115 full-time jobs and 449 part-time jobs as a result. Among these new jobs, 41% of them were held by women and 23% by youth [50].

Field evidence suggests that improved cookstoves have high potential to promote rural employment by engaging local entrepreneurs in manufacturing and distribution. Women are playing key roles in many parts of the improved clean cooking value chain. It is key to analyze the employment impact of the improved cooking sector through a rural employment and gender lens.

3. Workforce Trends

3.1. Retention and Level of Engagement

We define the level of engagement for direct, formal employees based on whether they are full-time, part-time, or contractors. The level of engagement is high across all three countries surveyed, as the vast majority of direct, formal jobs created by the DRE sector are full time. In India, 90% of the jobs are full time, 68% in Kenya, and 65% in Nigeria.

Furthermore, according to the survey, the average retention time for direct, formal, full-time DRE employees is more than 30 months across all three countries. The DRE sector's retention time and level of engagement is significantly higher than the large scale renewable energy sectors. For instance, in India, only 19% of wind power workers have permanent, full-time jobs [51], while the remaining jobs are short term, such as project construction [51]. Thus, high levels of worker engagement and employee retention are other major benefits the DRE sector offers India.

The survey also shows the level of engagement and retention across each company type. DRE end-user product providers and mini-grid operators provide more full-time employment than other company types. These two company types are not only employing the most full-time staff, but among employees, their retention time is also the highest. On average, their employees stay with companies for more than three years, as compared to two years for project developers and installers, manufacturing and upstream supply chain companies, and other service providers. Thus, among its direct, formal employees the DRE sector provides long-term jobs.

FIGURE 10. WORKFORCE BREAKDOWN BY LEVEL OF ENGAGEMENT

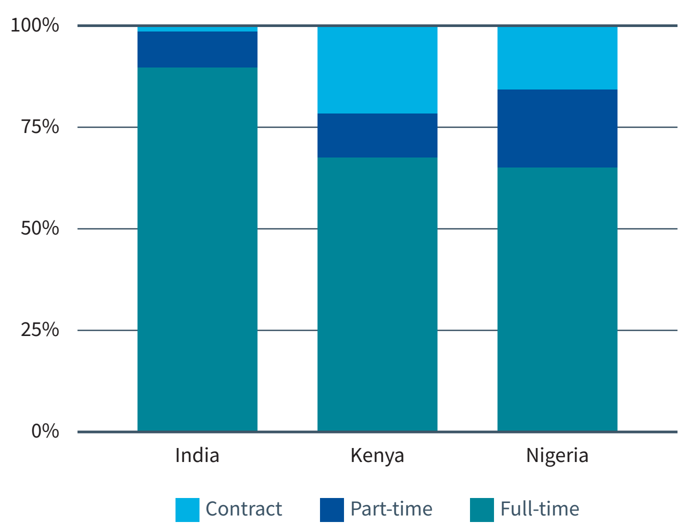
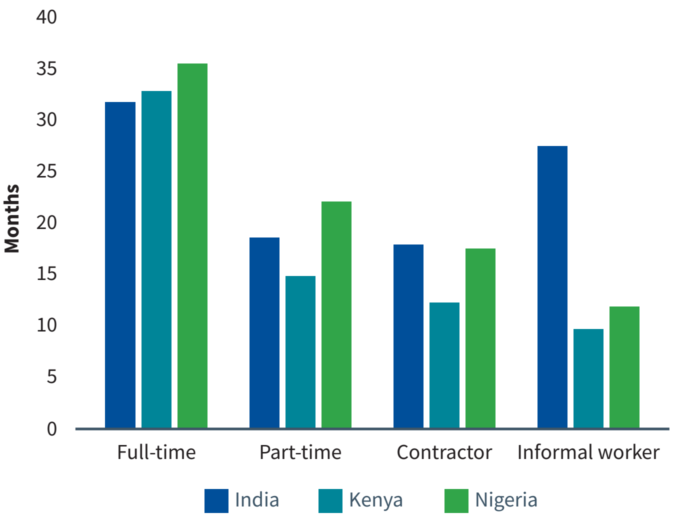


FIGURE 11. AVERAGE RETENTION IN MONTHS



3.2. Levels of Compensation

In terms of level of compensation, wages for direct, formal employment from the DRE sector largely fall within the middle-income range for their respective countries, positioning the sector as a strong employment opportunity for job seekers. Furthermore, compared to the average gender wage gap of 14.6% in low-income countries [52], the DRE sector may have greater parity in its compensation policies.

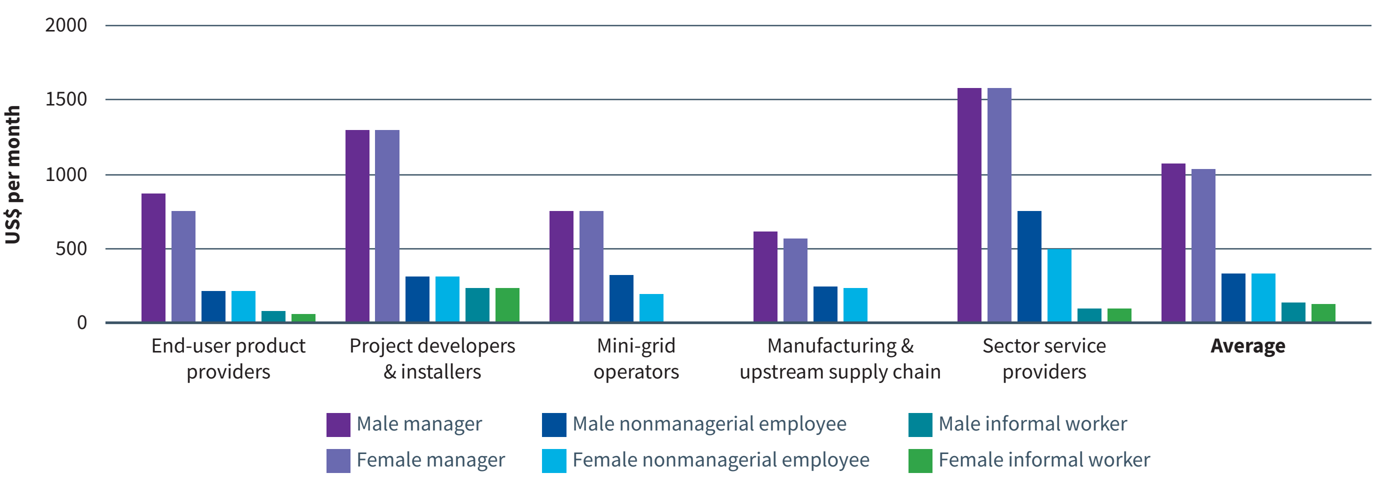
Differences in wage compensation across the DRE sector can be explored across different stakeholder groups. For instance, alongside observing the differences in monetary compensation across gender, we can also observe wage differences between formal and informal workers, or managerial and nonmanagerial employees. Note that only some surveys provided complete information on compensation: 50% of respondents from India, 40% of respondents from Kenya, and 30% of respondents from Nigeria either did not report wages or only reported wages for men. Thus, findings on compensation from the sample cannot be generalized. Other limitations are detailed in section 5.3.

3.2.1. Employment Compensation in India

In India, DRE sector wages are significantly higher than the national median wage. On average, in the DRE sector, direct, formal nonmanagerial employees earn about US$500 per month and senior managers, such as the CEO, CFO, CTO, and COO earn more than US$1,600 per month, all of which falls within India's reported middle income range of US$200–2,000 per month [53]. These wages are similar to those offered by the broader renewable energy sector, where an electrical engineer earns approximately US$400–500 per month and a business development manager earns about US$1,500 per month [54].

However, according to our survey, some company types seem to pay less than others. For example, the end-user product suppliers and manufacturing and upstream supply chain companies offer nonmanagerial employees around US$200–250 per month, which

FIGURE 12. MANAGERIAL, NONMANAGERIAL, AND INFORMAL WORKER EARNINGS IN INDIA



is roughly 50% less than nonmanagerial employees in the other company types.

Across India, men reportedly earn 35% more than women [55]. However, our survey data does not provide conclusive insights into wage differences in the Indian DRE sector, as 50% of respondents either did not provide wage data or only provided data for men.

Our data cannot compare total monthly wages for informal workers with the wages of formal employees as informal workers often engage multiple companies at the same time. That said, comparing informal worker groups across countries, those working for project developers and installers seem to earn more than those working informally for other companies.

3.2.2. Employment Compensation in Kenya

In Kenya, DRE employees earn, on average, wages that fall within the middle income range as defined by the Africa Research Institute, earning between US$764–1,204 per month [8]. The main wage differentiator seems to be the presence of foreign capital. There is a stark wage difference between employees of local companies and foreign companies operating locally. Managers working for foreign companies earn more than three times the average salary of managers working for local companies. Similarly, nonmanagerial employees in foreign companies earn more than double their counterparts. This trend does not seem to follow in India or Nigeria, where there was more reported wage parity across the foreign and local company responses. However, more comprehensive data on the employment behavior of local and foreign companies would be needed to draw definitive conclusions.

As mentioned before, the data are very limited, but do show there may be a slight wage gap in Kenya's DRE sector, where, according to those respondents that reported wages, male managers are earning 10% more than their female counterparts. Even in nonmanagerial roles, men earned 10% more than women on average.

3.2.3. Employment Compensation in Nigeria

Wages earned by DRE employees in Nigeria generally fall in the range of a middle-class income, or US$480–645 [56]. The survey shows that across most DRE company types, nonmanagerial employees have an average wage in this range, except for mini-grid companies, whose employees earn US$900 per month. Conversely, service provision company's nonmanagerial employees earn, on average, less than US$300 per month. In Nigeria, wages among men and women appear to be on par with one another.

3.3. Job Types and Job Function Breakdown

Survey data found that the majority of jobs in the DRE sector are skilled jobs. Skilled jobs are defined by the ILO as those involving leadership, management, professional, technical or associate professional skills generally at the International Standard Classification of Occupations (ISCO) Skill Level 3 or above [57]. In India, 82%

FIGURE 13. MANAGERIAL, NONMANAGERIAL, AND INFORMAL WORKER EARNINGS IN KENYA

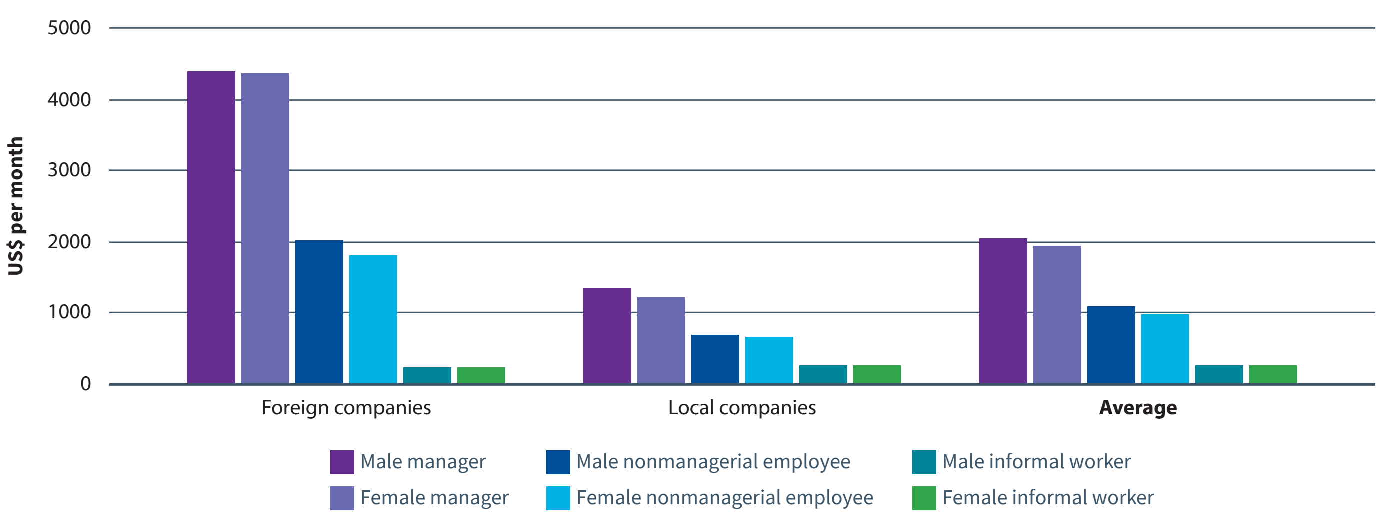
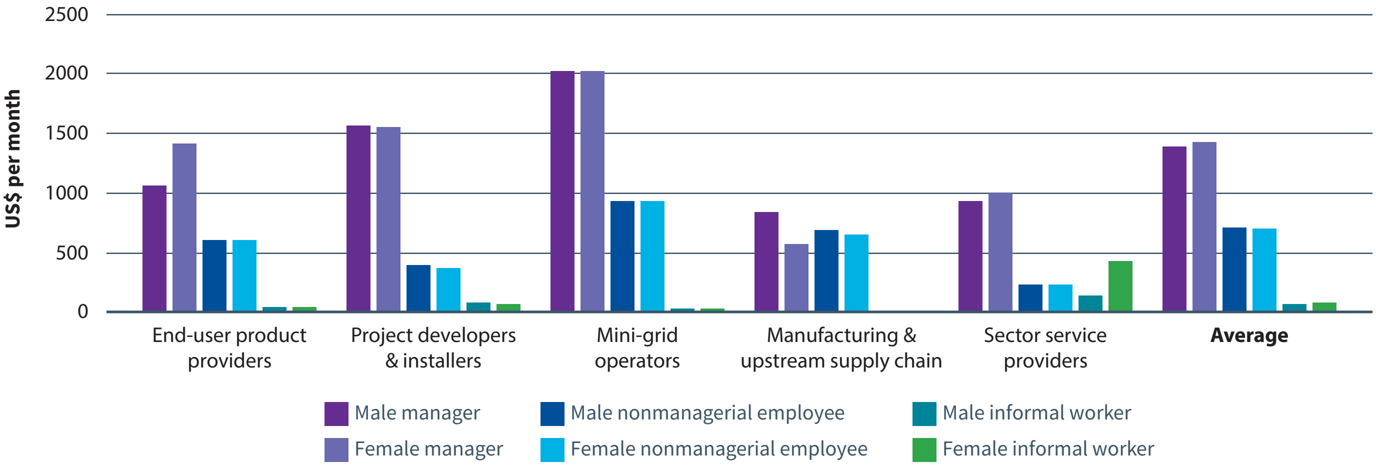


FIGURE 14. MANAGERIAL, NONMANAGERIAL, AND INFORMAL WORKER EARNINGS IN NIGERIA



of the jobs are skilled, compared to 66% and 70% in Kenya and Nigeria respectively. By comparison, the global utility-scale solar sector's workforce is less than 50% skilled [5]. This again points to another benefit of employment in the DRE sector: the opportunity for skilled workforce engagement.

The type of skills being recruited in each country and sector is different. For instance, in India and Kenya, more than a third of the workforce is engaged in sales and distribution, as these countries both have mature pico-solar appliance and SHS markets. On the other hand, the Nigeria workforce has only 8% of its direct, formal employees dedicated to sales and distribution. This could be due to the nascency of the market in Nigeria [30], or possibly due to the fact that the market is not distinctly segmented between rural and urban customers given the low quality of the national grid [35]. Rather, the dominant skills currently demanded in Nigeria are project development, installation, and O&M.

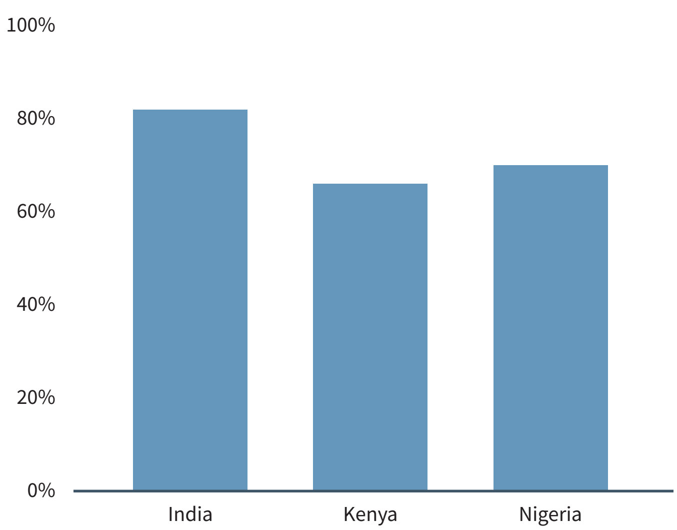
Management and business administration account for more than 15% of skills required by companies in each country, again demonstrating the need for skilled labor. Figure 16 shows the skill breakdown of the DRE sector by company in 2017–18.

3.4. Women's Participation

Women's participation in the workforce is a critical issue for emerging economies. Women are more likely than men to be unemployed in most parts of the world. Across sub-Saharan Africa, the unemployment rate for women is 6.2% while for men it is 5.6%. In South Asia, the female unemployment rate is 4.5% compared to 2.7% for males [10].

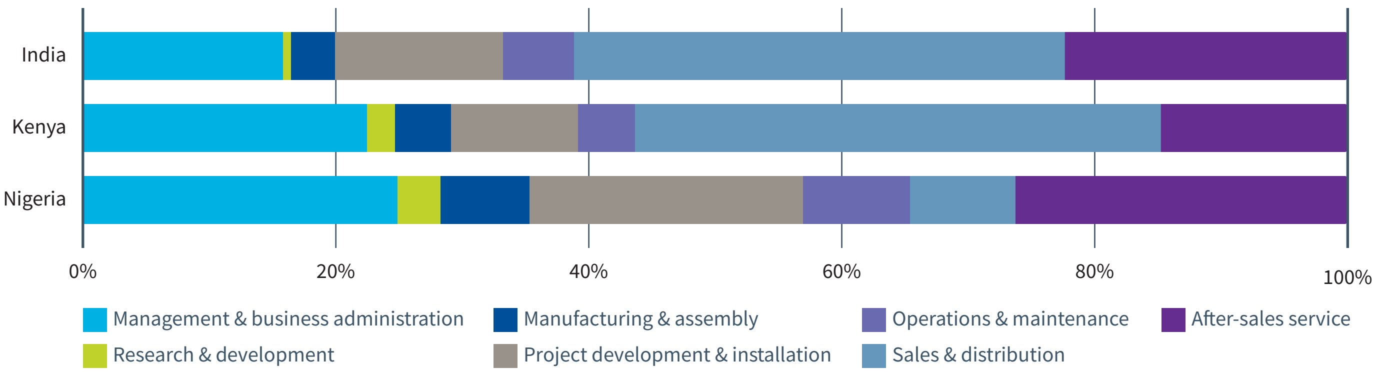
The survey found that women's participation in the DRE sector is low across all three countries. Women make up less than 30% of the workforce: 23% in India and Kenya, and 27% in Nigeria. This is lower than women's participation in the renewable energy industry in general. IRENA reported in 2019 that women represented an average of 32% of the global renewable energy workforce [6], and in

FIGURE 15. SKILLED LABOR IN DRE WORKFORCE



3. Workforce Trends

FIGURE 16. DIRECT JOB FUNCTION BREAKDOWN IN 2017–18



2017 found that gender discrimination in renewable energy is less pronounced than in the energy sector at large [2].

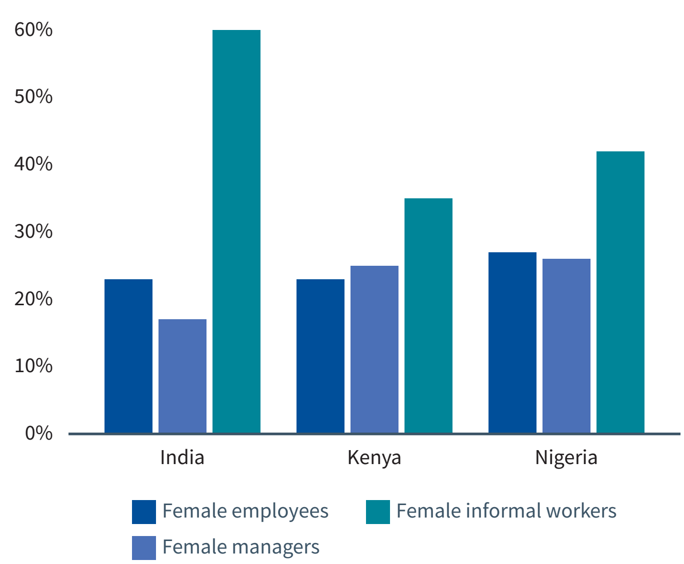
The survey data showed that women represented 16% of the senior managerial positions in India in 2018, 25% in Kenya, and 26% in Nigeria. It is difficult to compare the DRE sector to others due to limited data, however, focus groups highlighted that structural barriers do exist for women seeking to occupy leadership positions due to discriminatory social norms and gender stereotypes. For instance, during the Nigeria focus group, it was reported that DRE companies led by women were intentionally excluded from contract tenders because the sector lacks trust in female leadership. Deeper stakeholder analysis is merited to identify practical solutions.

However, it is worth noting that there is generally a higher representation of women in one particular category: informal workers with pico-solar appliance and SHS companies. The percentage of female informal workers was particularly high in India. The benefit of engaging women in the sales and distribution network is widely recognized by both SHS and mini-grid companies alike, and is validated by the literature, which shows that in rural communities women play important roles as entrepreneurs, social networkers, influencers, and leaders, making them suitable salespersons. For instance, in 2015, Solar Sister reported that its female sales agents performed 28% better than their male peers [58].

3.5. Youth Participation

Youth are defined as men and women between the ages of 15–24 years [59]. One of the most pressing challenges for emerging economies is a shortage of jobs among the youth. Youth comprise 34% of the working age population in sub-Saharan Africa, and 25% in India [10]. Every year some 13 million young people look for work in Africa, but only about 3 million find jobs [60]. By 2050, Africa's youth is projected to double to 840 million [11], and the World Bank, in its *Jobless Growth* report, warns that India needs to create 8 million jobs per year to satisfy the fast growing population of youth entering the workforce every year [12]. The latest data found that 10.4% of youth in India are unemployed, compared to 18.5% in Kenya and 19.7% in Nigeria [10].

FIGURE 17. PARTICIPATION OF WOMEN IN THE DRE WORKFORCE



3. Workforce Trends

Scaling DRE represents a major opportunity to help unemployed youth. The survey found that in Kenya and India the percentage of youth employed in the DRE sector is high. In both countries, more than 40% of the DRE workforce are youth. However, in Nigeria, which is a very young population, youth currently only make up 28% of the DRE workforce.

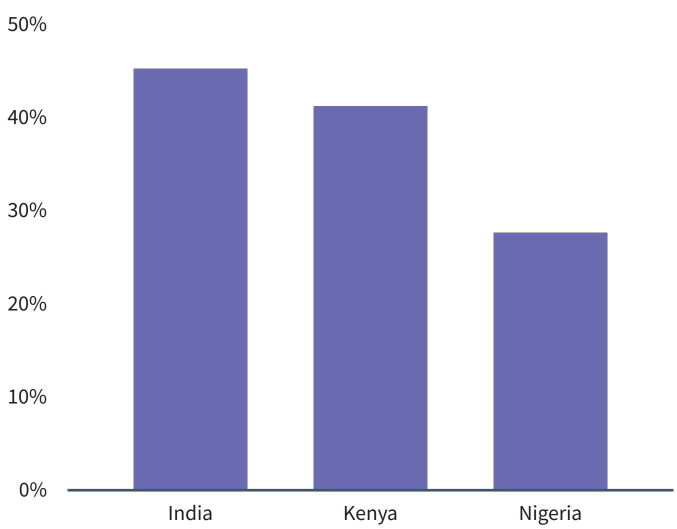
3.6. Recruitment Challenges and Training Needs

The characterizations above help unearth the nature of employment in the DRE sector and its potential to provide highly skilled, diverse, and well-paid jobs. However, local workforce readiness is crucial to unlocking this potential and is thus also crucial to achieving universal energy access. The survey results and our focus groups suggest that DRE companies struggle to recruit the necessary talent. Given that the sector creates long-term, skilled, middle-income jobs, it would be a strategic national policy to invest resources into training youth and easing recruitment challenges, thus building a strong DRE workforce. In this section we explore recruiting women and youth and the key skills gaps of the sector.

3.6.1. Recruitment Challenges for Women

According to the survey, it is more difficult to recruit youth and women than older men. The main challenge that DRE companies face when recruiting women is a limited talent pool. In all country focus groups, it was noted that the lack of women's participation in the DRE sector was related to the more general lack of female representation in science, technology, engineering and mathematics (STEM) education, which itself stems from broader, complex socio-cultural challenges. Moreover, representatives from training institutes in both Kenya and Nigeria explained that often, even when women are directly targeted during recruitment, the number of applications received is still low.

FIGURE 18. PARTICIPATION OF YOUTH IN THE DRE WORKFORCE



In India's focus group, practitioners explained that the low participation of women seems to result from the cultural perceptions of their traditional role in the workplace, compounded by negative perceptions of the industry's work demands—namely, that it is labor-intensive and requires extensive travel in potentially dangerous areas. There is also gender bias in recruitment, which is well documented in the literature [61]. Again, these perceptions derive from a larger culture of gender inequality, stereotypes, and discriminatory social norms.

Thus, there is a pressing need for more resources dedicated to engaging women in training programs, STEM education, and overcoming recruitment bias. Stakeholders directly engaged in women's empowerment should be part of the policy development process. In fact, during focus groups, national energy policy frameworks were recognized as one of the most effective tools to encourage greater representation by women in the DRE workforce. In a recent study, it was found that of the 45 energy policy frameworks in sub-Saharan Africa that were analyzed, 71% include gender keywords, making it the world leader in acknowledging gender needs in national energy frameworks. These legal frameworks consider women as stakeholders, beneficiaries, or agents of change and provide clear pathways to engage women through interministerial collaborations [62].

3.6.2. Recruitment Challenges for Youth

From the survey responses, youth employment in the DRE sector is higher in India and Kenya than in Nigeria. Companies surveyed in Nigeria said lower youth engagement resulted from a limited talent pool, lack of experience, and poor work ethic, noting that it is more difficult to find qualified youth than older candidates. In Kenya, youth had higher salary expectations, while in India the challenge was a lack of established recruitment channels for youth.

These findings shed light on the necessity of creating more accessible training and education avenues for young people and the need for more established recruitment pipelines to bring youth into the

DRE workforce. However, more insight is needed to tailor training programs can be tailored toward the sector's needs, as seen below.

3.6.3. Recruitment Challenges for Managers

The survey findings also point to a demand that is often overlooked in the DRE sector: the need for more business and innovation talent. In all three countries, business administration jobs, such as management, business development, and finance, make up 20% of the DRE workforce. Though not one of the largest job categories, according to all focus groups, managerial expertise is the most difficult skill set to recruit for. Most companies agreed that technical training is a secondary consideration, since staff can be trained internally if needed. The primary challenge is recruiting employees with a strong grounding in business skills, ethics, and workplace leadership. This corresponds to the findings of the *Mini-Grid Training Needs Assessment,* a report jointly prepared by Energy 4 Impact and INENSUS, which identified project and business management, finance, health and safety, monitoring and evaluation, O&M processes, and software as core skills that lack adequate training programs in emerging markets [63].

The challenges around recruiting and retaining managerial talent is compounded by competition for the limited talent pool. Further, as noted in India's focus group, managers from DRE companies tend to move to the utility-scale or rooftop solar sectors, which have more managerial positions and thus more upward mobility.

3.6.4. Training Needs, Solutions, and Best Practices

The survey and focus groups show that a strong TVET and career strategy which involves government, industry, education institutions, and investors is needed to close the skills gap for the sector. Past successes have been observed in many private sector-led training programs. Schneider Electric India Foundation, together with other partners, run electrician training centers in India and have trained 24,600 unemployed youth in 21 centers across the country [64]. During focus group discussions, participants shared success cases of industry working directly with universities to establish a presence and develop a pipeline that recruits students during their formal education into industry through internships and on-the-job training that quickly leads to full-time employment.

Gender equality should also be considered in the early design stage of these programs to increase uptake of employment opportunities among women. For instance, in the Energizing Education Program in Nigeria, DRE solutions have been deployed across 37 universities, recruiting 20 female engineering students from each university for on-the-job training. In total, more than 700 female students have been trained as a result of this program [65].

Direct engagement with formal education institutions can improve youth engagement, but can be costly and is usually only an option for larger companies. For smaller companies, like many of those in the DRE sector, an established external pipeline to bring young people into the DRE workforce is needed. An example is Energy Generation, a recently launched association that supports African youth by providing them with the technical and entrepreneurial skills training required for a career in the DRE sector. The programs take 10 months to two years to complete. Additionally, the association funds incubators and coworking spaces for graduate entrepreneurs who wish to launch their own DRE start-ups [66].

In addition to training programs driven by the private sector, public training initiatives are also key to transforming a young workforce. For example, the Indian government's Suryamitra program aims to develop the skills of youth considering employment in the solar PV project installation and the O&M industry. Since 2016, the program has certified over 20,000 electricians in the country [67].

For most DRE companies, technical talent is recruited from across many training institutes with different curricula, teaching standards, and levels of accreditation. Indeed, participants in all three country focus groups expressed concern over the quality of training, the lack of monitoring and evaluation metrics for such training programs, and the inability to transfer accreditation across countries or regions, both complicating and limiting the recruitment process. Thus, there is a need for better certification processes and, perhaps, for a collective industry-wide training curriculum.

Finally, another identified gap in recruitment is industry knowledge of available training services. Many companies are not aware of the training resources available for their staff or even where to source trained technicians. Participants expressed the need for accessible and up-to-date databases of existing training programs and services, as well as a current index of certified technicians. This would increase the visibility of certified, qualified technicians, improving their job opportunities while providing a ready source of vetted, quality talent. These insights have important implications for workforce development policy and the tailoring of interventions to the DRE sector's needs. More discussion on recommendations follows in Chapter 5.

4. Employment Projections

In this chapter, we provide a snapshot of potential gross future DRE sector employment by using our survey's 2017 employment factors and the latest published market estimates for each of the three countries (see Appendix B for methods). By 2022–23 employment from the DRE sector could more than double. In India, under a high mini-grid penetration scenario, 190,000 direct, formal jobs could be provided, while under a low mini-grid penetration scenario this number would rise only marginally to 110,000 direct, formal jobs. In Kenya and Nigeria, the DRE sector could provide more than 17,000 and 52,000 respective jobs. In terms of direct, informal jobs, the DRE sector could provide more than 210,000 direct, informal jobs in India, 30,000 in Kenya, and 24,000 in Nigeria.

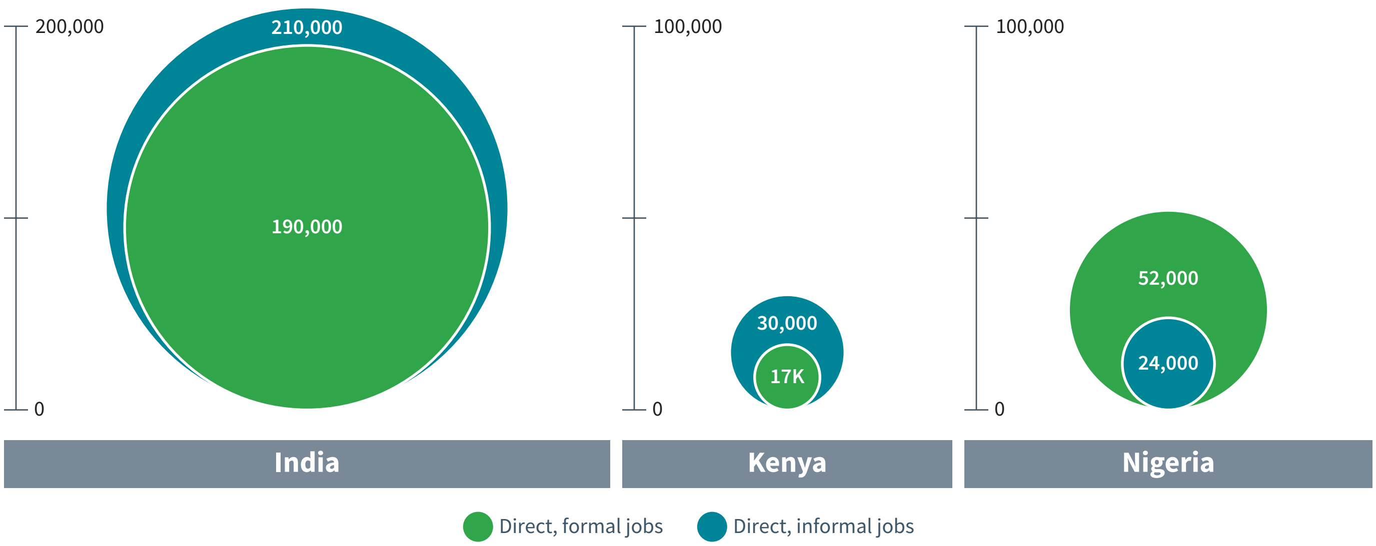
Employment factors and the nature of jobs needed often change over time as companies and sectors mature. For this reason, several years of employment history is required to understand the employment trajectory of a sector. We use our 2017 employment estimates with the caveat that these values will likely change in the future. Further, there are few future market estimates that comprehensively cover the range of DRE technologies captured in our survey, and those which exist are generally uncertain. In particular, the future of the mini-grid sector is much debated. While governments have shown interest in supporting the deployment of mini-grids in all three countries, many sector experts are skeptical of the level of deployment that will be achieved. We provided job estimate ranges where possible. As such, these future snapshots provide a general indication of employment potential, but cannot be generalized given the data limitations.

Our study projections show that the DRE sector is on track to provide more than 260,000 direct, formal jobs and 260,000 direct, informal jobs in just three countries by 2022–23, and those numbers are likely even larger given that 23% of emerging economies with low energy now have established DRE targets [15]. Moreover, future employment from productive use jobs is likely to be even greater than that of direct employment. We are unable to estimate productive use job projections based on available data, and thus plan to continue data collection on productive use jobs in subsequent reports.

These projections are in line with other recent studies of renewable energy employment, and demonstrate that the DRE sector has major potential to contribute to future employment. For instance, Greenpeace estimates that under a scenario where global temperatures rise by 1.5°C, the energy sector can employ 41 million people by 2025, with solar PV alone accounting for 33% of jobs. Specifically, by 2025, Greenpeace found that jobs from solar PV could reach over 806,000 in Africa with another 3.5 million created in India [68]. Additionally, IRENA projects that by 2030, the renewable energy sector in general could employ 24 million people [69].

4. Employment Projections

FIGURE 19. DIRECT, FORMAL AND INFORMAL JOBS PROJECTIONS FOR 2022–23



Based on these employment estimates, expected skill trends for India, Kenya, and Nigeria in 2022–23 can be seen in Figure 20. O&M jobs are projected to rise significantly in India and Nigeria because of the ambitious government-led mini-grid objectives in these two countries. The Kenyan DRE sector will likely continue to draw on a strong sales and distribution workforce. In all three countries, managerial and business talents will remain critical to the sector.

Below, we expand on the market estimation data used for these gross employment projections and the implications for each country. As private sector market growth projections for DRE technologies are not readily available in the publicly accessible literature, we focus on exploring the employment footprint of planned or ongoing public sector DRE initiatives and programs and only apply private sector market projections where official data is available. Stronger market estimates and more standard reporting are required to deeply understand future employment potential.

4.1. Key Projections and Insights for India

National strategies and planned policy interventions: The Jawaharlal Nehru National Solar Mission (JNNSM) is a major initiative by the Indian government and state governments to meet the growing energy demand while balancing climate change mitigation. JNNSM set a target of reaching 20 GW of solar capacity by 2022, and 2 GW of off-grid applications. Announced in 2010, JNNSM has a three-phase approach [70]. Between 2010 and 2013, JNNSM successfully deployed 252.5 MW of off-grid solar installations, completing the first phase. Phase II was revised to be 1 GW of power by 2017, while Phase III plans to add another 2 GW by 2022. [71].

To achieve the targets set out by JNNSM, the Ministry of New and Renewable Energy (MNRE) introduced incentive schemes to encourage the use of DRE technologies. For example, the Off-Grid and Decentralized Solar PV Applications Program will finance the deployment of 100 MW of standalone solar systems for public institutions, 300,000 solar street lights, and 2.5 million solar study lamps for school children [71]. Another scheme, Kisan Urja Suraksha Utthan Mahaabhiyan (KUSUM) [72], aims to provide or improve 1.75 million solar water pumps for farmers in off-grid areas by 2021. In terms of mini-grid deployment, the MNRE also set a goal of installing 500 MW of mini-grid capacity by 2023 [73].

Pico-solar appliance and SHS deployment and job projection: By 2023, GOGLA estimates that the total annual sales of pico-solar appliances will reach 5.8 million units, and SHS will reach 508,000 units. Assuming that the employment factor of 2017 holds into 2023, the DRE sector will need more than 80,000 direct, formal employees, and more than 200,000 informal workers to accomplish this expansion [74].

4. Employment Projections

Mini-grid deployment and job estimate: With MNRE's ambitious mini-grid deployment objective, the Indian mini-grid sector is expecting to be operating 500 MW of mini-grids by 2022–23 [73]. If the 2017 employment factor is the same as in 2022–23, more than 90,000 people will be become direct, formal employees, and about 8,000 informal workers will be hired by the sector. However, many sector experts are skeptical that this level of deployment will be achieved. While some project that the private sector along with sanctioned subsidies can achieve 250 MW of mini-grids installed by 2023, others are more conservative and project that the sector will only grow to 60 MW over the same period [46]. Respectively, these scenarios would result in 140,000 or 110,000 direct, formal jobs. As such, depending on future mini-grid penetration, the DRE sector's job footprint will vary, with the MNRE's 500 MW policy representing the high mini-grid penetration scenario. However, given that the mini-grid sector creates jobs primarily in O&M, the informal jobs footprint varies little.

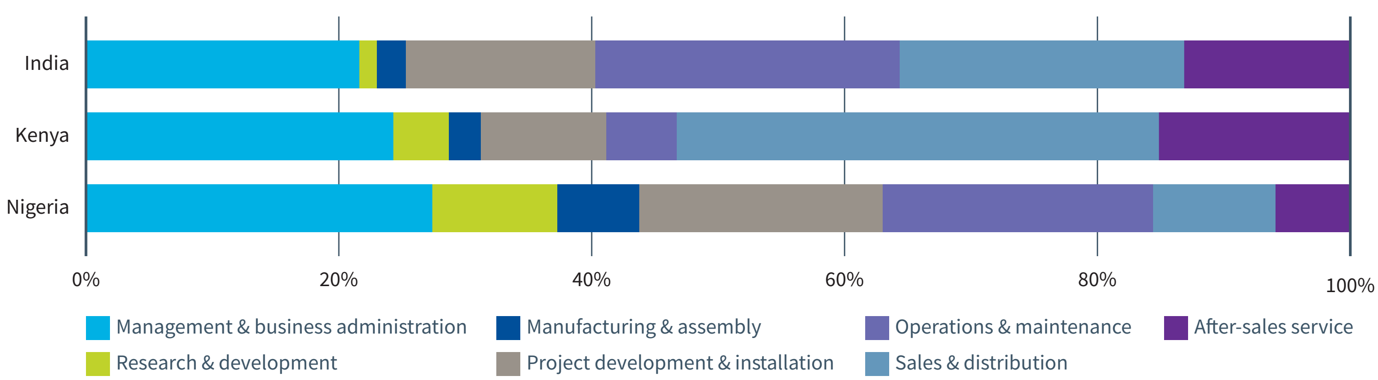
Job projection insights: Under a high mini-grid penetration scenario, the DRE sector will provide more 190,000 direct, formal jobs and 210,000 direct, informal jobs by 2022–23. About half of the projected DRE workforce will serve mini-grids and the other half pico-solar appliances, SHS, standalone and grid-tied C&I systems, and solar water pumps. We project that informal jobs will not grow as fast as direct jobs, holding at 210,000 jobs in 2022–23. As the DRE sector evolves, jobs may shift from the more informal nature of sales and distribution to the more formal positions of project development and O&M. However, far more data on the employment behavior of DRE companies is needed to make these claims.

4.2. Key Projections and Insights for Kenya

National strategies and planned policy interventions: In its recently released Kenya National Electrification Strategy (KNES), the Kenyan government aims to achieve universal electrification by 2022 [32] via several electrification programs that will finance grid extension, intensification, and densification. This includes the deployment of DRE solutions where the national grid cannot reach, such as the Last Mile Connectivity Program, Global Partnership of Output Based Aid, and the Rural Electrification Program, among others. The KNES envisions that 269,000 new connections will be added through grid extension. A further 2.77 million connections, including 100,000 mini-grid connections, will be added through grid intensification and densification, 35,000 through 147 new mini-grids, and 1.96 million through standalone SHS [32].

Pico-solar appliance and SHS deployment and job projection: GOGLA reported in 2018 that the Kenya off-grid solar market sold 750,000 units of product [75], [76]. On average, the annual growth rate of the Kenyan off-grid solar market was 11% between 2014–16 [30]. By 2022, assuming this growth rate holds, 1.1 million pico-solar appliances and SHS will be sold in Kenya. Assuming that private sector sales projections and publicly financed SHS deployment are mutually exclusive, and that the 1.96 million SHS are deployed evenly throughout the next four years, the Kenya DRE sector is projected to be selling 1.5 million pico-solar appliances and SHS annually. To achieve this sales projection, the Kenya pico-solar and SHS sectors will need to provide 12,000 direct, formal jobs and 24,000 direct, informal jobs.

FIGURE 20. DIRECT JOB FUNCTION BREAKDOWN IN 2022–23



4. Employment Projections

Mini-grid deployment and job estimate: By 2022, 135,000 new mini-grid connections will be added to existing and new mini-grids [32]. To operate these additional connections, approximately 5,000 direct, formal jobs and 5,800 informal jobs need to be created.

Job projection insights: By 2022–23, the DRE sector will be employing more than 17,000 direct, formal employees and 30,000 informal workers. While the mini-grid sector is growing fast, pico-solar appliance and SHS companies would still be the main source of jobs in the sector.

4.3. Key Projections and Insights for Nigeria

National strategies and planned policy interventions: The Nigerian government announced Vision 30:30:30, which aims to achieve a 90% electrification rate, with a generation capacity of 30,000 MW, 30% from renewable energy sources, by the year 2030 [77]. To achieve this goal, Sustainable Energy for All (SEforALL) built a model to estimate the growth of each type of energy technology required to achieve Vision 30:30:30. However, according to current market estimates, Nigeria will need an adequately trained workforce if it is to meet the needed growth rate [77].

To address this gap, the Nigerian government rolled out several incentive programs to encourage private sector participation and the use of DRE solutions. The Nigeria Electrification Project aims to incentivize the deployment of 1 million SHS, 44 standalone solar systems, and 330,000 households and local enterprises connected to mini-grids [78]. In addition, the Energizing Economies Initiative identified 340 economic clusters such as market and agro-processing plants, with a cumulative demand of 4 GW. If electrified, these alone could create 2,500 jobs [79].

Pico-solar appliance and SHS deployment and job projection: As estimated in Nigeria's *SEforALL Action Agenda,* 108 MW of SHS should be sold in the year 2022 [77]. To achieve this, the sector will need to provide 2,000 direct, formal jobs, doubling the pico-solar appliances and SHS jobs created in 2017. In addition to direct, formal jobs, the sector would need another 14,000 informal workers to support its activities by 2022.

Mini-grid deployment and job estimate: By the year 2022, in the *SEforALL Action Agenda,* a cumulative capacity of 405 MW of mini-grids will need to be operational in Nigeria [77]. To do so, the sector will need to provide about 50,000 direct, formal jobs and 9,500 informal jobs. However, the mini-grid sector may fall short of this projection. SEforALL estimated that in 2017, Nigeria should have installed 50 MW of mini-grids. Unfortunately, the Rocky Mountain Institute estimated that only 30 solar mini-grids with a total installed capacity of 1 MW were operational by 2017.

Job projection insights: Assuming that current direct, formal employment factors remain unchanged, Vision 30:30:30 should result in more than 52,000 direct, formal jobs and 24,000 direct, informal jobs by 2022–23.

5.Conclusions

5.1. Key Insights

In this section we explore five key insights from the survey data, focus groups, and literature, followed by our recommendations.

1. The DRE sector is already creating a large number of skilled, middle-income, long-term jobs and has the potential to become a major employer for emerging economies. The DRE sector is nascent and just beginning to scale, but even so, according to the first annual jobs census, it has already grown a workforce equivalent to the traditional utility-scale power sector. The DRE sector in India provided 95,000 direct jobs in 2017–18, compared to 92,400 jobs from the on-grid solar PV sector. In Kenya, the DRE sector provided 10,000 direct jobs in 2017–18, compared to 11,000 by the national utility company, KPLC. In Nigeria, the DRE sector provided 4,000 jobs in 2017–18, compared to 10,000 jobs in the electricity, gas, steam, and air conditioning sector. Furthermore, there is strong growth potential. By 2023, DRE jobs could more than double, up to 190,000 direct, formal jobs in India, depending on mini-grid penetration, 17,000 in Kenya, and 52,000 in Nigeria.

2. In addition to direct, formal employment, the DRE sector employs twice as many workers through informal jobs and five times as many through productive use jobs. This is critical as informal work is often the largest source of employment for the Least Developed Countries. While these are difficult job sectors to accurately assess, early estimates suggest that in 2017, the DRE sector accounted for 210,000 direct, informal jobs in India, 15,000 in Kenya, and 9,000 in Nigeria, almost double the DRE sector's direct, formal workforce. By 2022–23, the sector could provide as many as 210,000 direct, informal jobs in India, 30,000 in Kenya, and 24,000 in Nigeria. The number of productive use jobs stimulated through new or improved electricity access can be roughly estimated at 470,000 in India, 65,000 in Kenya, and 15,000 in Nigeria: five times the DRE sector's direct, formal workforce. Not only is the scale of informal and productive use DRE jobs important, but also the fact that they are predominantly rural in nature. In these emerging markets where agriculture is still the main source of livelihood, DRE simultaneously presents a solution to energy access and unemployment. As new micro-enterprise opportunities and agricultural value chains are explored, the impact could grow significantly.

3. Pico-solar appliance and SHS companies are currently the job engine of the DRE sector, though employment from mini-grids is likely to grow, potentially exceeding standalone solar in some regions. Pico-solar appliances and SHS accounted for 97% of India's total direct, formal DRE employment in 2017–18, providing over 92,000 jobs. Many of these were associated with government initiatives, but as the government phases out support for the sector, these numbers are not likely to grow. Rather, the government plans to put more focus on solar water pumps and mini-grids, such that 39% of DRE jobs may be found in development, installation, and O&M by 2022–23. Similarly, ambitious mini-grid plans in Nigeria mean that by 2022–23, mini-grids could account for 96% of the 52,000 anticipated direct, formal DRE jobs. These estimates are speculative and depend on actual growth of the various DRE technology markets, but show that the nature of the DRE workforce will likely evolve over time.

4. Sales and distribution skills are important for sustaining the DRE sector, while management skills represent a critical gap for unlocking further growth. Sales and distribution positions account for the largest share of jobs. In 2017–18, of the direct, formal workforce, 39% in India and 41% in Kenya are engaged in sales and distribution. In Nigeria, only 8% of the direct, formal workforce is involved in sales and distribution, though this may be related to the nascency of the sector there. As mentioned above, as mini-grid solutions become more mainstream in national electrification strategies, the need for project development, operations, and management skills will also grow. However, even mini-grid companies acknowledge the importance of sales and distribution skills, especially as their business model begins to drive demand by supporting micro-enterprise creation in local economies. Furthermore, a large majority of informal jobs are also in sales. Thus, growing the sales, distribution, and operations skill sets are important for the sector. Importantly, while management and business positions

TABLE 3. KEY NATIONAL EMPLOYMENT ESTIMATES FOR 2017–18 AND 2022–23 PROJECTIONS

	India	Kenya	Nigeria
Number of direct, formal jobs in 2017	95,000	10,000	4,000
Number of informal jobs in 2017	210,000	15,000	9,000
Projected number of direct, formal jobs in 2022–23	190,000	17,000	52,000
Projected number of informal jobs in 2022–23	210,000	30,000	24,000
Percentage change in direct, formal jobs between 2017–18 and 2022–23	Increased by 100%	Increased by 70%	Increased by 1200%
Percentage of women in direct, formal DRE workforce 2017–18	23%	23%	27%
Percentage of youth in direct, formal DRE workforce 2017–18	45%	41%	28%
Top 3 skills in 2017–18 (percentage of DRE direct, formal workforce positions)	1. Sales and distribution (39%) 2. After-sales service (22%) 3. Management and business administration (22%)	1. Sales and distribution (41%) 2. Management and business administration (22%) 3. After-sales service (15%)	1. After-sales service (26%) 2. Management and business administration (25%) 3. Project development and installation (22%)
Top 3 skills in 2022–23 (percentage of DRE direct, formal workforce positions)	1. O&M (24%) 2. Sales and distribution (23%) 3. Management and business administration (22%)	1. Sales and distribution (38%) 2. Management and business administration (24%) 3. After-sales service (15%)	1. Management and business administration (27%) 2. O&M (21%) 3. Project development and installation (19%)
Key assumptions for 2022–23 job projections	Based on the objectives set out by JNNSM, KUSUM, and the sales forecast of pico-solar appliances and SHS from GOGLA.	Based on specific KNES objectives, these estimates show the incremental employment impact of individual public sector DRE initiatives.	Based on SEforALL's 2030 action agenda, this projection may be high as the country is already falling short of its DRE deployment plan designed by SEforALL.

5.Conclusions

only compose a fifth of the sector's direct, formal jobs, across all countries surveyed this is reported as the most critical and difficult skill set to recruit, hampering the sector's expansion. Although not the largest contributor to jobs numbers, managerial skills are a critical gap for the sector.

5. Women's participation in the direct, formal DRE workforce is low, while youth participation is high. On average, women make up about a quarter of the DRE workforce, less than the broader global renewable energy sector where women account for 32% of employees. Women are even less represented in direct, formal managerial positions. Women's participation increases in the informal sector, where they make up more than half of the sector's informal workforce. For instance, in India, as many as 60% of informal jobs employ women. This may be due to the recognized importance of women's influence in rural sales and distribution networks. In India and Kenya, more than 40% of the workforce are youth, compared to 28% in Nigeria. DRE companies agree that there are more opportunities for youth if recruitment and training challenges can be overcome.

5.2. Recommendations

While the database on DRE employment will grow over the coming years, even the above insights lead to a series of clear recommendations for the sector and its stakeholders.

1. There are clear skills needed to unlock the DRE sector's potential to scale and create more employment, presenting an opportunity for collaboration between government, academia, training organizations, and industry associations. Managerial skills in particular are in high demand, being identified as the most difficult to recruit. Technical skills are also needed in sales, distribution, and operations. TVET institutions in the local markets require financial support to fill this gap, from updating curricula, to upgrading equipment, attracting highly qualified trainers, better branding and awareness, and standardized evaluation of training programs.

Likewise, higher education is critical to fill these gaps and prepare the future workforce. Stronger collaboration between government, industry, and academia is needed for development of standardized, accredited, industry-relevant curricula and for the establishment of career development programs for graduates. Opportunities for industry exposure, such as apprenticeships, practicum exercises, and short-term internships, are an important component of an excellent curriculum. Since the sector presents an important rural employment opportunity, it is key to develop training programs easily accessible by rural communities.

2. Alongside technical skills, DRE companies reported that general business soft skills are critically lacking, affecting every aspect of company performance. These soft skills include leadership, finance, strategic planning, communication, chains of command, project management, compliance, anti-harassment, and health and safety. Especially given the growing importance of productive use to the DRE business model, companies also pointed to the need for basic micro-enterprise training among rural end users, from bookkeeping to business planning.

Soft skills training may be an opportunity for shared training services across the sector, as this particular skills gap was noticed across the sector, and most DRE companies do not have the resource or bandwidth for internal training. More than two-thirds of DRE companies reported that they work across multiple parts of the value chain, so developing tailored, short, soft skills and rural micro-enterprise training programs for the entire DRE sector through collaboration with local higher education and TVET institutions would support the DRE companies themselves while also encouraging a well-rounded, qualified workforce. Shared technical training resources would be more difficult to achieve as companies often have proprietary technology that cannot be shared publicly or which would make standardization of the curricula difficult.

Furthermore, given the potential for productive use jobs, increased collaboration would aid the DRE sector and the other sectors that benefit from the productive capacity of DRE solutions, such as agriculture, food, water, and rural small and medium enterprises. Collaboration and further study of value chains is necessary to identify market opportunities and the interventions necessary to establish these businesses.

3. There is clearly opportunity for further youth engagement, which would be an important solution to the growing challenge of unemployed youth in many emerging economies. However, the lack of experience and pipelines for youth recruitment present their own challenges. As noted previously, stronger industry collaboration with higher education and TVET institutions is needed, however, well-functioning and highly visible recruitment channels, such as university clubs, open days, and job tours for graduates, are also important to help young people navigate the gap from campus

5.Conclusions

to employment. Established recruitment channels will increase awareness and improve perception about the relatively nascent DRE sector and its career opportunities. Likewise, this will expand opportunities for DRE companies to recruit from pools of qualified graduates. Many skills and recruitment programs have been recently established that provide examples for successful intervention.

4. Similarly, there is a need for greater participation of women in the sector. The low participation is related to many broader sociocultural challenges around gender stereotypes, recruitment biases, discriminatory business cultures, and women's representation in STEM education. Encouraging women's participation in the labor force is important, as unemployment rates are higher among women, especially rural women. At the same time, women are beneficial to the DRE sector in particular areas of the value chain. For instance, women are social influencers within their communities, thus playing an important role in successful sales, product distribution, and micro-enterprise development. Identifying other such areas where women provide direct value to companies is important, but engaging women in the DRE sector should begin with developing and implementing gender equality policies and practices across the sector, such as gender equality selection criteria for grants and tenders, as well as directly encouraging greater participation of women in the types of education and training programs mentioned earlier. Stakeholders directly engaged in women's empowerment should be part of the policy development process.

5. The sector's massive footprint in the informal sector presents an opportunity to encourage the formalization of labor to align with local and international decent work standards, compensation standards, and social protections. Not only do informal workers have less stability and lower wages, but they are often more exposed to macroeconomic risks. For example, sales agents are strongly affected by even short-term, seasonal fluctuations in electricity demand. Helping to secure and formalize the livelihoods of informal workers would allow the sector to better support local economies. This is particularly important as women account for a majority of informal jobs. Industry associations can play a key role in aligning the sector around such standards.

Developing pathways to certify skilled, but uncertified, technicians is another way to help formalize rural employment opportunities. Establishing updated, easily accessible, regional databases of certified technicians is another simple solution to provide companies with easier access to vetted, qualified skilled labor. There are many opportunities for the private sector, government stakeholders, funders, and training institutions to collaborate around formalization of the workforce.

5.3. Limitations of the Study

Finally, we address the key study limitations that impact results and interpretation of results.

Sample representation: The survey sample is the largest dataset on DRE jobs in emerging markets known at the time of publication. Nevertheless, the sample is still small for India, given the poor response rate, and does not evenly represent DRE activity in all states. There are several large DRE companies that, together, have a majority share of reported sales in the sample and therefore affect the employment factor strongly and its ability to be applied across the sector for national estimations. In these cases, we sought the opinion of industry experts on the market share of these big companies. In cases where the sample did not reflect the average market situation, outliers were removed from the study. As the survey is replicated over time the sample size should improve, thereby improving the statistical significance of the results.

Consideration of the role of private and foreign investments: This iteration of the census does not consider the role of investment on growth. Depending on international trends in investment, certain technologies may grow more quickly, or may have better paying jobs. On the other hand, if sufficient private financing is not leveraged, ambitious expansion targets, like those in India, will not be achieved. Thus, both current and future employment estimates depend heavily on investment and finance.

The availability of high-quality market estimate data: To scale survey results to the national level, the study applies employment factors derived from the survey data to future market estimates. Some DRE technologies, such as the solar water pump market in Kenya and Nigeria, lack market data and therefore their future employment footprint cannot be properly measured. Furthermore, future market estimates differ between governments and the private sector, when they exist. The most recent and best available estimates are used where possible.

Employment patterns over time: Given this is the first year of data collection, the survey is not able to provide comparative insight into how employment behavior changes over a DRE company's

5.Conclusions

trajectory. For instance, as companies grow to scale it is possible that less labor will be required per unit produced. These patterns greatly affect employment factors over time, impacting the accuracy of future employment estimates. Though the survey asked about company age, this provided little insight as there is only a single year's worth of data to observe. The static 2017 employment factors are used to estimate future employment, and are not discounted for change in employment patterns. A key reason to replicate this study yearly is to understand employment patterns over time.

Consideration of job displacement: Given the lack of available data, the study does not explore past, current, or future job displacement that may result from fuel switching or automation. The net employment impact of the DRE sector across direct, indirect, and productive use job categories will be significantly influenced by displacements elsewhere in the economy. This is a major limitation to understanding the scale of net employment. Broader macroeconomic studies are required.

Comparability of direct, formal, direct, informal, and productive use jobs: Direct jobs cannot be aggregated, nor can productive use jobs. Due to lack of data about the nature and time involved in work, direct, informal and productive use jobs are not readily translated into FTE terms and therefore cannot be compared in scale to direct, formal jobs. Further study is required.

Wages and compensation: Many companies chose not to answer survey questions on wage, or only reported male wages. In addition, the survey was directed towards DRE company leadership or human resource employees whose response to compensation policy may be more conservative. Employee oriented surveys and deeper analysis are required for stronger conclusions.

Comparability of wages between direct, formal and direct, informal employment: In the survey, companies reported the earnings received by informal workers for an average month of engagement with their company. This does not provide a full picture of an informal worker's total monthly income across various income streams. It also is not informed by the number of hours or days that an informal worker is engaged with said company. It is therefore difficult to compare levels of compensation between formal and informal workers according to survey data.

Indirect job estimates: Due to the limited number of upstream and sector service providers that responded to the survey, and the limited quantitative data in the literature, indirect jobs cannot be readily estimated. It is also difficult to attribute employment in these sectors directly to DRE companies. Further research into in-country and external supply chains is required.

Induced job estimates: Induced jobs are not included in the study scope. Future iterations of the study may leverage ongoing work from other research organizations building macroeconomic analysis tools for our target countries.

Productive use job estimates: Companies responding to the survey had very little confidence in productive use job estimates from their products or services. Standard measurement and evaluation frameworks are required for the sector. Productive use job estimates for SHS and mini-grids are derived from the literature and expert opinion solicited in focus groups. These estimates are thus incomplete, not considering productive use jobs from C&I, solar water pumping, or other DRE technologies. Furthermore, productive use employment factors from the literature are often anecdotal, or based on limited study not involving randomized controls. Further, these employment factors may be biased toward early adopter behavior. It can be misleading to apply these static employment factors to large geographic areas or over time. Finally, note that these employment factors do not provide insight into the level of engagement and retention, skill level requirements, quality of wages and compensation, social protection, or other employment characteristics. As mentioned, it is therefore difficult to aggregate productive use jobs in FTE terms or to compare qualities to other job categories. Estimates for productive use employment in this study have no statistical significance, and should not be generalized.

5.4. Conclusion

Delivering energy access to millions of people and businesses worldwide through DRE technologies will require employing substantial numbers of people. This study is the first of its kind, offering a bottom-up job census for the DRE sector in emerging economies. Early estimates show that while the potential for direct jobs is large, the potential for informal and productive use jobs may be far larger. However, more consistent and standardized data collection is needed by the sector.

The current size of the DRE workforce is already comparable to the utility-scale renewable energy sector in India and Kenya, and the electricity, gas, and steam sector in Nigeria. As the DRE sector

5.Conclusions

expands the workforce will only grow larger. The DRE sector is thus a potential solution to two of the biggest challenges in emerging economies: access to clean energy and job creation. Given that the DRE sector creates long-term, skilled, middle-income jobs, it is strategic national policy to invest resources to solve training and recruitment challenges, thus building a strong DRE workforce.

Future iterations of our job census will continue to explore the three countries surveyed to gather insight into their patterns of hiring and employment, allowing us to better understand future market growth and job creation. We plan on expanding the census to other key DRE markets across sub-Saharan Africa and Asia while implementing a broader set of survey tools that will allow more extensive research into productive use jobs. Additionally, this will also allow us to explore indirect jobs from upstream sectors and potential job displacement from traditional energy sectors. This level of data analysis will also allow for better insight into the job creation potential and workforce needs of specific value chain segments, such as manufacturing and service sectors. Finally, we aim to conduct a more comprehensive analysis of youth and women's participation in the energy access workforce.

The stakes are high for the DRE sector and national governments. Investment in the DRE workforce is critical to enable a timely skill transition and channel the growing population of potential young employees into the expanding sector. Working together, all DRE stakeholders could provide hundreds of thousands of jobs and bring clean energy to millions over the next five years. We invite all willing partners to join us in spreading awareness and unlocking the vast potential of this dynamic sector.

References

[1] “World Energy Access Outlook 2017,” International Energy Agency, 2017.

[2] M. Renner, C. Garcia-Baños, D. Nagpal, and A. Khalid, “Renewable Energy and Jobs - Annual Review 2018,” International Renewable Energy Agency, Abu Dhabi, 2018.

[3] R. Obala, “Kenya Power to review vendors’ contracts amid customer uproar,” *The Standard,* May 2018. [Online]. Available: https://www.standardmedia.co.ke/article/2001279375/kenya-power-to-review-vendors-contracts-amid-customer-uproar. [Accessed June 4, 2019].

[4] “Labour Force Statistics Vol. 2: Employment by Sector Report (Q3 2017),” Nigeria National Bureau of Statistics, Jan. 2018.

[5] “Renewable Energy Benefits: Leveraging Local Capacity for Solar PV,” International Renewable Energy Agency, Abu Dhabi, 2017.

[6] R. Ferroukhi, M. Renner, C. García-Baños, and B. Barua, “Renewable energy: A gender perspective,” International Renewable Energy Agency, Abu Dhabi, 2019.

[7] “Fact Sheet: The World Bank and Agriculture in Africa,” *The World Bank.* [Online]. Available: http://go.worldbank.org/GUJ8RVMRL0. [Accessed June 3, 2019].

[8] “How Kenya is failing to create decent jobs,” Africa Research Institute, June 2017.

[9] “Mind The Gap: The State of Employment in India,” Oxfam India, Mar. 2019.

[10] “Data Finder - World Employment and Social Outlook,” *International Labour Organization.* [Online]. Available: https://www.ilo.org/wesodata/. [Accessed: June 3, 2019].

[11] “Africa’s population explosion is a ticking time bomb - African Development Bank Governors,” *African Development Bank,* Mar-2018. [Online]. Available: https://www.afdb.org/en/news-and-events/africas-population-explosion-is-a-ticking-time-bomb-african-development-bank-governors-17900/. [Accessed May 1, 2019].

[12] *South Asia Economic Focus: Jobless Growth.* The World Bank, 2018.

[13] K. Ighobor, “Africa’s jobless youth cast a shadow over economic growth,” *Africa Renewal,* no. Special Edition on Youth, 2017.

[14] L. Cozzi, O. Chen, H. Daly, and A. Koh, “Population without access to electricity falls below 1 billion,” *International Energy Agency,* Oct-2018. [Online]. Available: https://www.iea.org/newsroom/news/2018/october/population-without-access-to-electricity-falls-below-1-billion.html. [Accessed May 1, 2019].

[15] “Decentralized Renewables: From Promise to Progress,” Power for All, Mar. 2017.

[16] R. Ferroukhi et al., “Renewable Energy and Jobs,” International Renewable Energy Agency, Abu Dhabi, Dec. 2013.

[17] L. Connolly-Boutin and B. Smit, “Climate change, food security, and livelihoods in sub-Saharan Africa,” *Reg Environ Change,* vol. 16, no. 2, pp. 385–399, Feb. 2016.

[18] “Fostering Effective Energy Transition: A Fact-Based Framework to Support Decision-Making,” World Economic Forum, Mar. 2018.

[19] “Renewable Energy Jobs and Access,” International Renewable Energy Agency, Abu Dhabi, June 2012.

[20] E. Mills, “Job creation and energy savings through a transition to modern off-grid lighting,” *Energy for Sustainable Development,* vol. EEE33, pp. 155–166, Aug. 2016.

[21] “Employment opportunities in an evolving market. Off-grid solar: creating high-value employment in key markets,” GOGLA, Briefing Note, Nov. 2018.

[22] “Energizing job creation: employment opportunities along the off-grid solar value chain,” GOGLA, May 2019.

[23] N. Kuldeep et al., “Greening India’s Workforce - Gearing up for Expansion of Solar and Wind Power in India,” Council on Energy, Environment and Water, June 2017.

[24] “Opportunities and Challenges in the Mini-Grid Sector in Africa: Lessons Learned from the EEP Portfolio,” Energy and Environment Partnership Trust Fund, Sep. 2018.

[25] L. Mayer-Tasch, M. Mukherjee, and K. Reiche, “Productive Use of Energy - PROUSE: Measuring Impacts of Electrification on Small and Micro-Enterprises in Sub-Saharan Africa,” GIZ, 2013.

[26] M. Willcox, L. Waters, H. Wanjiru, A. Pueyo, D. Palit, and K. R. Sharma, “Utilising Electricity Access for Poverty Reduction,” Practical Action Consulting, Jan. 2015.

[27] “Energy Impact Report,” Acumen, 2017.

[28] “Powering Opportunity: the Economic Impact of Off-Grid Solar,” GOGLA, July 2018.

References

[29] S. Khan, “Acumen Lean Data phone interview with rural businesses,” Mar. 2019.

[30] “Off-Grid Solar Market Trends Report 2018,” GOGLA, Lighting Global, ESMAP, Dalberg Advisors, Washington, D.C., Jan. 2018.

[31] “Office Memorandum: Pradhan Mantri Sahaj Bijli Har Ghar Yojana - Saubhagya,” Government of India, Oct-2017.

[32] “Kenya National Electrification Strategy: Key Highlights,” Kenya Ministry of Energy, 2018.

[33] “Rural Electrification Strategy and Implementation Plan,” Federal Government of Nigeria, July 2016.

[34] “Saubhagya Dashboard,” [Online]. Available: https://saubhagya.gov.in/. [Accessed June 4, 2019].

[35] “Nigeria: Energy needs assessment and value chain analysis,” All On, 2017.

[36] “2019 Tracking SDG 7: The Energy Progress Report,” International Bank for Reconstruction and Development, The World Bank, 2019.

[37] “Women and Men in the Informal Economy: A Statistical Picture (Third Edition),” International Labour Organization, Geneva, 2018.

[38] “Informal Enterprises in Kenya,” The World Bank Group, Nairobi, Jan. 2016.

[39] “State of Decentralised Renewable Energy Sector in India,” Clean Energy Access Network, Oct. 2018.

[40] “Light and Livelihood: A Bright Outlook for Employment in the Transition from Fuel-Based Lighting to Electrical Alternatives,” GOGLA, 2014.

[41] W. Prabhu, “Top Eight Inverter Manufacturers Account for 96 Percent of India’s Solar Inverter Market,” *Mercom India,* Jan. 2017.

[42] “ABB India doubles solar inverter manufacturing capacity with a new state of the art factory.” ABB India, Sep. 2016.

[43] “M-KOPA goes ‘Made In Kenya’ with PV panels,” *M-KOPA Solar,* Jan. 2018.

[44] C. Mama, “What’s the Current State of Solar Equipment Import Trade in Africa?,” *Solar Magazine,* Aug. 8, 2017.

[45] A. Okafor, “Phone interview with Change Partners International for indirect and induced jobs insights,” Mar. 2019.

[46] “Interview with Smart Power India for productive use jobs insight,” Dec. 2018.

[47] “Sustainable Energy and Livelihood,” SELCO Foundation, 2018.

[48] J. Cook, “Cooking up a storm at the Modern Energy Cooking Services Programme Launch,” *Modern Energy Cooking Services,* Apr. 2019.

[49] “Kenya: Improved Cookstoves,” Natural Capital Partners, 2016.

[50] “Market Acceleration of Advanced Clean Cookstoves in the Greater Mekong Sub-region,” Energizing Development, Mar. 2018.

[51] “Clean energy powers local job growth in India,” Natural Resources Defense Council, Interim Report, Feb. 2015.

[52] “Global Wage Report 2018/19: What lies behind gender pay gaps,” International Labour Organization, Geneva, 2018.

[53] “India’s median per capita income lowest among BRICS: Gallup,” *Business Standard India,* New Delhi, Dec. 17, 2013.

[54] “India Salary Guide 2019,” Kelly Service India, 2019.

[55] “India Wage Report: Wage policies for decent work and inclusive growth,” International Labour Organization, Geneva, 2018.

[56] C. Robertson, N. Ndebele, and Y. Mhango, “A survey of the Nigerian middle class,” Renaissance Capital, Sep. 2011.

[57] “International Standard Classification of Occupations: Structure, group definitions and correspondence tables,” International Labour Organization, Geneva, 2012.

[58] “Solar Sister: Empowering Women Through Clean Energy Entrepreneurship,” International Center for Research on Women, 2015.

[59] “Youth Definition,” *United Nations Educational, Scientific and Cultural Organization.* [Online]. Available: http://www.unesco.org/new/en/social-and-human-sciences/themes/youth/youth-definition/. [Accessed February 18, 2019].

[60] “African Development Bank launches Youth Advisory Group to create 25 million jobs,” *African Development Bank.* [Online]. Available: https://www.afdb.org/en/news-and-events/african-development-bank-launches-youth-advisory-group-to-create-25-million-jobs-17607/. [Accessed May 1, 2019].

[61] “Winning the fight for female talent: How to gain the diversity edge through inclusive recruitment,” PwC, Mar. 2017.

[62] “Energizing Equality: sub-Saharan Africa’s integration of gender equality principles in national energy policies and frameworks,” Power Africa, Washington, D.C., May 2018.

[63] “Mini-Grid Training Needs Assessment: Gap Analysis for Developers,” Energy 4 Impact, INENSUS, Sep. 2018.

[64] B. Jairaj, P. Deka, S. Martin, and S. Kumar, “Can renewable energy jobs help reduce poverty in India?,” World Resources Institute India, 2017.

References

[65] "Energizing Education Programme," *Nigeria Rural Electrification Agency,* Sep. 2017.

[66] "Energy Generation | Formation à l'entrepreneuriat," *Energy Generation | Formation à l'entrepreneuriat.* [Online]. Available: https://www.energy-generation.org. [Accessed April 29, 2019].

[67] "Suryamitra Skill Development Programme," *Vikaspedia.* [Online]. Available: http://vikaspedia.in/energy/policy-support/renewable-energy-1/suryamitra-skill-development-programme. [Accessed June 5, 2019].

[68] S. Teske, E. Dominish, C. Briggs, F. Mey, and J. Rutovitz, "Outlook on employment effects of a global energy transition," Greenpeace, 2018.

[69] "Renewable Energy and Jobs – Annual Review 2017," International Renewable Energy Agency, Geneva, 2017.

[70] "Subject: Jawaharlal Nehru National Solar Mission," Government of India, Ministry of New and Renewable Energy, Jan. 2010.

[71] "Continuation of Off-grid and Decentralized Solar PV Application Programme in Phase II for Financial Years 2018–19 and 2019–20," Government of India, Ministry of New and Renewable Energy, Aug. 7, 2018.

[72] "KUSUM Yojana: Solar Agriculture Pumps Subsidy Yojana," *Online Yojana,* Feb. 2019.

[73] D. G. Prasad, "Subject: Draft National Policy on RE based Mini/Micro grids.," *Government of India, Ministry of New and Renewable Energy,* p. 25, June 2012.

[74] "Peering into the future: India and the distributed standalone solar products market," GOGLA, Jan. 2019.

[75] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data. January – June 2018," GOGLA, Oct. 2018.

[76] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data. July – December 2018," GOGLA, 2019.

[77] "Sustainable Energy for All Action Agenda (SE4ALL-AA)," Federal Republic of Nigeria, July 2016.

[78] "The Nigeria Electrification Project," *Nigeria Rural Electrification Agency,* July 2018.

[79] "Energizing Economies Initiative," *Nigeria Rural Electrification Agency,* 2019.

[80] "Features of Pico-PV Systems," *Energypedia.* [Online]. Available: https://energypedia.info/wiki/Features_of_PicoPV_Systems. [Accessed April 10, 2019].

[81] "Mini-Grids," *Energypedia.* [Online]. Available: https://energypedia.info/wiki/Mini_Grids. [Accessed April 10, 2019].

[82] R. Hussmanns, "Statistical definition of informal employment: Guidelines endorsed by the Seventeenth International Conference of Labour Statisticians," presented at the 7th Meeting of the Expert Group on Informal Sector Statistics, New Delhi, 2003.

[83] B. L. Das and M. Baruah, "Employee Retention: A Review of Literature," *IOSR Journal of Business and Management,* vol. 14, no. 2, pp. 08–16, 2013.

[84] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data. January – June 2017," GOGLA, Oct. 2017.

[85] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data. July – December 2017," GOGLA, Apr. 2018.

[86] "On-Site Solar is a Cost Saver and a Hedge on Energy Prices for African Businesses," *Bloomberg New Energy Finance,* Jan. 24, 2019.

[87] J. Mukherji, "Smart Power Connect: A magazine for the Mini-Grid Sector from the Smart Power for Rural Development India Foundation," *Smart Power India,* vol. 2, no. 1, May 2017.

[88] S. Duby and T. Engelmeier, "Kenya: The World's Microgrid Lab," TFE Consulting, 2017.

[89] "Mini-grid Investment Report: Scaling the Nigerian Market," Nigerian Economic Summit Group and Rocky Mountain Institute, 2018.

Photos generously provided by: Mlinda (p. 22), Mobisol (cover), Oorja Solutions (p. 33), Practical Action/Edoardo Santangelo (p. 29), REEEP/Jason Mulikita (p. 8, p. 16, p. 21, p. 38)

Appendix A. Acronyms and Glossary of Terms

C&I	Commercial and industrial
CEEW	Council on Energy, Environment and Water
DRE	Decentralized renewable energy
FTE	Full-time equivalent
GOGLA	Global Off-Grid Lighting Association
ILO	International Labour Organization
IRENA	International Renewable Energy Agency
ISCO	International Standard Classification of Occupations
JNNSM	Jawaharlal Nehru National Solar Mission
KPLC	Kenya Power and Lighting Company
KUSUM	Kisan Urja Surksha Utthan Mahaabhiyan
KNES	Kenya National Electrification Strategy
MFI	Microfinance institutions
MNRE	Ministry of New and Renewable Energy (India)
O&M	Operations and maintenance
SDG	Sustainable Development Goal
SEforALL	Sustainable Energy for All
SHS	Solar Home Systems
STEM	Science, technology, engineering, and mathematics
TVET	Technical, vocational education and training

TECHNOLOGY TERMS

» **Commercial and industrial systems:** Commercial and industrial (C&I) systems are standalone or grid-tied rooftop solar systems that are component-based, larger than 200 W, and often connect public institutions or commercial buildings. For our purposes, C&I does not include large, ground-mounted, industrial solar systems [80].

» **Market penetration:** As defined by GOGLA, market penetration is the percentage of total sales in a given year as compared to adjusted market potential of the same year, which is an estimate of the maximum number of eventual adopters that would buy a pico or plug-and-play SHS if market economics allowed [30].

» **Mini-grid:** A mini-grid, sometimes referred to as a microgrid or isolated grid, can be defined as a set of electricity generators, and possibly energy storage systems, interconnected to a distribution network that supplies electricity to a localized group of customers. They involve small-scale electricity generation (10 kW to 10 MW) which serves a limited number of consumers via a distribution grid that can operate in isolation from national electricity transmission networks [81].

» **Pico-solar appliance:** A pico-solar appliance generally comprises three components: a solar panel, battery, and lamp. These appliances generally have a capacity smaller than 10 W [80].

» **Solar home systems:** Solar home systems (SHS) are stand-alone photovoltaic systems that offer a cost-effective mode of supplying power for lighting and appliances to remote, off-grid households. In the context of this study, whenever the term SHS is used, it refers to standardized plug-and-play systems. These systems are generally between 10–200 W [80].

» **Solar water pumps:** A solar water pump is a pump powered by electricity generated from solar panels. There are different types of solar water pumps, including submersible or surface pumps, and AC or DC pumps. Depending on the design of the pump system, it can either be powered by only solar energy, or a hybrid system with a diesel generator or storage system, enabling more flexible use.

EMPLOYMENT TERMS

» **Employment factor:** An employment factor measures the number of jobs created per unit of produced product or service. For instance, direct employment factors are calculated based on the number of total direct, formal jobs and number of products sold or systems built, in sales unit or capacity terms.

» **Full-time employment:** A full-time employee is on the payroll with a registered company, enjoys benefit as an employee, and works full-time hours, which is generally more than 35 hours per week, but may differ according to company policy.

» **Part-time employment:** A part-time employee is on the payroll with a registered company but does not work full-time hours, which is defined according to company policy.

» **Full-time equivalent (FTE) job**: An FTE job is the equivalent of one employee working full time over the course of a year where full-time work is defined in accordance with the country context. Part-time and contract work are converted to FTE based on number of hours worked or length of contract. All estimates of direct, formal jobs are presented in FTE job terms. All other references to jobs outside of direct, formal employment do not assume full-time equivalency.

- **Direct, formal jobs:** In the scope of this study, direct, formal jobs are those created through contractual engagement with an incorporated company in the DRE sector. For example, an IT professional or a project manager who is employed by a DRE company.
- **Indirect jobs:** Indirect jobs are those created by backward-linked industries or companies that serve and supply the DRE sector. That is, those vendors and suppliers who serve the DRE sector upstream or provide services for the DRE sector's day-to-day operations either contractually or non-contractually. For example, indirect jobs are those created by an inverter manufacturer or an importer who supplies DRE companies. Literature on indirect jobs is cited where available.
- **Informal sector:** According to the ILO, the informal sector comprises all work for unincorporated enterprises and for which no complete accounts are available that would permit a financial separation of the production activities of the enterprise from other activities of its owner(s). Informal jobs can even be extended to include non-remunerative work of contributing family members, and thus can be difficult to bound definitively [82].
- **Direct, informal jobs:** Informal jobs are created through contractual or non-contractual engagement with an incorporated company in the DRE sector. Informal employment in the sector takes on various forms—from long-term arrangements with companies (e.g. product retail) to commission-based sales activities. For example, a home business owner who works as a village sales representative for a SHS company [82].
- **Induced jobs:** Induced jobs are those created through forward linkages as workers in the DRE sector spend salaries on goods and services throughout the larger economy. For example, during the construction of a mini-grid plant, induced jobs are created for food vendors and water fetchers at the construction site. The study does not explore the macroeconomic effects of spending on the economy and further job creation thereof. Induced jobs are thus excluded from the analysis and this report [16].
- **Productive use jobs:** Productive use jobs are those created by the DRE end users themselves as a result of newly-acquired or enhanced electricity access. For the purpose of this study, productive use is defined as any income-generating application of a DRE product or service [25]. For example, the new jobs created by the purchase of a solar milling plant. Productive use jobs are estimated through insights from focus groups and literature, as most surveyed respondents did not readily have data on jobs created by their product or service offers at the customer level.
- **Retention:** Retention is the total period of time that an employee continues to work with an organization [83].
- **Senior managers:** For the purpose of this study, senior managers include the top executive management of a company, such as the CEO, CFO, and COO.
- **Skilled workers:** Skilled workers are those who hold leadership, management, professional, technical, or associate professional positions. Their responsibilities typically involve the performance of complex technical and practical tasks that require an extensive body of factual, technical, and procedural knowledge in a specialized field, as defined by the International Standard Classification of Occupation (ISCO-08) Skill Level [57]. Workers in Skill Level 3 or above are considered skilled workers.
- **Youth:** Youth are defined as persons between the ages of 15 to 24 [59].

Appendix B. Methods

This appendix provides the formulae and assumptions used in each analysis, including formulae for translating different types of work into FTE terms, for estimating direct, formal, informal, and productive use jobs, and for projecting future jobs based on available market forecasts. In the report text we round all analysis results to two significant figures for readability.

1. FTE Job Calculation

We calculate full-time equivalence by using the following formulae to equate part-time and contract work with the work load of a full-time job.

$$\textit{FTE for a part-time job} = \frac{\textit{part-time working hours}}{\textit{full-time working hours}} \qquad \textit{FTE for a contract job} = \frac{\textit{average length of contract}}{\textit{full-time retention}}$$

2. Total Direct, Formal Jobs in 2017–18

We calculate total direct, formal jobs for each country in 2017–18 by applying the following formulae to each practitioner grouping:

Employment factor = total number of direct, formal jobs ÷ total number of products sold
Total direct, formal jobs = employment factor × 2017 market estimate

TABLE 4. ESTIMATES FOR DIRECT, FORMAL JOBS IN 2017–18

	India	Kenya	Nigeria
Employment factor for pico-solar appliances and SHS companies	13.7 jobs per 1,000 products sold	8.2 jobs per 1,000 products sold	5.0 jobs per 1,000 products sold
Pico-solar appliances and SHS market estimate for 2017	6,700,000 products sold [39]	915,643 products sold [84], [85]	215,575 products sold [84], [85]
Pico-solar appliances and SHS direct, formal jobs estimate	**91,790 jobs**	**7,508 jobs**	**1,078 jobs**
Employment factor for C&I companies	80.8 jobs per MW installed	120.4 jobs per MW installed	132.7 jobs per MW installed
C&I market estimate for 2017	9.5 MW [39]	15 MW [86]	20 MW [86]
C&I direct, formal jobs estimate	**771 jobs**	**1,806 jobs**	**2,654 jobs**
Employment factor for mini-grid companies	180.7 jobs per MW operated	4.0 jobs per system operated	3.9 jobs per system operated
Mini-grid market estimate for 2017	3.5 MW operated [87]	65 systems operated [88]	30 systems operated [89]
Mini-grid direct, formal jobs estimate	**632 jobs**	**260 jobs**	**117 jobs**
Employment factor for solar water pump companies	29.9 jobs per 1,000 pumps sold	9.5 jobs per 1,000 pumps sold	N/A
Solar water pump market estimate for 2017	50,000 pumps sold [39]	10,000 pumps sold	N/A
Solar water pump direct, formal jobs estimate	**1,495 jobs**	**95 jobs**	**N/A**
Total direct, formal jobs	**94,688 jobs**	**9,669 jobs**	**3,838 jobs**

Appendix B. Methods

3. Total Direct, Informal Jobs in 2017–18

We calculate total direct, informal jobs for each country in 2017–18 by applying the following formulae to each practitioner grouping:

Informal employment factor = total number of direct, informal jobs ÷ total number of products sold
Total direct, informal jobs = informal employment factor × 2017 market estimate

TABLE 5. ESTIMATES FOR DIRECT, INFORMAL JOBS IN 2017–18

	India	Kenya	Nigeria
Employment factor for pico-solar appliances and SHS companies	31.9 jobs per 1,000 products sold	16.0 jobs per 1,000 products sold	38.8 jobs per 1,000 products sold
Pico-solar appliances and SHS market estimate for 2017	6,700,000 products sold [39]	915,643 products sold [84], [85]	215,575 products sold [84], [85]
Pico-solar appliances and SHS direct, informal jobs estimate	**213,730 jobs**	**14,650 jobs**	**8,364 jobs**
Employment factor for C&I companies	20.0 jobs per MW installed	13.2 jobs per MW installed	19.5 jobs per MW installed
C&I market estimate for 2017	9.5 MW [39]	15 MW [86]	20 MW [86]
C&I direct, informal jobs estimate	**191 jobs**	**198 jobs**	**390 jobs**
Employment factor for mini-grid companies	16.4 jobs per MW operated	4.5 jobs per system operated	0.3 jobs per system operated
Mini-grid market estimate for 2017	3.5 MW operated [87]	65 systems operated [88]	30 systems operated [89]
Mini-grid direct, informal jobs estimate	**57 jobs**	**293 jobs**	**9 jobs**
Employment factor for solar water pump companies	N/A	N/A	N/A
Solar water pump market estimate for 2017	50,000 pumps sold [39]	10,000 pumps sold	N/A
Solar water pump direct, informal jobs estimate	**N/A**	**N/A**	**N/A**
Total direct, informal jobs	**213,978 jobs**	**15,141 jobs**	**8,763 jobs**

4. Total Productive Use Jobs in 2017–18

We calculate total productive use jobs for each country in 2017–18 by applying the following formula to each practitioner grouping:

Total productive use jobs = productive use employment factor × 2017 market estimate

TABLE 6. ESTIMATES FOR PRODUCTIVE USE JOBS IN 2017–18

	India	**Kenya**	**Nigeria**
Employment factor for pico-solar appliances and SHS companies	70 jobs per 1,000 products sold [28]	70 jobs per 1,000 products sold [28]	70 jobs per 1,000 products sold [28]
Pico-solar appliances and SHS market estimate for 2017	6,700,000 products sold [39]	915,643 products sold [84], [85]	215,575 products sold [84], [85]
Pico-solar appliances and SHS productive use jobs estimate	**469,000 jobs**	**64,095 jobs**	**15,090 jobs**
Employment factor for C&I companies	N/A	N/A	N/A
C&I market estimate for 2017	9.5 MW [39]	15 MW [86]	20 MW [86]
C&I productive use jobs estimate	**N/A**	**N/A**	**N/A**
Employment factor for mini-grid companies	9 jobs per system operated [46]	9 jobs per system operated [46]	9 jobs per system operated [46]
Mini-grid market estimate for 2017	106 systems operated [87]	65 systems operated [88]	30 systems operated [89]
Mini-grid productive use jobs estimate	**954 jobs**	**585 jobs**	**270 jobs**
Employment factor for solar water pump companies	N/A	N/A	N/A
Solar water pump market estimate for 2017	50,000 pumps sold [39]	10,000 pumps sold	N/A
Solar water pump productive use jobs estimate	**N/A**	**N/A**	**N/A**
Total productive use jobs	**469,954 jobs**	**64,680 jobs**	**15,360 jobs**

Appendix B. Methods

5. Total Direct, Formal Jobs in 2022–23

We calculate total direct, formal jobs for each country in 2022–23 by applying the following formula to each practitioner grouping:

Total direct, formal jobs projection = employment factor × market projection or policy objectives

TABLE 7. PROJECTIONS FOR DIRECT, FORMAL JOBS IN 2022–23

	India	Kenya	Nigeria
Employment factor for pico-solar appliances and SHS companies	13.7 jobs per 1,000 products sold	8.2 jobs per 1,000 products sold	18.8 jobs per MW sold
Pico-solar appliances and SHS market projection for 2022–23	6,308,412 products sold [74]	1,490,000 products sold (1,100,000 private sector-driven sales and 390,000 public sector-driven sales) [30], [32], [75], [76]	108 MW sold [77]
Pico-solar appliances and SHS direct, formal jobs projection	**86,425 jobs**	**12,218 jobs**	**2,030 jobs**
Employment factor for C&I companies	80.8 jobs per MW installed	120.4 jobs per MW installed	132.7 jobs per MW installed
C&I market projection for 2022–23	20 MW installed (assuming the target is evenly achieved between 2018–23) [71]	N/A	N/A
C&I direct, formal jobs projection	**1,616 jobs**	**N/A**	**N/A**
Employment factor for mini-grid companies	180.7 jobs per MW operated	36.9 jobs per 1,000 connections operated	123.4 jobs per MW operated
Mini-grid market projection for 2022–23	High mini-grid penetration: 500 MW operated [73] Low mini-grid penetration: 60 MW operated [46]	135,000 connections operated [32]	405 MW operated [77]
Mini-grid direct, formal jobs projection	**High mini-grid penetration: 90,350 jobs** **Low mini-grid penetration: 10,842 jobs**	**4,982 jobs**	**49,977 jobs**
Employment factor for solar water pump companies	29.9 jobs per 1,000 pumps sold	9.5 jobs per 1,000 pumps sold	N/A
Solar water pump market projection for 2022–23	350,000 pumps (assuming the target is evenly achieved between 2018–23) [72]	N/A	N/A
Solar water pump direct, formal jobs projection	**10,465 jobs**	**N/A**	**N/A**
Total direct, formal jobs	**High mini-grid penetration: 188,856 jobs** **Low mini-grid penetration: 109,581 jobs**	**17,200 jobs**	**52,007 jobs**

Appendix B. Methods

6. Total Direct, Informal Jobs in 2022–23

We calculate total direct, informal jobs for each country in 2022–23 by applying the following formula to each practitioner grouping:

Total direct, informal jobs projection = informal employment factor × market projection or policy objectives

TABLE 8. PROJECTIONS FOR DIRECT, INFORMAL JOBS IN 2022–23

	India	Kenya	Nigeria
Employment factor for pico-solar appliances and SHS companies	31.9 jobs per 1,000 products sold	16.0 jobs per 1,000 products sold	131.5 jobs per MW sold
Pico-solar appliances and SHS market projection for 2022–23	6,300,000 products sold [74]	1,490,000 products sold (1,100,000 private sector-driven sales and 390,000 public sector-driven sales) [30], [32], [75], [76]	108 MW sold [77]
Pico-solar appliances and SHS direct, informal jobs projection	**201,238 jobs**	**23,840 jobs**	**14,202 jobs**
Employment factor for C&I companies	20.0 jobs per MW installed	13.2 jobs per MW installed	19.5 jobs per MW installed
C&I market projection for 2022–23	20 MW installed (assuming the target is evenly achieved between 2018–23) [71]	N/A	N/A
C&I direct, informal jobs projection	**400 jobs**	**N/A**	**N/A**
Employment factor for mini-grid companies	16.4 jobs per MW operated	42.9 jobs per 1,000 connections operated	23.4 jobs per MW operated
Mini-grid market projection for 2022–23	High mini-grid penetration: 500 MW operated [73] Low mini-grid penetration: 60 MW operated [46]	135,000 connections operated [32]	405 MW operated [77]
Mini-grid direct, informal jobs projection	**High mini-grid penetration: 8,200 jobs** **Low mini-grid penetration: 984 jobs**	**5,792 jobs**	**9,477 jobs**
Employment factor for solar water pump companies	N/A	N/A	N/A
Solar water pump market projection for 2022–23	350,000 pumps (assuming the target is evenly achieved between 2018–23) [72]	N/A	N/A
Solar water pump direct, informal jobs projection	**N/A**	**N/A**	**N/A**
Total direct, informal jobs	**High mini-grid penetration: 209,956 jobs** **Low mini-grid penetration: 202,761 jobs**	**30,270 jobs**	**23,662 jobs**