International Labour Organization

STRENGTHEN2

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Employment impact assessment of the Green Mini-Grid (GMG) Facility, Kenya

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Acronyms and abbreviations

AC	alternating current
AFD	Agence Française de Développement
AITF	Africa Infrastructure Trust Fund (European Union)
BoP	bottom of the pyramid
DC	direct current
DFID	Department for International Development (United Kingdom)
EmpIA	employment impact assessment
EPRA	Energy and Petroleum Regulatory Authority
ERC	Energy Regulatory Commission
EU	European Union
FCDO	Foreign, Commonwealth and Development Office (United Kingdom)
FTE	full-time equivalent
GDP	gross domestic product
GIS	geographic information system
GMG	Green Mini-Grid
GoK	Government of Kenya
HH	household
IED	Innovation Energie Développement
IPP	independent power producer
KenGen	Kenya Electricity Generating Company
KES	Kenyan shilling
KNBS	Kenya Bureau of Statistics
KNES	Kenya National Electrification Strategy
KPEA	KUDURA Power East Africa
KPLC	Kenya Power, formerly Kenya Power and Lighting Company
kWh	kilowatt hour
kWp	kilowatt peak
ME	Managing Entity
MoE	Ministry of Energy
MW	Megawatt
NHIF	National Hospital Insurance Fund
NSSF	National Social Security Fund
PAC	Practical Action Consulting
PAYG	pay-as-you-go

PIDG	Private Infrastructure Development Group
PV	photovoltaic
REPP	Renewable Energy Performance Platform
REREC	Rural Electrification and Renewable Energy Corporation
RVE.SOL	Rural Village Energy Solutions
SMEs	small and medium-sized enterprises
SMS	service message text
SMSD	Structural Model for Sustainable Development
SSA	sub-Saharan Africa

Glossary of terms

Direct employment: created directly by construction, operation or maintenance activities (including workers directly recruited by contractors and subcontractors, technicians, supervisors and other skilled professional staff).

Indirect employment: created in the backward-linked industries, supplying tools, materials, plant and equipment for construction and maintenance activities.

Induced employment: created through forward linkages as households benefiting from direct and indirect employment spend some of their additional income on goods and services in the economy.

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Executive Summary

The ILO STRENGTHEN2 project is conducting employment impact assessments of investments in sub-Saharan Africa funded by the European Union (EU) to promote the creation of more and better jobs. This report presents an employment impact assessment (EmpIA) of the second phase of the Green Mini-Grid Facility Programme in Kenya (GMG Facility Kenya, n.d.). The programme aims to improve access to energy for people in Kenya, where the EU-funded phase envisages 33 mini-grid sites split across two developers. Quantitative and qualitative data were collected through observations during a field visit, semi-structured interviews and a questionnaire to obtain information on the operational side of mini-grids and on direct employment generated from the design and construction phase. Indirect and induced employment were estimated using the ILO-STRENGTHEN2 estimation tool, based on ILO's Structural Model for Sustainable Development (SMSD).

Based on data availability, the number of jobs created are expressed as either the headcount, which includes all workers, whether full-time or part-time. For the estimates on direct employment, jobs are also expressed in terms of the full-time equivalent (FTE), which totals the hours worked by all employees to compute the number of full-time positions. The results estimate that the EU-funded phase of the GMG programme produced:

- **4,407 total** number of jobs created, expressed as the headcount.
- **3,755** of these are **direct jobs**, created during the design and construction phase of the project. **3,663** of these direct jobs are **temporary** and **92 are permanent**.
- Converting the direct jobs created to the annual FTE, it is estimated that **406 FTE jobs** are created from direct employment under the programme.
- For **indirect and induced** employment, **652** jobs are estimated, expressed as the headcount.
- This is equivalent to **58 annual FTE jobs** created through direct employment **per million Euros** of investment.

The results also show that there is a clear bias towards male and unskilled jobs. During the construction phase, workers were often unskilled and male. Youth accounted for 86 per cent of employment during construction. For the estimates of indirect and induced employment, out of the 652 jobs created, 79.5 per cent go to men and 12 per cent make up skilled jobs. The majority of these indirect and induced jobs, fall within the services sector. It is estimated that 12 per cent of the indirect / induced jobs go to youth. To address this bias through future initiatives, it is recommended to invest in further training and work-based learning to upskill employees, particularly targeted at female staff. Due to the high number of imported goods used in the construction of the mini-grids, the indirect and induced employment may have the potential to be higher. In order to increase the number of indirect/induced jobs created in future similar projects, it is recommended to explore options to reduce the dependency on imported goods and to source locally where possible, to increase the employment generation within Kenya.

Available data collected on employment quality was limited; however, from information available on contract type for direct employment, all employees with permanent jobs have a contract. For temporary jobs during the design and construction phase of the project, the majority of employees are without a formal contract. For future similar programmes, it is recommended that there is an emphasis on collecting and publishing more information related to employment quality for developers, including information on social protection, working conditions and gender and youth breakdowns, to record progress made not only on the number of jobs but also towards decent work.

The GMG programme is providing access to sustainable, affordable and reliable energy through the construction of mini-grid sites across Kenya. Along with providing access to energy for the communities served, it is estimated that the mini-grids produce three permanent jobs at each site, within the local community. Access to electricity will increase long term employment opportunity and economic development for the benefitting population, through productive use of energy. It is recommended that the Government of Kenya invest further in these sustainable energy solutions in areas that are not served by the national grid, to increase access to electricity for the population of Kenya.

Résumé exécutif

Le projet STRENGTHEN2 de l'OIT réalise des évaluations de l'impact sur l'emploi des investissements financés par l'Union Européenne (UE) en Afrique subsaharienne afin de promouvoir la création d'emplois plus nombreux et de meilleure qualité. Ce rapport présente une évaluation de l'impact sur l'emploi de la deuxième phase du programme Green Mini-Grid Facility au Kenya (GMG Facility Kenya, s.d). Le programme vise à améliorer l'accès à l'énergie des habitants du Kenya, où la phase financée par l'UE envisage 33 sites de mini-réseaux répartis entre deux promoteurs. Des données quantitatives et qualitatives ont été collectées lors d'une visite sur le terrain à travers des constatations, des entretiens semi-structurés et d'un questionnaire permettant d'obtenir des informations sur l'aspect opérationnel des mini-réseaux et sur les emplois directs générés par la phase de conception et de construction. Les emplois indirects et induits ont été estimés à l'aide du « ILO-STRENGTHEN2 estimation tool » qui est basé sur le Modèle Structurel pour le Développement Durable de l'OIT.

En fonction de la disponibilité des données, le nombre d'emplois créés est exprimé en effectif total, comprenant tous les travailleurs, qu'ils soient à temps plein ou à temps partiel. Concernant les estimations d'emploi direct, les emplois sont aussi exprimés en termes d'équivalent temps plein (ETP), qui totalise les heures travaillées par tous les employés pour calculer le nombre de postes à temps plein. Les résultats estiment que la phase financée par l'UE du programme GMG a produit :

- 4 407 emplois, en nombre total d'emplois créés exprimé en effectif.
- Dont 3 755 emplois sont des emplois directs, créés pendant la phase de conception et de construction du projet. 3 663 de ces emplois directs sont temporaires et 92 sont permanents.
- En convertissant les emplois directs créés en ETP annuels, on estime que 406 emplois ETP ont été créés à partir des emplois directs du programme.
- Pour les emplois indirects et induits, on estime à 652 le nombre d'emplois en effectif total.
- Cela équivaut à 58 emplois ETP annuels créés par l'emploi direct par million d'euros d'investissement.

Les résultats montrent qu'il existe un biais évident à l'égard des hommes et des emplois non qualifiés. Pendant la phase de construction, les travailleurs étaient souvent des hommes non qualifiés, et les jeunes représentaient 86 pour cent des emplois. Concernant les estimations d'emplois indirects et induits, 79,5 pour cent des 652 emplois créés sont occupés par des hommes et 12 pour cent sont des emplois qualifiés. La majorité des emplois se situent dans le secteur des services. On estime que 12 pour cent des emplois indirects / induits sont occupés par les jeunes. Pour remédier à ce biais dans le cadre d'initiatives futures, il est recommandé d'investir dans la formation continue et l'apprentissage sur le lieu de travail afin d'améliorer les compétences, en particulier celles des femmes. En raison du nombre élevé de biens importés utilisés dans la construction des mini-réseaux, l'emploi indirect et induit pourrait avoir un potentiel plus élevé. Afin d'augmenter le nombre d'emplois indirects/induits créés par de prochains projets similaires, il est recommandé d'explorer des opportunités pour réduire la dépendance aux biens importés et de s'approvisionner localement lorsque cela est possible, afin d'augmenter la création d'emplois au Kenya.

Les données recueillies sur la qualité de l'emploi sont limitées, mais d'après les informations disponibles sur le type de contrat concernant les emplois directs, tous les employés ayant un emploi permanent disposent d'un contrat. Concernant les emplois temporaires de la phase de conception et de construction du projet, la majorité des employés n'ont pas de contrat formel. Dans le cadre de futurs programmes similaires, il est recommandé pour les promoteurs de mettre l'accent sur la collecte et la publication de davantage d'informations relatives à la qualité de l'emploi, y compris des informations sur la protection sociale, les conditions de travail et la répartition selon le genre et l'âge, afin d'enregistrer les progrès réalisés non seulement en termes de nombre d'emplois mais aussi en termes de décence du travail.

Le programme GMG fournit un accès à une énergie durable, abordable et fiable par la construction de sites de mini-réseaux au Kenya. En plus de fournir un accès à l'énergie aux communautés desservies, on estime que les mini-réseaux créent trois emplois permanents sur chaque site, au sein de la communauté locale. L'accès à l'électricité augmentera les opportunités d'emplois à long terme et le développement économique de la population bénéficiaire, grâce à un usage productif de l'énergie. Il est recommandé que le gouvernement du Kenya investisse davantage dans ces solutions énergétiques durables dans les zones qui ne sont pas desservies par le réseau national, afin d'accroître l'accès à l'électricité des habitants du Kenya.

1. Introduction

The STRENGTHEN2 project aims to leverage employment impact assessment (EmpIA) in sub-Saharan Africa for the creation of more and better jobs. STRENGTHEN2 is working to assess the employment impact of infrastructure investments funded by the European Union (EU) in Kenya, among other countries. The Green Mini-Grid Facility (GMG) Programme enhances access to energy in Kenya by encouraging private investment in renewable energy-based mini-grids. It aims to support economic development in rural communities through productive usage of electricity and job creation, improving the lives of 100,000 Kenyans whilst respecting the environment. The project is funded by the United Kingdom's Department for International Development (DFID) (now the Foreign Commonwealth and Development Office (FCDO)) and the European Union (EU). The first phase, GMG1, was funded by DFID and was completed in October 2020, four years after it began in 2016. The second phase, GMG2 is funded by the EU and currently under implementation by the Agence Française de Développement (AFD), due to be completed by the end of 2022. In total, the project has 80 mini-grid sites from four developers, split across GMG1 with 47 sites and GMG2 with 33 sites.

This employment impact assessment focuses on the short- to mid-term employment effects created by GMG2, the second EU-funded phase of the project that is currently under implementation. The assessment focuses on the direct employment created during the construction of mini-grid sites, where data was collected from project developers through questionnaire and semi-structured interview. The indirect and induced employment effects were estimated using the ILO's Structural Model for Sustainable Development (SMSD). Indirect jobs are defined as those relating to the manufacturing of equipment and materials used in the mini-grid project, the supply chain that fabricates and delivers these materials, and the finance and banking sectors that provide services for the construction and operation of the project. Induced jobs are the jobs created due to spending of additional income by people directly or indirectly employed by the project. Dimensions such as gender, youth, skill-level and formality were included in employment estimations where data was available. Jobs are expressed as either the full-time equivalent (FTE) or headcount, dependent on information available on working hours.

This report outlines the background on renewable energy and mini-grids in Kenya to provide some insight into the existing landscape of this sector. Research into the operational side of the GMG developers and their associated mini-grid sites is covered before moving onto the results of the collected direct employment impacts and estimated indirect and induced employment generated by the GMG programme. A summary of employment is provided, including recommendations for how to potentially increase employment in future interventions and considerations for further employment impact assessments.

2. Background on mini-grids in Kenya

2.1. Country overview

Kenya is a country in sub-Saharan Africa (SSA) within East Africa, with a population estimated to be about 54 million (World Bank 2020a). It has an average annual population growth rate of 2.2 per cent. The country is divided into 47 semi-autonomous counties and has a population density of 74 per square kilometre (EAC 2019). The average household size is 3.9 people (KNBS 2020). The rural population represents 72 per cent of the total population, with 28 per cent of the population living in urban areas (World Bank 2020b).

Kenya is a lower middle-income economy, registering an average annual GDP growth of 5.6 per cent from 2015 to 2019. The Kenyan economy grew by 6.8 per cent in 2021 and decreased by 0.3 per cent in 2020, due to COVID-19. This is expected to improve in 2022, where GDP is forecast to grow by 5.9 per cent. Similarly, GDP per capita, which stood at about US$1,970 in 2019, declined to approximately US$1,940 in 2020, and is expected to bounce back and increase gradually in subsequent years (AfDB 2021). As of 2020, Kenya was the third largest economy in sub-Saharan Africa after Nigeria and South Africa.

Kenya's total employment (outside small-scale agriculture and pastoralist activities) stood at 18.3 million persons in 2021 (KNBS 2022). The informal sector accounted for 81.4 per cent of jobs outside small-scale agriculture and pastoralist activities. The urban employment-to-population ratio is 58 per cent, and the rural ratio is 59 per cent (Timmis 2018). Male employment accounted for 60.7 per cent of the total wage employment in 2021 (KNBS 2022). Kenya's youth unemployment rate for 2021 was 13.84 per cent, a 0.26 per cent increase from 2020 (World Bank 2022).The major economic sectors in Kenya with high value-added and that contribute the most to the national GDP are the services sector at about 56 per cent, followed by agriculture at 23.5 per cent and industry at 21 per cent (AfDB 2021). The agriculture sector's contribution to employment is significant, employing between 56 per cent to 54 per cent between 2017 and 2019, the services and industry sectors employed approximately 39 per cent and 6 per cent between 2017 and 2019 respectively (World Bank 2022).

Unemployment in Kenya increased from 7 per cent in 2015 to 10.4 per cent in 2020, largely due to the economic slowdown caused by COVID-19. The majority of the unemployed (about 85 per cent) are under the age of 35 (AfDB 2021), with about 30 per cent having attained primary-level education, 35 per cent secondary, 11 per cent mid-level and 9 per cent university education.

Kenya seeks to become a highly industrialized but environmentally clean middle-income nation by 2030. The main national development blueprint is Vision 2030, which is broken down into five-year medium-term plans. The current medium-term plan (MTP III) covers 2017-22, and is focused on achieving four strategic objectives, known as "The Big Four": (i) Expand manufacturing from 9.2 per cent of GDP to 15 per cent; (ii) attain 100 per cent food and nutrition security; (iii) achieve universal health coverage; and (iv) build 500,000 affordable houses.

Among others, MTP III also addresses entrenched challenges of poverty, unemployment, and socio-economic inequalities as well as mitigation of the effects of climate change in the context of the Paris Agreement, guided by the Climate Change Act, National Climate Change Framework Policy, National Climate Change Action Plan, and National Climate Change Response Strategy. Hence, "The Big Four" concerns supporting sectors with proven potential for high value addition and job creation to assist industrialization and achieve the needed structural transformation and improved welfare. Furthermore, the National Treasury has launched the Kenya Vision 2030 Fourth Medium Term Plan (MTP) 2023-2027 preparatory process that will guide the development agenda for the country in promoting social and economic growth. This is in line with Sustainable Development Goal (SDG) 8, to promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

2.2. Overview of the energy sector in Kenya

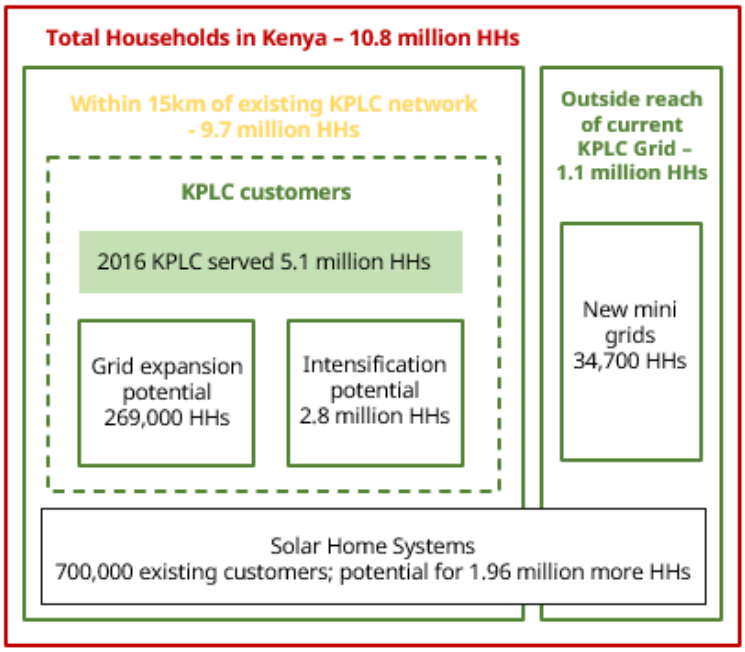
The World Bank (2018), states that electricity is critical to achieving the economic and productive sector objectives defined in Kenya's Vision 2030. Realizing the Vision 2030 objectives is feasible if all sectors of the economy – from manufacturing, services, mining, agriculture and agro-based industry for food security to households – have quality energy services provided in a sustainable, cost-effective and affordable manner.

Kenya has one of the most developed power sectors in sub-Saharan Africa, having opened its market to independent power producers (IPPs) in the mid-1990s (USAID 2022). Private companies are allowed to generate electricity, which they can sell to government-controlled entities for transmission and distribution or use toward rural electrification in mostly off-grid areas (GET.invest 2022). In 2019, the Kenya Electricity Generating Company (KenGen) generated about 61 per cent of total production, while IPPs covered the rest. Nevertheless, demand for electricity in Kenya continues to grow at an average rate of 4.5 per cent year-on-year, driven by high business activity as the country recovers from the effects of the global COVID-19 pandemic (KenGen 2021). At the same time, Kenya has scaled up use of renewable sources, further boosting the country's standing in the fight against climate change.

Access to reliable, affordable and sustainable energy is one of the 17 SDGs of the United Nations. In line with SDG 7, Kenya aims to achieve universal access to sustainable energy for all (households and businesses), double the global rate of energy efficiency, and double the global share of renewable in the energy mix by 2030. To achieve this, the Kenyan Government launched the Kenya National Electrification Strategy (KNES) in 2018 to provide off-grid options, mini-grids, and stand-alone solar systems to rural communities. The Government is currently in the process of reviewing and updating the KNES which means these figures may be likely to change. As presented by the World Bank (2018), this aims to provide adequate, quality, reliable and affordable energy to stimulate and support high economic growth – which is expected to lead to higher incomes, more employment opportunities and less poverty. The World Bank (2018) highlights that the KNES identifies potential (see figure 1) for:

- 269,000 connections to the grid through grid expansion (within 15 km of the Kenya Power (KPLC) distribution system).
- 2.77 million connections to the grid through grid intensification and densification (including 100,000 connections through intensification of existing mini-grids). Grid densification is achieved by installing additional transformers on existing medium voltage to connect housing clusters within 600 metres of existing distribution transformers, and grid intensification is achieved by extending short (up to 2 km) medium voltage lines and additional transformers to connect more consumers.
- 35,000 connections through 121 new mini-grids to serve housing clusters too distant from the network or too small to be connected to the national grid.
- 1.96 million connections through standalone solar home systems.

▶ Figure 1. Least-cost household distribution in grid and off-grid areas



Source: KNES 2018

Challenges to achieving universal access still exist; the main ones include: (i) high connection costs; (ii) high costs of supplying electricity to rural and peri-urban households; (iii) lack of appropriate incentives to attract private investors; (iv) inappropriate technical standards given the nature of settlements; (v) difficulties and delays in obtaining wayleaves consents, rights of way and demands for high compensation; and (vi) weak implementation capacity (World Bank 2018).

While Kenya's national grid has also reached many rural villages, reliability remains a critical concern. "Urban areas are mostly electrified while only two thirds of rural areas have access to electricity. Nationally, one quarter of the population remains without electricity, equivalent to 3.5 million households. Tariffs are highest for low voltage domestic and small commercial users, at an average of around €c12/kWh, which may impede affordability for some" (GET.invest 2022).

There is thus a huge potential for programmes such as GMG Facility Kenya, with the role of providing access to reliable electricity to rural and poor populations outside the reach of the national grid, including mini-grids for hard-to-reach population pockets difficult to serve through the national grid. The KNES estimates that about 1.1 million households are out of reach of the current KPLC grid. Furthermore, the KNES aims to connect about 35,000 household through mini-grids (as shown in figure 1), implying an additional 121 new mini-grids nationally, although this target may be subject to change based on an ongoing review of the KNES. GMG Facility Kenya has also advanced a target of connecting a maximum of 25,000 new connections, implying a potential coverage of about 71 per cent of the KNES target. Further programmes, such as the WB-supported Kenya Off-Grid Solar Access Project (KOSAP) also add to this coverage target. KOSAP has a target of approximately 120 mini grids, serving between 100-700 users each.

2.3. Renewable energy, mini-grids and policy environment in Kenya

Renewable energy is one of the key energy subsectors that significantly contribute to the larger energy sector in Kenya. Most of Kenya's electricity is generated through renewable energy sources – renewables provided 92.3 per cent of Kenya's electricity generation in 2020 (CleanTechnica 2021). Despite significant strides in renewable energy development, there is need for policy improvement to diversify the energy generation mix and promote public-private partnerships for financing renewable energy projects. Scaling this sector, now widely acknowledged as a critical part of rural electrification and universal energy access, requires a skilled and engaged workforce. With adequate policy and financial support, the sector could contribute directly to ameliorating unemployment (Power for All 2019). The Renewable Energy department of Kenya's Energy and Petroleum Regulatory Authority (EPRA) is responsible for leading the planning, development, implementation, promotion, and execution of structures for the development and regulation of renewable energy and energy efficiency. Notably, EPRA is one of the main public stakeholders in the Kenyan mini-grid sector, and regulates mini-grids and the Rural Electrification and Renewable Energy Corporation (REREC) (see table A.1 in the Annex for the key energy sector players in Kenya and their core functions).

Mini-grids are stand-alone energy systems that offer grid-quality electricity for an entire community, its businesses and even small-scale industries. A mini-grid also has clearly defined boundaries, where the World Bank has adopted the working definition of mini-grids as "electric power generation and distribution systems that provide electricity to just a few customers in a remote settlement or bring power to hundreds of thousands of customers in a town or city. They can be fully isolated from the main grid or connected to it but able to intentionally isolate ('island') themselves from the grid" (quoted in Day and Kurdziel 2019). Sub-Saharan Africa has an estimated 1,465 mini-grids serving 14.9 million people (Day and Kurdziel 2019), as shown in table A.2. A report from the Africa Minigrid Developers Association (AMDA), looking at 28 developers across 12 countries, shows that Kenya has a large share of sites and developers, accounting for 66 per cent of all sites surveyed on the continent (AMDA 2020). Nevertheless, with over 600 million Africans still living without access to electricity, mini-grids are recognized as the most appropriate technology for around half of this energy-poor population. The World Bank has estimated that over 140,000 mini-grids are needed in Africa alone to solve this problem. However, because the sector is relatively new and the customer base for these mini-grids represents poor, rural and often vulnerable and marginalized groups, there are both government sensitivities and investor scepticism around wholesale support of this technology from their respective viewpoints. There is currently a wide variety of business models and changing environments regarding policies and regulations applicable to private mini-grids.

Mini-grids can help reduce energy poverty, boost electricity demand, create jobs, improve the electricity supply quality and offer a complementary solution to national electrification efforts (Joshi et al. 2021). They increase energy reliability, delivering a consistent energy supply for both income production and household needs. Mini-grid deployment efforts within communities have also demonstrated that mini-grids can bring significant socio-economic development around the predominantly rural areas where they operate – for rural enterprises, grid-electricity use is often constrained. The possibility of aligning mini-grid development initiatives with national grid expansion efforts has led to some uncertainty regarding the scalability of mini-grids in Kenya. One of the risks developers face is the liability of stranded assets if the national grid arrives or if grid reliability improves in the villages serviced by the mini-grid provider. Mini-grids can be most successful when they have government support, so mini-grid solutions that can be integrated with national efforts and policies to improve electricity quality and reliability are important.

As presented in Day and Kurdziel (2019), mini-grids in Kenya provide electricity access to households, public facilities and businesses using decentralized electricity generation technologies managed by government institutions, private enterprises, or community cooperatives. In some contexts in Kenya, they are also referred to as isolated grids or micro-grids. Mini-grids can generally be classified as public-utility operated, private-sector operated, community operated, or hybrid (a mix of two or all of the aforementioned models). The specific systems vary in terms of generation capacity, technology and technical specifications, selected business and management models, service level, and number of connections, among other characteristics. In addition to offering a sustainable, cost-effective option for the accelerated electrification of rural households, the deployment of mini-grids brings about other benefits such as job creation, local industry development, and health improvements. To date, there is very little information available worldwide or from specific countries regarding the quantified employment impact and potential benefits of mini-grids compared to other electricity supply options. This, along with the generally limited availability of statistical information on mini-grids, remains a considerable barrier for research and policy planning.

There are a number of policies in place to support the adoption of mini-grids in Kenya, such as the National Energy Policy, and Feed-In Tariff Policy, Energy (Solar Photovoltaic Systems) Regulations, among others.

Although the 2018 KNES estimates that only less than 1 per cent of the 5.6 million connections are to be reached through mini-grids, political momentum and attention for mini-grids has increased in recent years. The policy position of supporting mini-grids is actively being translated into action through sector reform, while existing draft mini-grid regulations have been adopted in the new Energy Act (2019). Among others, these regulations cover how mini-grid tariffs are calculated, verified and approved, and the process to be followed if and when the grid arrives at a mini-grid location. These aspects of the new mini-grid regulations show how the Government is cognizant of the need to improve the environment for private investment and demonstrates government recognition of the growing role that privately developed and operated mini-grids will specifically play in achieving universal electricity access.

2.4. Public and private sector mini-grids in Kenya

Public-operated mini-grids serving isolated towns have been in operation in Kenya for many years. These were initially diesel-powered, but more recently renewable energy (mostly wind and solar) has been integrated into these mini-grids. Most existing larger-scale mini-grids are part of the public-sector operated electricity supply infrastructure. “The national power supply consists of an interconnected grid system, and 21 public sector mini-grids, of which 19 are owned by the Rural Electrification and Renewable Energy Corporation (REREC) and managed by KPLC, while the other two are owned and managed by the Kenya Electricity Generating Company (KenGen)” (Day and Kurdziel, 2019). Electricity prices for public mini-grid consumers are identical with those connected to the national grid, and the mini-grids’ higher operating costs are partially cross-subsidized by other national grid customers through the so-called “Rural Electrification Programme Levy”. The Government of Kenya (GoK) through the Ministry of Energy (Me) has also initiated programmes intended to electrify social infrastructure, including schools and health facilities in rural areas using solar systems. However, there appears to be lack of current and updated data and information on the operations of public mini-grids in Kenya.

In addition to the public sector mini-grids, Kenya has recently witnessed the emergence of private-sector mini-grid projects, generally at a smaller scale than the public systems. While most of the public-sector mini-grids have a standardized method of connecting customers, setting tariffs, and providing customer care support, private-sector mini-grids have the flexibility to integrate smart and cost-effective technology and deploy innovative business models. Private mini-grid operators can also integrate the local population into the development of their projects, where the local community is responsible for parts of the infrastructure and/or grid operation. However, since local communities often lack technical expertise and financial resources, they usually rely on a private actor or organization to develop and implement the project (Day and Kurdziel 2019). Again, several players in the industry have developed customized solar solutions such as solar home systems, solar lanterns, solar refrigerators and air conditioners that intend to meet the power needs of the rural population.

Private mini-grids in Kenya face numerous challenges including:

- Limited understanding of the demand for electricity in the unserved areas and sizing of systems;
- Insufficient funding for capital investments;
- A changing institutional and regulatory environment;
- Higher mini-grid tariffs as compared to national tariffs; and
- Uncertainty on compensation when the national grid and mini-grid meet.

3. The Green Mini-Grid Facility in Kenya

The Green Mini-Grid Facility Kenya (GMG Facility Kenya) was established in 2016, with funding from DFID for the first phase, to support the Kenyan Government's commitment to national electrification. The programme provides grants and technical assistance to promote renewable energy-based mini-grid development in Kenya through the private sector. DFID's (now FCDO) Kenya office has been providing oversight to the GMG Facility. The Agence Française de Developpement (AFD) is the implementing partner of the GMG Facility and is supported by Innovation Energie Développement (IED) in partnership with Practical Action Consulting (PAC) and I-DEV as the Managing Entity (ME) for the day-to-day operations of the programme.

The ME also implements sector-level initiatives to assist mini-grid practitioners develop and deploy high-priority productive use of energy applications, co-developing a suite of financial products and services with financial partners to improve access to finance. The GMG Facility Kenya is also supporting the MoE and in particular EPRA in formulating a regulatory framework conducive to private investment in the sector (development of mini-grid regulations, tariff modelling, electronic processing and increasing capacity in EPRA.

The GMG Facility Kenya is guided, monitored and overseen by a GMG Programme Committee chaired by the MoE; and includes EPRA, REREC, Kenya Power (KPLC) and the supporting development partners (European Union-Africa Infrastructure Trust Fund (EU-AITF), AFD and initially DFID). The Facility also monitors the impact of the mini-grids on the users and the communities through its Internal Monitoring & Evaluation Programme by carrying out baseline and impact surveys.

The Facility's objective is to promote economic development and social impact in rural areas; reduce inequalities between rural and urban/peri-urban areas; improve the standard of living for these communities; and reduce greenhouse gas emissions. Outcomes from Kenya will inform the region and operators on key opportunities for regional scale and replication. The GMG Facility programme is expected to achieve the following results:

- Access for 75,000-100,000 Kenyans to reliable green electricity for businesses in their communities.
- Approximately 19,000-25,000 expected new connections (Note: about 71 per cent of the KNES goal).
- A minimum of eight to ten GMG entities funded responsibly with grants and/or technical assistance.
- 1.5 megawatts of energy provided to Kenya's national energy supply.
- GMG-sector technical assistance to support a self-sustaining GMG sector in Kenya.
- Contribution to improving mini-grid regulations and policy.
- Private sector engaged in the funding of the GMG sector in Kenya.

With funding of £9.1 million received from DFID, the first phase of the GMG Facility Kenya (also referred to as "GMG1" or the DFID-funded phase of GMG Facility Kenya) covered the period 1 October 2016 to 31 October 2020. Three mini-grid developers were awarded contracts under GMG1 implementation, including PowerGen, Powerhive and Rural Village Energy Solutions (RVE.SOL)/KUDURA Power East Africa (KPEA)) (AFD 2018). The support covered the development and construction of solar-powered mini-grids through investment grants based on defined milestones at different stages, and through output-based grants according to the number of connections. This resulted in around 1,300 kWp[1] solar power and 10,000 connections across over 50 sites, all in rural areas in Western Kenya.

In 2018, the GMG Facility Kenya secured additional funding of €5.65 million from the EU-AITF for investment grants and output-based connection grants, with additional limited funds for technical assistance to support green

[1] Kilowatt hour (kWh) shows how much electricity a system generates, while the Kilowatt peak (kWp) shows how high its output is. Kilowatt peak (kWp) is the unit of measurement for the power of a photovoltaic (PV) system. It describes the maximum power in kilowatts that a PV system can produce. Kilowatt hour (kWh) is the unit of measurement for the system's energy produced and /or sold to consumers.

mini-grid development in Kenya. This made up the second phase, GMG2, which began in 2018 and is currently under implementation. Under GMG2, the targeted developers were RVE.SOL/KPEA and Renewvia.

Since its launch, the GMG Facility Kenya has thus supported four Kenyan mini-grid developers with investment grants under the framework of GMG1 and GMG2. These are: (i) RVE.SOL/KPEA with 33 sites in Busia County (11 in developed under GMG1 and 22 planned under GMG2); (ii) Renewvia (GMG2) with 11 sites: two in Siaya, one in Kajiado, seven in Turkana and one in Homabay, Ringiti; (iii) PowerGen with 13 sites in Kericho County (GMG1); and iv) Powerhive with 23 sites in Kisii and Nyamira counties (GMG1). The support has also covered technical assistance in demand assessment, productive use of energy, business modelling and capital structuring. Initiatives have also included a mapping of barriers to market development and opportunities for impact in “bottom of the pyramid” (BoP) markets, as well as technical assistance to EPRA on strengthening mini-grid regulations and tariff models.

4. Operations of selected mini-grid sites

The sections below describe the operations of select mini-grid sites visited, namely: RVE.SOL/KPEA, Renewvia and Powerhive sites in Kenya. RVE.SOL/KPEA and Renewvia were visited due to the focus of the assessment on GMG2, where they are the two developers involved. Powerhive from GMG1 was visited to provide some context of mini-grid sites that have been operational for a longer period of time.

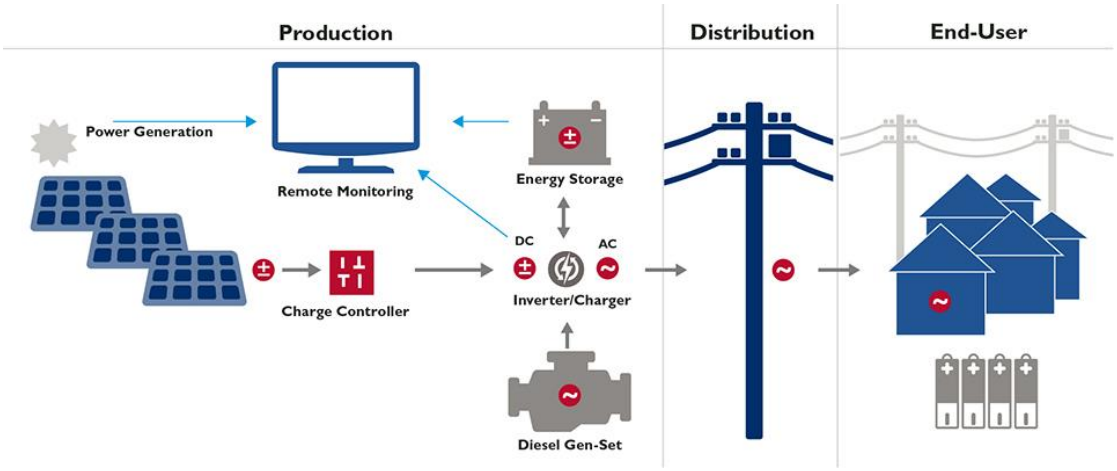
Information was collected from observations during site visits and follow-up semi-structured interviews with developers. The sites visited include two from Renewvia, the island sites of Ndeda and Oyamo, two from RVE.SOL in Busia and two from Powerhive in Kisii. The sites varied in time from completion, which enabled insight into the different effects that could be identified based on how long the sites had been operational. The developers differ in approach, commitment and ambition towards rural development. Site-specific conditions such as cultural orientation and rural accessibility may also render the projects more of a success in some areas than others. This report provides qualitative descriptions as well as typical impacts observed from the three developers.

4.1. Developers' set-up and operations

4.1.1. General considerations

This section is adapted from USAID (2018) with insights from field visits to the GMG sites. All the selected mini-grid set-ups included technical components grouped into three systems: (i) production, which generates electricity from either a single energy source or a mix of sources; (ii) distribution, which moves electricity from the generation site to end users; and (iii) end user, which provides connections that allow customers to use electricity (figure 2). Each system includes varied components, which are based on available resources, desired services and user characteristics.

▶ **Figure 2. Technical components of selected mini-grid sites**



Source: USAID 2018

The production system consists of energy-generation technologies, inverters, a management system and storage (batteries). The production system determines the mini-grid's overall capacity to provide electricity to end users (USAID 2018). Incorporating battery back-up, the mini-grids range in size from 5–60kWp. The energy-generation technologies for these mini-grids mainly include solar photovoltaic (PV) modules. Some GMG mini-grid sites have additional diesel generators, while one has a wind turbine.

The production systems use power inverters since the solar photovoltaic (PV) modules produce direct current (DC), which then needs to be converted to alternating current (AC) required by nearly all mainstream appliances. Battery charging, on the other hand, requires the DC power. In addition, the mini-grids have power management systems which measure, monitor and control electrical loads. A charge controller connects the solar panel and the battery or inverter/charger to prevent over-charging of the battery. Likewise, metering and monitoring equipment allows the mini-grid managers to gather data about energy use across end users, which informs operational decisions. These management systems couple computerized energy management tools with smart metering to optimize performance. The management systems also allow the operators to control the system remotely, including shedding loads as needed. All the mini-grid production systems also have energy storage (batteries), that adds stability to the system by storing energy for peak consumption and providing power when the renewable resource is not available, according to user demand. These batteries are located in well-ventilated locations (utility rooms or outbuildings), with basic portable structures – a stand-alone container flexible in size, function and location, and easy and quick to install, for the rugged rural areas. The containerized solution is safe, reliable, and weatherproof, and is designed and built to last for over 20 years. For all the mini-grid sites visited, nearly all the production system equipment is imported and is not available locally.

The distribution system consists of distribution and/or transmission lines, transformers and the infrastructure to support the lines, such as poles. Lines for the assessed mini-grids are mainly overhead as they are cheaper. Nevertheless, some sites were noted to include some underground transmission. The distribution systems also use a variety of voltages: either single- or three-phase power depending on type of connection. Step-up transformers increase the AC output voltage to transmit electricity more efficiently over a distance, while step-down transformers decrease the voltage from high- or medium-voltage transmission lines to 120V or 220V for residential use. For all the mini-grid sites visited, the majority of the distribution system materials and equipment are available locally.

The end-user systems provide an interface for end users to access, use and monitor electricity from the mini-grids, taking into account consumers' needs and energy uses. Businesses operating machinery for productive uses need different systems from households that use electricity for lighting and small appliances. The end-user system consists of connections to and from the mini-grid systems, and provides information to end users to allow them to monitor their energy consumption, estimate the cost of their consumption and understand the status of the system. They also provide useful data back to the system operator, reporting on consumption rate and timing, including when and how much energy is used, which enables the operator to estimate and predict demand and consumption patterns. The data also allow regulators to establish tariffs that balance the needs of the operator and the consumer, while ensuring that differing use cases are priced fairly and competitively. Furthermore, the end-user system provides important electrical bond and grounding mechanisms to ensure the safety of its users and protect valuable and expensive equipment. The mini-grids assessed utilize individual meters (one per end user) to provide the greatest degree of control over energy use. These meters generally fall under pre-paid meters typically called pay-as-you-go (PAYG) and the newer generation smart meters. In some PAYG metering systems, customers purchase minutes or quantities of electricity using mobile-phone-based banking, such as Kenya's M-PESA. After a purchase, the customer receives a code via a short service message text (SMS). The user then enters the code into the PAYG meter, which registers the credit.

Smart meters, on the other hand, gather data on energy consumption and facilitate two-way communication between the energy provider and end user, usually using cell phone technology. Smart meters do more than transmit payment and consumption data. They can log and report power quality and reliability data in real time, which enables operators or technicians to address power quality issues before they become problems. Smart meters can even allow the grid operator to shut down troublesome loads before they jeopardize the entire system and cause problems for other consumers. These features help the grid operators to deliver a higher quality of service to all customers. For all the mini-grid sites, most of the end-user system materials and equipment are available locally.

The approach used in setting up and running the developer sites appear similar. In general, the setting up of mini-grids by each of the developers generally follows the sequence: customer surveys, acquiring permits, geographic information systems (GIS) surveys and lease of land including seeking wayleave, estimation of required materials and technical specification/design, construction, conditional assurance and tests, Ministerial No Objection, EPRA's tariff and license approval, on-boarding (training) and finally billing. The whole process can take as long as three months to up to one year, depending on the site. Once up and running, developers' operations and maintenance personnel are locally-based, allowing the developers to build trust with the

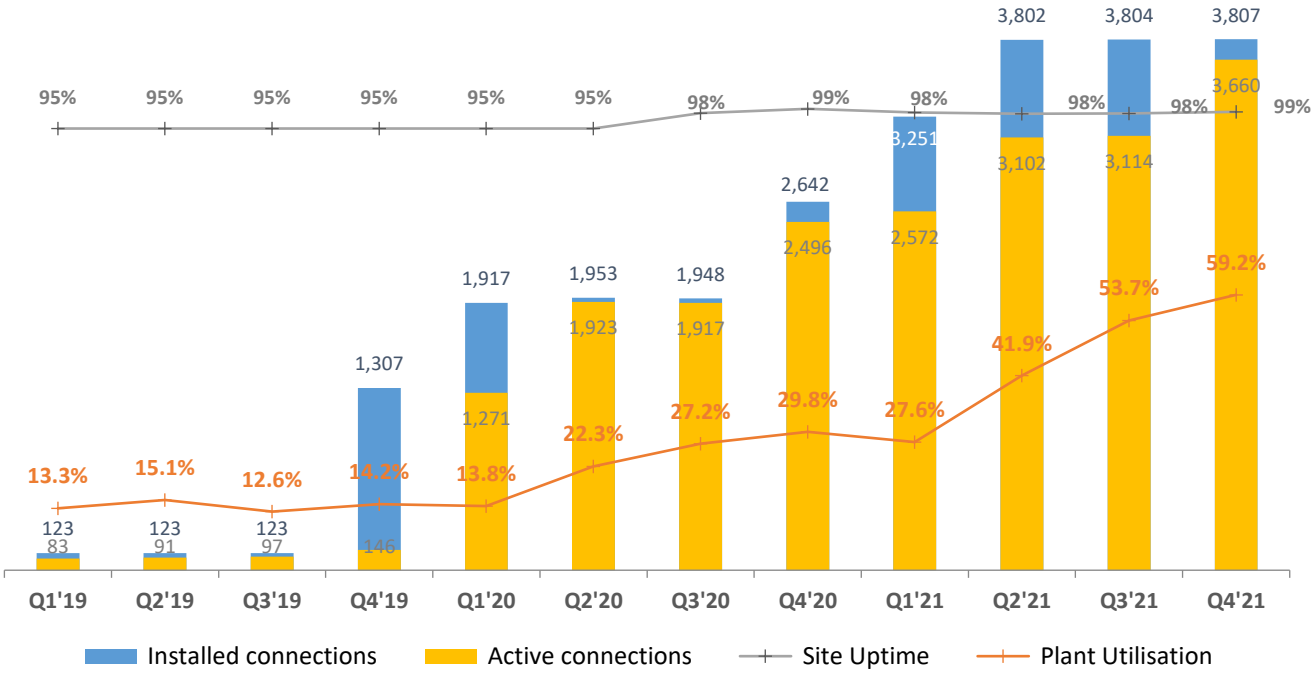
community members they serve. They also have a development team dedicated to working with communities to support micro-enterprises, involving adopting tailored strategies such as connection to markets, specific skills training, and productive use appliance financing.

4.1.2. Kudura Power East Africa (KPEA): GMG1 and GMG2

Renewable energy developer Rural Village Energy Solutions (RVE.SOL) supports the scale-up of its innovative multi-sector KUDURA Power East Africa (KPEA) business. KPEA is about implementing renewable energy-based technologies through locally sustainable community-led business models to create opportunity for jobs, increased income, sustainable rural development and, ultimately, eradication of poverty. KPEA aims to power rural villages, rural schools, rural clinics and hospitals as well as small-scale farms, businesses and private residences. It aims to offer rural communities high-quality, sustainable and renewable energy, and drinking water on an affordable PAYG basis. With their implementation of a more inclusive business model, KPEA aims to overcome industry barriers to provide reliable electricity and fostered greater local economic activity.

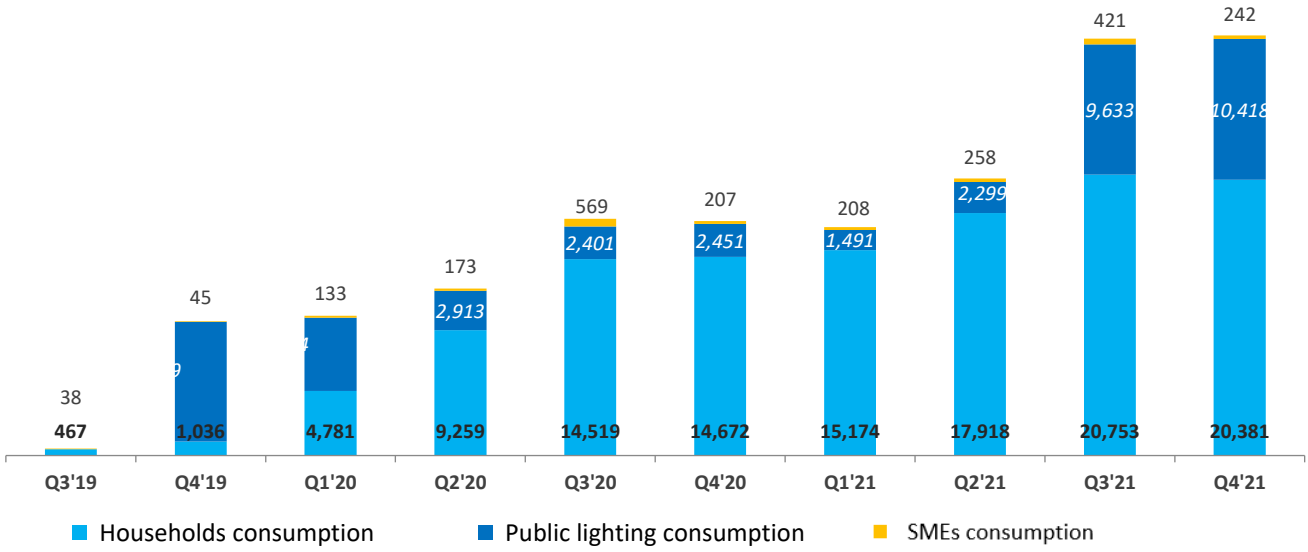
RVE.SOL has so far established 14 mini-grids across Kenya, with the majority in Busia county (11 sites): two of these were visited during the field mission in Kenya. All the 14 mini-grids currently serve 3,948 live connections. The average capacity of each of these community mini-grids is typically between 10 kWp and 60 kWp, with a combined installed capacity of 283 kWp. Furthermore, KPEA, with its headquarters in Busia, has been in operation for about 11 years (eight years in pilot in the Sedonge site and three years in full operation). During the operation period from Q1 2019, KPEA has connected 3,783 rural households out of a targeted 3,958 households (95.6 per cent). In addition, KPEA has connected 130 commercial enterprises and 57 institutions. All the 3,970 KPEA connections imply an average of about 284 customers per mini-grid site. The connection to 3,783 rural households translates to providing electricity to about 14,754 people (average household size is 3.9) (KNBS 2020). According to KPEA, the national KPLC grid electrification rate in Busia County stands at only 40 per cent. Figure 3 presents data on KPEA site connections and utilization over time, while figure 4 shows data on KPEA sites' power consumption over time (kWh) by consumer type.

▶ **Figure 3. KPEA site connections and utilization, by quarter, 2019-21**



Source: KPEA data

► **Figure 4. KPEA sites, power consumption over time (kWh), by consumer type, 2019-21**



Source: KPEA data

According to the data, site uptime has been generally stable (over 95 per cent), implying reliable provision of electricity to rural consumers. Whereas plant utilization has increased over time (from 13.3 per cent in Q1 2019 to 59.2 per cent in Q4 2021). Total consumption has increased due to an increase in the number of connections over time and it should be noted that the consumption includes public lighting consumption, household consumption and consumption by small and medium-sized enterprises (SMEs). Notably, public lighting consumption increased tremendously over the last three quarters shown in figure 3 (from 2,299 kWh in Q2 2021 to 10,418 kWh in Q4 2021) and is responsible for the general increase in power consumption. The average public lighting consumption per consumer increased from 2.3 kWh to 10.6 kWh in the same period.

Having identified appliance cost as a key barrier to its customers' establishing value-added businesses once clean, reliable power arrives in their community, KPEA now offers tiers of appliance financing. Finance is available to customers for kitchen appliances, barbershop equipment, phones, televisions and refrigerators, which are provided to enhance energy usage. SMEs and farmers can also access financing for computer, carpentry and welding equipment, incubators, drip irrigation systems and flour milling. The productive uses of energy that are currently supplied include incubators for chicks, juice blenders, shaving machines (barber shops), TVs, electric pressure cookers, fridges and freezers, and *posho* mills, which are electric mills that crush grains to produce flour. Furthermore, KPEA has so far conducted two SME trainings for customers (targeting 40 customers) on market approach.

GMG Facility Kenya (under GMG1) provided investment support to KPEA during the early years, which resulted in 11 mini-grids, translating to 11 electrified villages in Busia County. Notably, the KPEA mini-grid project planned to expand and build an additional 22 mini-grids in Kenya's Busia County (GMG2), with the support of InfraCo Africa, part of the Private Infrastructure Development Group (PIDG). Consequently, InfraCo Africa became a 40 per cent shareholder in KPEA. The project has also secured grant funding from PIDG technical assistance to support a variety of capacity-building initiatives and technical studies. This follow-on investment is based on the successes in the early phases of the GMG1 project. The project will not only expand access to clean, reliable solar power in rural areas, but also pilot delivery of street lighting, water pumping and purification, and appliance financing, to ensure that communities and businesses can truly maximize the health, security and economic benefits of clean and renewable power. It is anticipated that the project will provide approximately 6,100 new connections (implying an average of 277 connections per mini-grid site), mainly for rural households, and will densify existing KPEA grids to connect a further 910 households (InfraCo 2022). The new mini-grids were expected to be fully commissioned by Q3 2022. However, due to regulatory issues, KUDURA could not proceed with the expansion in Busia county as was originally planned. Instead, the company is now preparing for new sites in Turkana county with the ongoing support of GMG and InfraCo.

▶ Figure 5. Images from KPEA sites. Left: a house with satellite tv due to access to electricity. Centre: a poshon mill. Right: solar panels.

Source: Own research

4.1.3. Powerhive East Africa: GMG1

Powerhive – headquartered in Berkeley, California – is a technology venture founded in 2011 that partners with utilities and independent power producers to provide access to productive, affordable and reliable mini-grid electricity for millions of rural homes and businesses around the globe. Powerhive East Africa is a Powerhive subsidiary that became the first private utility in Kenya's history to be licensed to develop mini-grids and to sell electricity to the public. The success of the venture has increased governments' attention to the sector and arguably made it easier for other private developers to operate in Kenya. Powerhive East Africa operates in Kisii and Nyamira counties. It has been in operation for about 11 years, with most recent sites being developed in 2020. Currently, Powerhive runs 21 mini-grids in the country (18 in Kisii County and three in Nyamira County) serving about 6,000 customers, with the majority of connections being residential. This implies an average of about 286 customers per mini-grid site.

Powerhive has also introduced a micro-financed poultry programme for customers, and financing for electric pressure cookers to encourage less carbon-intensive cooking. It has also facilitated the roll-out of electric mills, motorbikes and tuk-tuks, and hatcheries across its sites. More recently it started the production of black soldier flies as feed stock for chicken production. These economic opportunities support climate-resilient agricultural practices, enhancing livelihoods and increasing the overall resilience of the project community (REPP 2022). JICA have supported Powerhive in conducting SME trainings to farmers on the market approach model, while BSF supports trainings on larvae production for chicken feeds. Powerhive is also piloting several value-chain activities, such as in the poulty subsector. They offer leases to end users for productive energy assets (such as hatcheries and incubators for chickens). They also provide outlet markets (acting as the buying agent for chicken producers).

▶ Figure 6. Images from Powerhive sites. Left: solar panels. Centre: mini grid system. Right: fly larvae produced at a SME, as part of an operation created from the productive use of energy

Source: Own research

4.1.4. Renewvia Energy: GMG2

Renewvia Energy – headquartered in Atlanta, Georgia, United States – is a solar developer aspiring to bring clean, reliable power to the world. Renewvia builds, installs and operates mini-grids using a combination of energy generation (developed solar and wind) and energy storage (in batteries) to produce energy and supply it on demand. The company was launched in 2009, entering the African market in 2015, where it now has mini-grid sites in Kenya and Nigeria.

In Kenya, Renewvia runs 14 mini-grid sites (with 11 sites funded under GMG2): two sites are locations in Siaya, one is in Kajiado and seven are in Turkana. The two site locations in Siaya are situated on islands, Ndeda and Oyamo, in Homa Bay, Lake Victoria. Until 2018 and the mini-grid site, Ndeda island had no source of power besides kerosene, petrol and disposable batteries.

Renewvia has introduced a water treatment facility on one of their island sites on Lake Victoria, which is run using the renewable energy supply and enabling access to clean water for the population living there. Access to affordable and reliable electricity for the general population has also increased opportunities for small businesses such as hairdressing and the selling of new goods produced by using small electrical appliances such as blenders and electric cookers.

▶ Figure 7. Images of solar panels from Renewvia mini-grid sites

Source: Own research

4.2. Running of sites, connection fees, tariffs and tier systems

This section describes the running of GMG mini-grid sites for the selected developers. Information has been collated and descriptions for the selected developers presented as Developer 1, Developer 2 and Developer 3 to maintain anonymity.

Mini-grid deployment requires substantial investments. Without grants or incentives, developers need to balance recouping capital and operating costs, and charging cost-reflective tariffs – often higher than the national grid electricity tariffs – that customers can pay. The customer base, connection fees, tariffs and tier systems tend to differ across the assessed mini-grid sites. About 70 per cent of all Developer 1 customers are in Tiers 1 and 2, similar to the other developers. The majority of customers for all developers also appear to be residential, due to the characteristics of the areas of the site locations.

The connection fee for Developer 1 residential customers ranges between KES (Kenyan shillings) 3,000 and 10,500, based on the multi-tier framework (Tier 1 (50W) – 3,000; Tier 2 (100W) – 4,750; Tier 3 (200W) – 6,500; Tier 4 (300W) – 8,200; Tier 5 (500W) – 9,500; and Tier 6 (1000W) -10,500). The rate charged per kWh for its residential consumers is KES 72.33, while for public lighting it is about KES 30 (table 1). Developer 2 charges a standard connection fee of KES 9,980 for all connections and a rate of KES 70.22/kWh per residential consumer (table 2). Commercial and institutional rates charged vary across the developers. Commercial consumers pay a rate of between KES 43.28 and 68.73 per kWh, while institutions pay a rate of between KES 34.36 and 52 per kWh (being highest at Developer 2).

▶ Table 1. Developer 1: Tariffs and connection fees based on customer type

Type	Watts	No. of connections	Connection fee (KES)	Rate charged per kWh (KES)
Residential	50 - 1000	3 783	-	72.33
Commercial	2000	130	9 280	68.73
Institutions	2000	57	9 280	34.36

Source: Developer 1, quantitative data 2022

▶ Table 2. Developer 2: Tariffs and connection fees based on customer type

Type	Amps	No. of connections	Connection fee (KSH)	Rate charged per kWh (KES)
Residential	16	Majority	9 980	70.22
Commercial	60	-	9 980	43.28
Institutions	60	-	9 980	52.00

Source: Developer 2, qualitative interview data 2022

The current Kenya Power grid electricity tariff (effective from November 2018) for energy consumption charges is only KES 15.80/kWh for ordinary domestic consumers, and between KES 10.10 and 15.60 per kWh for commercial consumers. The rate for street lighting is KES 7.50/kWh (table 3). These rates are exclusive of taxes and surcharges applied on all tariff categories that include fuel cost charge, Forex levy, inflation adjustment, value added tax (VAT), Energy Regulatory Commission (ERC) levy, Water Resources Management Authority levy and Rural Electrification Program levy. The fuel cost charge, Forex levy, inflation adjustment and Water Resources Management Authority levy vary monthly, with the cost components published in the official *Kenya Gazette*. As of December 2021 the total cost comes to about KES 25.93/kWh for domestic ordinary consumers. It should be noted that KPLC also has a country wide universal tariff, this enables them to cross subsidy rates between different consumers in urban areas and those in rural areas, where consumption is lower and OPEX costs are higher.

▶ Table 3. Approved Kenya Power charge rates, effective from November 2018

Code	Customer type (code name)	Energy limit kWh/month	Charge method	Unit	Approved non-fuel charge rates
DC-L	Domestic - Lifeline	0 - 10	Energy	KES/ kWh	12.00
DC-O	Domestic - Ordinary	>11	Energy	KES/ kWh	15.80
SC	Small commercial	0 - 15,000	Energy	KES/ kWh	15.60
CI1	Commecial/Industrial	>15,000	Energy	KES/ kWh	12.00
			Demand	KES/ kVA	800.00
CI2	Commercial/Industrial	No limit	Energy	KES/ kWh	10.90
			Demand	KES/ kVA	520.00
CI3	Commercial/Industrial	No limit	Energy	KES/ kWh	10.50
			Demand	KES/ kVA	270.00
CI4	Commercial/Industrial	No limit	Energy	KES/ kWh	10.30
			Demand	KES/ kVA	220.00
CI5	Commercial/Industrial	No limit	Energy	KES/ kWh	10.10
			Demand	KES/ kVA	220.00
SL	Street lighting	No limit	Energy	KES/ kWh	7.50

Source: Kenya Power, 2018.

Moreover, the Ministry of Energy through EPRA has recently gazetted the approval of new electricity tariffs that will see a reduction of 15 per cent in bills, effective 1 January 2022, and will cover a period of 12 months from January to December 2022 (EPRA 2021). Effectively, the new rate (without surcharges) comes to about KES 12.60/kWh for domestic ordinary consumers. Mini-grid tariffs for residential consumers (about KES 71/kWh) thus appear much higher than the national grid rates for domestic ordinary consumers (of about KES 26/kWh). The same also applies to commercial consumers.

Notably, the developers provide reliable energy services in which even non-customers in some rural villages with a grid connection and access to less expensive power have developed interest. The developers offer a 24/7 energy supply that meets the community's livelihood and household needs; local support and assistance that improve energy use and incomes; and measures that help to reduce energy poverty – something the national grid does not. They work with the community to power income-generating activities, thereby improving their customers' ability to pay. They provide training on the use of appliances for economic activities and offer appliance-leasing programmes to enhance local entrepreneurs' capabilities. Nevertheless, innovative financing, scaling capacity, and supportive policy measures will be essential drivers to help bring down mini-grid tariff costs and ensure that mini-grid energy is not strictly a premium service that only some users can afford.

Various personnel at the operational level normally run the selected mini-grid sites. In summary, there exist various departments handling different activities, including: management/administration, human resources, engineering support, operations support, sales and marketing, maintenance, information systems and monitoring, occupational safety and health (OSH), customer experience/service stakeholder management and security. These departments are usually comprised of managers, engineers, technicians, security officers, drivers, customer support/liaison officers, supervisors, support staff/assistants and sales teams, as well as site agents/caretakers. These personnel cut across the production, distribution and end-user systems of the mini-grid set-ups. However, some of the services required are outsourced from competent and skilled third parties (or other companies), for instance EmpIA experts and KPLC contractors. The local community also supports most of the activities, particularly the unskilled part of labour.

5. Direct employment effects

Mini-grids create local direct jobs during design/feasibility and construction/commissioning, as well as during the operations phase. Solar mini-grids offer opportunities for job creation, especially if paired with skill development, connection to markets, and affordable and longer tenure financing. Mini-grids can also create local indirect and induced jobs, and many more support the creation of productive use jobs through entrepreneurial opportunities from access to electricity.[2] They can also enhance the rural electricity supply quality and efficiency, delivering reliable and clean electricity to power local businesses and stimulate rural economies.

As defined by Joshi et al. (2021), direct jobs include permanent, temporary and short-term contractual jobs associated with the design, management, construction/installation, operation and maintenance of mini-grid projects. The construction and deployment of mini-grids span approximately 1-4 months (i.e. pre-construction, modular grid instalment, powerhouse construction, pole erection, and wiring). Once construction and deployment is completed, these functions and the associated jobs are no longer needed. For the last phase of the project (i.e. operations and maintenance), the employment lasts for the mini-grid's lifetime, and those jobs are classified as direct full-time jobs. Indirect jobs are related to the manufacturing of equipment and materials used in the mini-grid project, the supply chain that fabricates and delivers these materials, and the finance and banking sectors that provide services for the construction and operation of the project. Induced jobs are the jobs created due to expenses by people directly or indirectly employed by the project. Productive use jobs are those created by the end users of the mini-grids. They include existing and new entrepreneurial jobs that have been enhanced due to access to electricity. Productive use jobs can vary significantly based on geography, the business model of the mini-grids, and operators.

The sections below provide typical estimates of direct employment (jobs) created and impacts observed from the operators in Kenya, with a focus on how the mini-grid business model provides direct jobs, as well as additional income opportunities in rural Kenya.

5.1. Direct employment at a typical GMG mini-grid site

Information regarding employment and mini-grid development strategies was obtained through semi-structured interviews and quantitative data collection with the developers between May and August 2022. The interviews informed analysis on operational strategies, organizational structure, and employed workforce. The information gathered was complemented by a literature review and data from secondary sources, including the developers' project documentation.

In particular, quantitative data were collected from one developer's 11 mini-grid sites (which were part of the first phase of the project, under GMG1). From this information, data have been averaged to calculate the amount of employment generated per one mini-grid site. These figures have then been extrapolated to provide an estimation of the direct jobs created for the second phase of the GMG project, for a total of 33 sites (GMG2).

Table 4 provides estimates of direct jobs created in the design and construction phases for one mini-grid site (serving on average 300 connections). The product of number of staff, number of days worked, number of hours worked per day and number of months worked in a year was computed and the result divided by 2,080 (8 hours a day, 260 days in a year) to estimate the number of full-time equivalent (FTE) jobs. Since the design and construction phases last about one month each, with very short-term jobs, the total FTE job coefficients were derived from such direct short-term jobs to depict the number of annual jobs created from short-term contractual work.

[2] Access to electricity contributes to economic development; using it to power small businesses, mechanization and electrified agricultural equipment are examples of productive use loads.

▶ Table 4. Jobs created at a typical mini-grid site, design and construction phases

	Activity/staff Involved	No. of staff	Duration (days)	Months	Hours per day	Total hours	Annual FTE	Type of contract*	Average daily wage (KES)
Design/ feasibility phase (1 month)	Household mapping	4	25.0	1	8	800	0.4	P	2 700
	Estimate of materials	1	25.0	1	8	200	0.1	T	3 200
	Logistics (drivers)	1	25.0	1	8	200	0.1	C	1 080
	Mgt/ administration	1	25.0	1	8	200	0.1	T	10 360
	Total	**7**					**0.7**		
Construction & commissioning phase (1 month)	Permanent field staff	4	25.0	1	8	800	0.4	P	2 700
	Holes/excavation (females)	2	15.0	1	5	150	0.1	W	500
	Holes/excavation (males)	6	25.0	1	8	1 200	0.6	W	1 775
	Distribution	15	25.0	1	8	3 000	1.4	W	500
	Erecting poles (females)	3	20.0	1	8	480	0.2	W	500
	Erecting poles (males)	19	25.0	1	8	3 800	1.8	W	500
	Overheads	10	25.0	1	8	2 000	1.0	W	500
	Wiring	23	25.0	1	8	4 600	2.2	W	1 600
	Dropping & metering	21	12.5	1	8	2 100	1.0	W	1 432
	Logistics (drivers)	1	25.0	1	8	200	0.1	W	1 080
	Total (1 mini-grid)	**104**					**8.8**		

Note: *Type of contract: P=Permanent contract; T=Temporary contract/outsourced personnel; C=Casual workers (very short term) with contracts; W=Casual workers (very short term) without contracts.
Source: Developer 1 data based collected in November 2020

Based on the above projections, a mini-grid deployment effort has the potential of creating an estimated 9.5 annual FTE jobs during the design and construction phases.

During the design/feasibility phase, four permanent staff conduct surveys and household mapping exercises as well as managing logistics for community engagement, acquisitions, and procurement. They are assisted by one hired person for estimate of materials, and a driver. One management person oversees accounts, design, procurement, and operations. From semi-structured interviews, it was noted that approximately 57 per cent of these workers are from the local community, while youth (18-35 years) represent about 86 per cent. No females are reported during the design/feasibility phase.

The interviews revealed that during construction, four permanent staff oversee the mini-grid installation and manage the casual workers, who are normally on very short contracts. The permanent staff include two engineers and two technicians who are also responsible for overseeing the modular grid and powerhouse installation. Nevertheless, building the modular grid and powerhouse is normally subcontracted to third-party companies due to skills required (and includes civil works and installation for generation, grid and reticulation). Workers involved in pole erection and distribution lines (holes/excavation, distribution, erecting poles) are usually unskilled workers (n=45), all from the local community, with youth representing about 82 per cent. Females seem to be only involved in excavation (n=2) and pole erection (n=3) during the construction phase, accounting for 11 per cent of the jobs involved in pole erection and distribution lines. Workers involved in connections and household wiring (overheads, wiring, dropping and metering) are usually skilled workers (n=55), all males and 87 per cent from the local community, with youth representing about 89 per cent. One vehicle plus a driver is hired for the distribution and dropping of the poles, among other logistics. Developer 1 reported a period of one year for the construction of 11 mini-grids.

The operations and maintenance phase creates direct full-time jobs that last the lifetime of a mini-grid project. Initially under GMG1, Developer 1 reported four permanent staff, mainly local workers, managing 11 sites during the operations and maintenance phase. They include a social impact officer, customer relations/experience officer, operations manager, and information systems officer. They work together with two engineers and two technicians who are in charge of monitoring, periodic maintenance, cleaning (panels and internal systems) and new connections. Occasionally, temporarily contracted engineers and technicians are hired based on existing workloads. These contracted personnel are usually drawn from skilled KPLC contractors and undergo some

training before engaging in the wiring activities. The permanent staff also interface with the local site agents/customer experience liaison teams. Normally there exists one site agent/customer experience person and one security guard per site. Table 5 provides estimates of direct jobs created by occupation during the operation and maintenance phase for all the 11 mini-grid sites of Developer 1.

▶ Table 5. Jobs created at 11 mini-grid sites, operation and maintenance phase

Activity/staff Involved	No. of staff (FTE)	Type of contract*	Average. daily wage (KES)
Permanent staff	4	P	2 700
Engineers	2	T	3 400
Technicians	2	T	2 000
Site agents/customer experience	11	C	1 080
Security	11	C	183
Logistics (drivers)	1	C	1 080
Total (11 mini-grids)	**31**		

Note: *Type of contract: P=Permanent contract; T=Temporary contract/outsourced personnel; C=Casual workers (very short term) with contracts.
Source: Developer 1 data collected in November 2020

Based on the above projections, a mini-grid deployment effort has the potential of creating an estimated 2.8 FTE jobs during the operations and maintenance phase (31 divided by 11). This could imply two FTEs in the community and one FTE at the central office/headquarter. It is important to note that the security staff may work for longer hours per day but not regularly, and this is treated as one FTE. All other staff work full time, so the headcount is treated as the FTE.

Staffing has since increased as Developer 1 of the project transitioned into GMG2. Developer 1 reports a current total workforce of 47 employees, and an average of 20 temporary employees operating per month. The permanent workforce also includes six managers/permanent full-time staff, up from the initial four under GMG1. The new additions appear to be a health and environment officer and a project developer.

Only one accident has been reported by Developer 1, involving a local male casual worker (very short-term without a contract). No fatalities have been recorded, and it was not possible to obtain data on benefits provided for workers (e.g. social security (NSSF), social protection (NHIF), paid leave and accident insurance).

5.2. Summary of direct employment impacts

Table 6 presents a summary of direct employment at GMG mini-grid sites in Kenya. In order to calculate the number of jobs created per connection and mini-grid site, data on the number of connections was obtained from the developers. This information was then used to calculate the average cost per connection and to assess the number of jobs created per million EUR of investment. Currently (at the time of the study), the number of connections of 14 sites covered by Developer 1 is 3,970, with an average of 284 per mini-grid site, including sites under GMG1. Based on projections of Developer 1 GMG2 of 6,100 connections across 22 sites, the average per site comes to 278. Developer 2 also estimates 6,000 connections over 21 sites, implying an average of 286 per site. With densification, the average number of connections per mini-grid site thus appears to be 300 and this is used as the average number of connections for the calculations in Table 6.

Costs on capital expenditure were provided for ten Developer 1 sites, from which an average investment cost per site was estimated at €195,275. The estimated investment cost per connection by the end of GMG1 (31 October 2020) appeared to be €1,103. This is based on an initially planned total number of 1,850 connections. Under GMG2, the developer increased the number of connections based on the already installed generation/storage capacity and the distribution systems. Computing this cost with the current estimates under GMG2 gives an investment cost of about €688 per connection.

Using this estimated cost per connection of €688, there is an average of 1,454 connections per million Euros of investment. Taking into account the number of FTE jobs created per site, 12.3, produces an estimated 0.04 FTE jobs created per connection, based on the estimate of 300 connections per site. This provides an estimated number of 58 FTE jobs per million Euros of investment. For the 33 sites under GMG2 (22 sites from one developer and 11 sites from another), the estimated number of permanent FTE jobs to be created is 92 and the estimated number of temporary jobs is 314 FTE, creating a total of 406 annual FTE jobs under the programme.

The estimated number of mini-grid sites, using the optimum 300 connections per site, required to serve the KNES target of 35,000 households is 117, which could provide the potential to create an additional 1,439 annual FTE jobs. KNES (2018) suggests that 1.1 million households are outside the reach of current KPLC grid. If the GMG programme were to expand and reach these households, an estimated 45,100 annual FTE jobs could potentially be created.

▶ Table 6. Summary of direct employment at GMG mini-grid sites in Kenya, expressed as annual FTE

Unit	Parameter	Value
Per one mini-grid site	Average investment per site	**€195 275**
	Design/feasibility phase, total Jobs (FTE) per site (temporary)	0.7
	Construction & commissioning phase, total Jobs (FTE) per site (temporary)	8.8
	Operations & maintenance phase, total Jobs (FTE) per site (permanent)	2.8
	Total direct Jobs (annual FTE) per site (temporary + permanent)	**12.3**
Per connection	Estimated investment cost per connection, GMG2	€688
	Estimated no. of annual FTE Jobs per connection (300 connections per site)	0.04
	Estimated no. of annual FTE Jobs per € million of investment	**58**
Targets	Estimated no. of mini-grid sites required for 35,000 households target	117
	Estimated no. of annual FTE Jobs created by 35,000 households target	1 439
	Estimated of annual FTE Jobs created if GMG were to expand and reach 1.1 million households outside KPLC grid	45 100
Total sites (33 sites GMG2)	**Estimated permanent FTE Jobs created for 33 GMG2 sites**	**92**
	Estimated temporary FTE Jobs created for 33 GMG2 sites	**314**
	Estimated total (temporary + permanent) annual FTE Jobs created for 33 GMG2 sites	**406**

Source: Developer 1 and 2 data

6. Indirect and induced employment effects

As mentioned above, capital expenditure breakdowns for a "typical" mini-grid site were provided across ten sites from one developer. The breakdowns covered eight categories relating to mini-grid construction, and these categories were mapped to the corresponding GTAP SAM/IO sector for use in STRENGTHEN2 estimation tool, on the ILO's Structural Model for Sustainable Development (SMSD) to estimate the indirect and induced employment effects.

The model was developed at the ILO and is based on a framework that adopts elements of the input-output (I-O) analysis modelling framework while incorporating additional features such as price effects and capacity constraints. The model has been applied in a few country pilots and case studies (La Marca and Jiang 2021) and can be adapted to meet the needs of the impact assessment analysis as it has the flexibility to: (a) incorporate factual features of low-income developing economies with chronic underemployment and commodity dependence; (b) achieve internal consistency between the real time horizons of the impacts of the shock to be assessed and the model presumptive adjustment time; and (c) maintain a close correspondence between the model and internationally agreed statistical concepts and definitions (Jiang and La Marca 2021).

The total employment created from the GMG project investment is obtained taking into consideration only the goods and services demanded within the country by different sectors of the economy. The cost of all imported goods used in the GMG project were subtracted to avoid overestimating its job creation impact. The logic behind this procedure is that imported goods generate jobs in a country outside Kenya. Since our interest is in domestic job creation, the cost of imports is eliminated. From the data collected, three types of goods were imported, including solar modules, battery storage and part of the meters and reticulation, making up 46 per cent of the total goods. One way in which economic policy (such as trade policy) in Kenya can help the creation of more jobs is by making efforts to produce locally what was previously imported.

The results were produced for a scenario of 33 mini-grid sites, the number of sites included in GMG2. The results are highlighted in table 7, for indirect and induced[3] employment separately and combined. These effects represent the indirect and induced employment generated in the short to medium term, from the construction phase of the project. They do not include employment that may result from the long-term operation of the mini-grid sites.

▶ Table 7. Indirect and induced employment effects for GMG2, 33 minigrid sites

Sector	Male	Female	Skilled	Unskilled	Youth	Total
Agriculture	79	41	10	110	15	119
Manufacturing	110	57	16	151	21	167
Services	329	37	53	313	44	366
Total	**518**	**134**	**79**	**573**	**80**	**652**

Source: STRENGTHEN2 estimation tool.

[3] See the glossary at the beginning of the document for these two terms.

The results from the analysis with the STRENGTHEN2 estimation tool show that Phase 2 of the GMG project is estimated to produce a total of 652 indirect and induced jobs. These are disaggregated by sectors of agriculture, manufacturing and services. The highest number of jobs created fall under the services sector, with a total of 366. The majority of jobs are male, with 518 compared to female (134 jobs). There are an estimated 80 jobs for youth (young people aged between 15 and 24), which makes up 12 per cent of total employment. Twelve per cent of employment is also estimated to be made up of skilled jobs. These jobs are expressed as headcount rather than FTE, due to a lack of information on working hours and a distinction between full time or part time jobs.

7. Conclusions and recommendations

This section presents the conclusions of the study and recommendations for future evaluations of similar investments.

7.1. Total employment

7.1.1. Summary of total jobs created

The GMG programme has the aim of providing access to electricity to support livelihoods and enhance economic development for communities in rural Kenya. This assessment focused on GMG2, the EU-funded phase of the project which has 33 mini-grid sites across the country. From the data collected from the developers of the project and information from the first phase (GMG1), it is estimated that the total number of direct, indirect and induced jobs created during GMG2 is 4,407, which is expressed as the headcount. It should be noted that this includes direct temporary jobs with a duration of one month that are required during the construction phase of the mini-grid sites, which account for 83 per cent of this total. This equates to a total of 134 jobs (headcount) per mini-grid site, or 300 connections.

Information on jobs created expressed as the FTE can only be sourced for the numbers on direct employment, as information on working hours was not available for the indirect/induced jobs estimation. The total annual FTE jobs created from direct employment of the GMG2 programme are 406, which is equivalent to 58 annual FTE jobs created per million Euros of investment. This includes 92 permanent jobs, which equates to 14 permanent FTE jobs created per million Euros of investment. Looking at the number of permanent jobs created by the number of connections, this comes to approximately three permanent jobs per 300 connections, the average number of connections per mini-grid site. The total number of indirect and induced jobs estimated to be generated in the short-to-medium term are 652, which is also expressed as the headcount. The total number of direct jobs expressed as the headcount, including temporary and permanent staff, is estimated to be 3,755 for GMG2. This is composed of 3,663 (97.5 per cent) temporary jobs lasting one month and 92 (2.5 per cent) permanent jobs.

7.1.2. Gender, skill and youth bias

When examining the gender, skill and youth dimensions of the employment impacts, there is a clear bias towards male and unskilled jobs. From the direct employment created during the construction of the mini-grid sites, from the information collected, there was no female employment recorded during the design/feasibility phase and the connections and wiring. Female jobs made up 11 per cent of jobs involved in the setting up poles and distribution lines. These workers are often unskilled. For the estimates on indirect and induced employment, the majority of jobs created are in the services sector, male and unskilled. This highlights a bias towards male employment, where the share of male jobs counts for 79.5 per cent of the total indirect and induced employment generated. There is a further bias towards unskilled jobs which accounts for 88 per cent of indirect and induced employment. Regarding youth employment, out of the direct jobs, youth account for a total of 86 per cent of employment during the construction phase. This is much lower for indirect and induced employment, where youth jobs make up only 12 per cent.

7.1.3. Quality of employment

Regarding the quality of employment and decent work for direct jobs, all employees with permanent jobs had a formal contract of work, from data collected from one developer. For temporary jobs that have a duration of one month during the design and construction phases of the project, the majority of employees are without a formal contract. Data on other decent work indicators were unavailable during the time of data collection.

7.1.4. General considerations

Comparing the estimated employment from the GMG programme with traditional connections to the main grid, Kenya Power has an estimated staff headcount of 9,843 people (Mutuko 2022), with 5.9 million connections across the country. This produces an estimate of 0.0016 jobs per connection, or 0.5 per the 300 connections that equal one mini-grid site. In further comparison, a portfolio assessment of EU blending operations, undertaken as part of the ILO STRENGTHEN2 project, used I-O analysis to estimate the potential employment impact of different infrastructure projects. For projects in power generation, approximately 180 FTE jobs per million Euros invested are estimated. For energy transmission this is approximately 160 FTE jobs, and for other infrastructure types, roads could provide 270 jobs and water projects were estimated to provide 400 jobs (STRENGTHEN2 2020).

Although when comparing the number of jobs to other infrastructure type, the total number is lower, at the local-level, three permanent jobs are created per 300 connections at one mini-grid site or in one community. These jobs are usually created within the local communities that the site operates within. There is also high potential for expansion, with 1.1 million households outside the area of the KPLC grid, that could potentially be served by solar mini-grids. This provides an estimated potential of 45,100 annual FTE jobs to be created, if mini-grids were built to serve this population currently excluded by the existing grid. The impact that the mini-grids have on improving livelihoods of the population should also not be ignored; where providing access to electricity is a necessary step in to increase economic development and employment opportunity for the benefitting communities.

7.2. Recommendations

7.2.1. Data collection

With a growing impetus to meet energy demand through mini-grids in rural and semi-urban locations in sub-Saharan Africa, the need to accurately assess market drivers, policy requirements and job creation impacts of this energy system typology cannot be ignored. Currently, no formal methodology for employment impact assessment (EmpIA) is followed by practitioners, with each using their own methods and approaches to quantify indicators of interest to their unique business model or service offered. The key impact area of interest is economic, specifically increased uptake of productive uses of energy, and the effect of mini-grid electricity on household and business incomes.

Moving forward, the relevant donors of programmes such as GMG should prioritise the need for EmpIA from the inception phase and include it in the project design and financing of programmes. This should include requirements for the collection and management of data necessary for conducting such an assessment. GMG Facility Kenya should aim to undertake both qualitative and quantitative EmpIA and further promote making data available across developers for use in such assessments. Expenditure breakdowns required to estimate the indirect/induced employment effects should be made available for the sector, for use in estimating employment effects of future similar initiatives. Further studies should focus on developing models to broadly investigate the indirect, induced and productive job effects of mini-grid systems. This study particularly recommends baseline household/community-based surveys (on long-term employment), including productive energy use, to be conducted in the coming year, and an end-line survey after a pre-determined period. The study designs may take the form of cross-sectional design, panel designs, or a quasi-experimental approach. It should also be encouraged to conduct EmpIA of mini-grids in other countries and contexts, to expand the baseline information on the employment impacts generated by such programmes.

Data on the quality of employment should be recorded systematically and made available to be able to accurately assess what contribution the project is making with regard to not only the number but also the quality of jobs. Further information related to social protection, social security, access to insurance and other variables included

under the ILO decent work indicators should be prioritized for collection, to highlight areas that could be further improved. This would also offer insight into the informal economy in this sector. Data on workers' unions and representation should also be collected, in order to provide an assessment related to social dialogue.

7.2.2. Job creation

When assessing the results on the indirect and induced employment effects of this study, the number of indirect/induced jobs estimated could be increased if a larger share of inputs were produced and sourced locally, 46 per cent of the goods and services used in the construction of the mini-grid sites were imported, such as the solar panels, battery storage and parts of the meters and reticulation. If more goods were produced locally, it would increase the indirect and induced employment generation in Kenya. The effort to incorporate and promote more local goods and services into the construction of mini-grids should be a requirement in the design of future projects. It is acknowledged though that there are limits to such increases in locally produced inputs, some of which may only be available from abroad.

It is clear from the results that there is a bias towards male and unskilled jobs, both from the direct employment and estimated indirect and induced employment. Although this can be expected for the direct employment as it relates specifically to jobs created in the construction phase of the mini-grid sites, along with the indirect and induced effects that also correspond to this phase and highlight the short to mid-term employment effects. It is recommended to place emphasis on addressing gender gaps during the design and implementation of these programmes, to try to increase the number of female jobs, particularly for skilled work. To ensure female and youth workers are properly targeted, this should be addressed in the design of future projects. The ILO's Employment Intensive Investment Programme (EIIP) provides examples of programmes where these issues are addressed, which can provide guidance on the design of infrastructure programmes whilst successfully attracting women in male dominated sectors, such as construction. This could be addressed by incorporating work-based learning and training, to invest in re- and upskilling, particularly aimed at women and young people. At the government level, this can also be addressed more broadly, by promoting and improving access to vocational training for these groups.

Although there has been increasing attention given to mini-grids at the national level, regarding job creation, the number of direct jobs created is less than when investing in other types of infrastructure, such as roads. However, the implementation of mini-grids provides electrification to areas that would otherwise not be served by the national grid. Access to electricity for these populations is essential for future sustainable development, important for increasing long-term employment opportunities and poverty alleviation. As the areas targeted by the mini-grids are not covered by the national grid, sometimes with no plans for future coverage from the grid, the government should invest further in mini-grids and other renewable energy solutions that can provide electricity to these populations, to ensure no one is left behind in accessing reliable, affordable and sustainable energy.

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Annex

▶ Table A.1. Energy sector stakeholders in Kenya

Stakeholder	Core functions
Ministry of Energy	Formulates policies and regulations on the energy sector, in addition to administering the Rural Electrification Scheme. It also oversees the Energy & Petroleum Regulatory Authority (EPRA).
Energy & Petroleum Regulatory Authority (EPRA)	Reviews electricity tariffs and enforces safety and environmental regulations in the power sector as well as safeguarding the interests of electricity consumers. It implements policies and regulations developed by the Ministry of Energy and conducts due diligence into off-grid companies to determine whether they can qualify for Kenya Revenue Authority tax exemptions. It replaced the Energy Regulatory Commission (ERC) in 2019.
Kenya Electricity Generating Company (KenGen)	Manages and develops all public power electricity generating facilities. It sells electricity in bulk to Kenya Power. The company is responsible for electricity generation and bulk selling to distributors. KenGen is 70 per cent government owned.
Rural Electrification and Renewable Energy Corporation (REREC)	Previously Rural Electrification Authority (REA), the entity is responsible for rural electrification efforts (feasibility studies, development and operation) and renewable energy at large. Implements rural electrification projects on behalf of the Government.
Kenya Power, formerly Kenya Power and Lighting Company (KPLC)	A publicly- and privately-owned institution responsible for transmission and distribution of electricity. The main distribution company in Kenya. The Rural Electrification Authority assists with extending distribution lines.
Kenya Electricity Transmission Company (KETRACO)	State-owned utility responsible for electricity transmission. It is mandated to design, construct, operate and maintain new transmission lines above 132 kV with government funding to accelerate infrastructure development and is responsible for all electricity transmission lines that have been built since the company's inception in 2008. Kenya Power continues to operate the transmission lines that were under its mandate prior to the establishment of KETRACO.
Geothermal Development Company (GDC)	Tasked with developing geothermal steam fields to reduce upstream power development risks so as to promote rapid development of geothermal electric power. The company conducts surface exploration and steam drilling and sells the steam to KenGen for electricity generation.
Kenya Nuclear Electricity Board (KNEB)	Established in 2010, the board is tasked with driving the nuclear energy generation programme for Kenya. This will be achieved through development of a road map for the realization of the requirements and guidelines by the International Atomic Energy Agency (IAEA).
Kenya Renewable Energy Portal	The purpose of the portal is to provide easy access to relevant information about administrative entry requirements and procedures for operating a power plant based on renewable energy, the legal and regulatory framework for such investments (e.g. tariff regulation) and relevant market information.
Private electricity suppliers	**Independent power producers (IPPs):** Build, own and operate power stations and sell the power in bulk to Kenya Power. Provide 1,000 MW of capacity (30 per cent of total capacity) and US$2.4 billion in investment. **Private companies Involved in off-grid solutions:** Provide mini-grids and standalone renewable energy systems to more than 700,000 consumers.

Stakeholder	Core functions
Clean Cooking Association of Kenya (CCAK)	Contributes to the development of an enabling market for clean cook stoves and is involved with capacity building of its members.
National Land Commission (NLC)	Supports acquisition of land (public and trust land) and wayleave processes for generation, transmission and distribution.
The Energy Tribunal	Responsible for dispute resolution between players in the sector and is funded by the national Government.
Kenya Investment Authority (KenInvest)	A statutory body with the primary goal of promoting investments in the country.
County governments	Prepare county energy plans for the Cabinet Secretary. Some counties provide supplementary funding for rural electrification.

Source: Authors' elaboration

▶ Table A.2. Installed mini-grids, by region

Region	No. of mini-grids	No. of connections (millions)	No. of people (millions)	No. of developers identified	Mean capital cost (US$/kW)	Total capacity (MW)	Total investment (US$ millions
South Asia	9 339	2.9	16.2	537	1 850	298	632
East Asia & Pacific	6 905	2.9	12.1	4 158	4 379	1 721	8 236
Africa	1 465	3.0	14.9	479	6 668	783	3 966
Europe & Central Asia	594	0.1	0.3	56	5 015	1 007	5 050
United States & Canada	519	0.2	0.6	246	3 973	2 152	8 551
Latin America & Caribbean	283	0.7	2.7	188	3 800	456	1 632
Middle East & North Africa	31	0.1	0.1	17	3 387	32	110
Other territories	27	>0.1	>0.1	9	3 986	31	125
Global	**19 163**	**10.1**	**46.9**	**5 690**	**4 410**	**6 481**	**28 302**

Source: Based on World Bank 2019; and ESMAP 2019.

▶ Table A.3. Policy and regulations supporting mini-grid development in Kenya

Policy/Regulation	Description
The National Energy Policy	Enunciated in Sessional Paper No. 4 of 2004 and operationalized by the Energy Act No. 12 of 2006 now the Energy Act, 2019. The policy recognizes that renewable energy sources have potential to generate income and employment, over and above contributing to the electricity supply and diversification of generation sources.
Energy (Solar Photovoltaic Systems) Regulations, 2012	The Energy and Petroleum Regulatory Authority has developed and gazetted Energy (Solar Photovoltaic Systems) Regulations, 2012 that seek to streamline the solar PV industry. The regulation provide for licensing of solar practitioners (technicians and contractors) in the industry to ensure standards are upheld when carrying out solar installations.
Feed-in-Tariff Policy	The government Feed-in-Tariff Policy allows power producers to sell renewable generated electricity to an Off-taker at a predetermined tariff for a given period. The sources covered by this policy include wind power, biomass, small hydro, solar, biogas and geothermal.
The Climate Change Act, 2016	The Act seeks to provide the legal and institutional framework for mitigation and adaptation to the effects of climate change, to facilitate and enhance response to climate change and to provide guidance and measures for achieving low-carbon climate-resilient development. In support of the Climate Change Act, 2016, Kenya has put in place its Nationally Determined Contribution (NDC) 2016, the Climate Risk Management Framework (2017), the National Climate Change Framework Policy (2018), the National Climate Finance Policy (2018) and the Green Economy Strategy and Implementation Plan (GESIP) 2016-2030.
Sustainable Energy for All (SE4ALL) Action Agenda (AA)	As part of efforts to support Kenya's SDG 7 ambitions, Kenya has in place a Sustainable Energy for All (SE4ALL) Action Agenda (AA) and the Investment Prospectus (IP) signed off in December 2015.

Source: Authors' elaboration

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