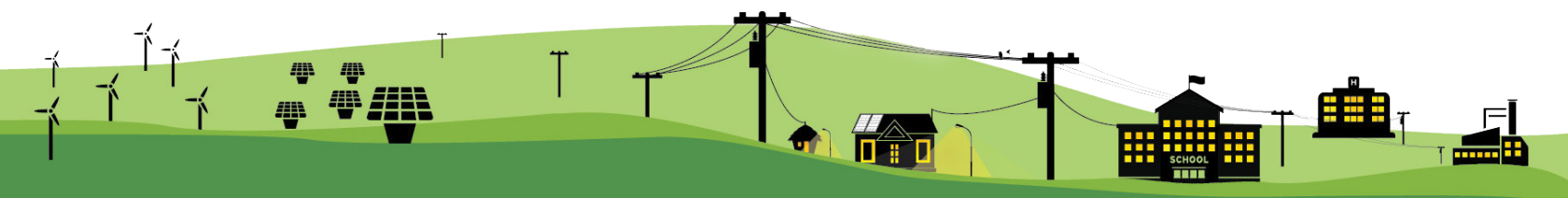
Kenya National Electrification Strategy:

Key Highlights

2018



Foreword

The Kenya National Electrification Strategy (KNES) is the roadmap to achieving universal access to electricity as a key plank of powering the Country's development agenda.

Energy is critical to the realization of Kenya's Vision 2030 which seeks to transform Kenya into a newly industrializing middle-income country providing a high quality of life to its entire citizenry.

Further, the Government's "Big 4 Agenda" comprising of Food and Nutrition, Security, Manufacturing, Affordable Housing and Healthcare, unveiled by the President in 2017, is dependent on provision of adequate and competitively-priced energy.

Consequently, the government has over the last few years embarked on an ambitious journey to provide access to competitively-priced, reliable, quality, safe, and sustainable energy.

Tremendous achievement in scaling up connectivity was made in the last three years with the access rate rising from 32% in 2014 to 75% in 2018 (both from grid and off-grid options). This has been achieved through interventions by the government in collaboration with development partners. These interventions include, Last Mile Connectivity Programme, electrification of all public primary schools, Global Partnership of Output Based Aid (GPOBA) and the Rural Electrification Programme, among others, which the Ministry implemented through KPLC and REA.

Despite this achievement by the government in connecting Kenyans to electricity, there are still Kenyans without access to electricity. This has been attributed to many challenges including high connection charges; high costs of supplying electricity to rural and peri-urban households; lack of appropriate incentives to attract private sector investors; inappropriate technical standards; nature of settlements; weak implementing capacity; difficulties and delays in obtaining way leaves consents and rights of way and demands for high compensation. The Government has integrated off-grid interventions as integral part of energy service delivery and embarked on an ambitious program in the underserved counties to reach all Kenyans.

In 2014, the government realized that, it will not be possible to address the above concerns without a paradigm shift in the electrification strategy. There was a need to come up with a new National Electrification Strategy to deal with the existing challenges and emerging issues. Thus this strategy addresses the broad spectrum of the necessary policy direction, investments and collaborative environment required to achieve universal access to electricity in Kenya by 2022.

It is my sincere hope that, once implemented, this strategy will lead to more employment opportunities, reduction of poverty and higher incomes among the people and contribute to the momentum towards industrial development in Kenya. The flagship policies and other projects outlined by the strategy are expected to accelerate economic growth to an average of 10% per year as well as bring modern and clean energy sources to Kenyans' households, markets and trading centres, schools, hospitals, polytechnics and administrative centres in the rural areas.

Hon. Charles Keter, EGH
Cabinet Secretary, Energy

Preface

The development of the Kenya National Electrification Strategy (KNES) is a culmination of a long and consultative process that included local and international stakeholders.

The Ministry of Energy is grateful to have collaborated with our partners including the World Bank, who from the onset provided requisite support to kick-start the consultative process. Other development partners that provided support include the AFD, AFDB, EIB, EU, Power Africa and JICA.

The development of this strategy has benefited from an electrification workshop in September 2014 where global experiences of countries that have achieved universal access to energy such as Peru, Columbia Bangladesh and Vietnam were presented.

Various key actors in the energy sector such as Energy Regulatory Commission (ERC), Kenya Power and Lighting Company (KPLC), Rural Electrification Authority (REA), Kenya Electricity Generating Company (KenGen) Geothermal Development Company (GDC) and Kenya Electricity Transmission Company (KETRACO) all contributed immensely. The 47 County Governments, Private Sector and Civil Society Organizations presented their perspective in the development of the strategy. The KNBS and other Government departments also provided invaluable information that made this process a success.

I also wish to acknowledge the leadership and facilitation of the National Rural Electric Cooperative Association (NRECA) International that guided the inter-agency team in the development of this strategy and the underlying geospatial planning platform.

KNES is anchored on six (6) themes that taken together will define the means and process by which electrification expansion can be better organized and implemented during the period of rapid investment and accelerated implementation. The themes are:

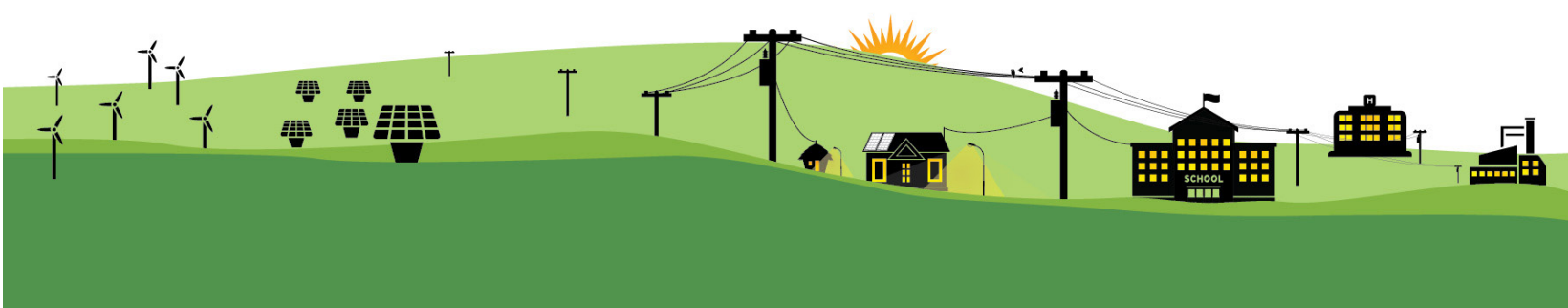
i. Definition of service levels for off-grid projects – establishing the definition of an electrified household or small business
ii. Strategies for identifying projects and prioritizing them for implementation
iii. Definition of technical aspects of future electrification investments including modification of design & construction standards and quality of service standards.
iv. Definition of the roles and responsibilities of the key participating institutions.
v. Definition of procurement arrangements to optimize future electrification program results.
vi. Evaluation of financial requirements and how these can be met by local and external sources of program financing.

The KNES implementation plan will employ multiple modalities to achieve the goal of universal access in the coming years. These modalities include: grid densification and intensification, grid expansion, and the deployment of mini-grids and standalone systems.

The Government of Kenya therefore is keen on implementing this Strategy to achieve universal access to electricity by the year 2022. Based on initial estimates; the cost of universal access to electricity both from public and private financing is approximately USD 2,750 Million, where over 5 Million customers will be connected through the grid and off-grid solutions.

We trust that the implementation of the strategy will receive the same level of support as was witnessed in its development process.

Eng. Dr Joseph Njoroge, CBS
Principal Secretary,
Ministry of Energy



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Abbreviations

EPMU	Electrification Program Management Unit
GDP	Gross domestic product
KNES	Kenya National Electrification Strategy
KPLC	Kenya Power and Lighting Company
MW	Megawatt
REA	Rural Electrification Authority

All dollar amounts are U.S. dollars unless otherwise indicated.

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SUMMARY

Kenya, with its roughly 48 million people, is a leader in economic growth in Sub-Saharan Africa. Its dynamic economy boasts a gross domestic product of $70 billion that has grown an average of 5 percent over the past several years, outperforming the average for Sub-Saharan Africa. Kenya aspires to be a newly industrialized middle-income country providing a high quality of life to all its citizens by 2030 (Vision 2030). The Medium-Term Plan (2018-22) of Vision 2030 (the Big 4 Agenda) is centered on four pillars- universal healthcare, affordable housing, food security, and manufacturing; and all four depend on the provision of adequate, affordable, and reliable electricity.

Kenya boasts a continually evolving low-carbon, affordable, and diverse energy mix. Generation capacity stands at a comfortable 2,670 megawatts (MW), with peak demand of 1,841 MW. As of June 2018, renewable energy accounts for 65 percent of total installed capacity and 78 percent of total electricity generation (7.9 terawatt-hours). Geothermal represents more than 40 percent of electricity generated making Kenya one of the global leaders in the use of this low-cost renewable energy resource. Lower generation costs, thanks to geothermal's prominent role, have contributed to lowering the costs of supply to consumers.

Over 2018–22 power demand is projected to grow from 1,841 MW in 2018 to between 2,633 MW (reference scenario) and 3,348 MW (Vision 2030 scenario).

UNIVERSAL ACCESS TO ELECTRICITY IN KENYA

Vision 2030 aspires to universal access to electricity by 2030, but in 2013 the government revised the target year to 2022 to accelerate the achievement of this goal. Connectivity has been scaled up tremendously over the past several years, with the access rate more than doubling between 2014 and 2018. As of February 2018, access is estimated at 75 percent from both grid and off-grid options.[1]

In 2014 the government realized that universal access to electricity would not be possible by 2022 without a paradigm shift. In 2015, the Government decided to develop the Kenya National Electrification Strategy (KNES) with the principal objective of defining a strategy to achieve electricity access for all households and businesses in Kenya over the shortest timetable and at acceptable quality of service.

CHALLENGES TO ACHIEVING UNIVERSAL ACCESS

The key challenges to achieving universal access to electricity in Kenya included: .

- High connection costs
- High costs of supplying electricity to rural and peri-urban households.
- Lack of appropriate incentives to attract private investors.
- Inappropriate technical standards given the nature of settlements.

1 Multi-Tier Framework Survey Report: February 2018; World Bank.

- Difficulties and delays in obtaining wayleaves consents and rights of way and demands for high compensation.
- Weak implementation capacity.

KEY PRINCIPLES BEHIND THE KNES

- ***Balancing consumer intensification with service beyond the grid.*** This entails expanding grid electric power to areas where expansion costs are below a reasonable ceiling ("grid compatible") at an accelerated pace and identifying off-grid solutions that can meet the energy needs of lower income remote population centers at reasonable costs and within the government's timeframe.
- ***Integrating planning processes.*** Both the Kenya Power and Lighting Company (KPLC) and the Rural Electrification Authority (REA) have planning processes, but the processes do not focus on systematically expanding grid and off-grid coverage. KPLC focuses on meeting load growth within its footprint, while REA focuses on extending electricity service to public facilities. The KNES is based on an integrated planning for both grid and off-grid areas.
- ***Developing a geospatial platform to focus investment on equitable expansion of access.*** A geospatial platform would allow KPLC and REA to identify opportunities for grid intensification and expansion and to coordinate deployment of off grid services (mini-grids and solar photovoltaic systems).
- ***Scaling up off-grid service.*** Off-grid service plays a key role in rural and remote areas. Scaling up off-grid service has proved very challenging in many countries because of many reasons including high cost of service and low affordability, inadequate customer financing, low-quality projects, and lack of enabling frameworks for off-grid services. However, pay-as-you-go photovoltaic systems that provide basic lighting and cell-phone charging have achieved high market penetration, especially in Kenya proving the critical role that this technology can play in helping Kenya achieve universal access to electricity by 2022.

SUPPLY SOLUTIONS TO ACHIEVE UNIVERSAL ACCESS TO ELECTRICITY

To determine how best to connect the remaining households, small business, and public facilities and achieve universal access to electricity in the most cost-efficient manner in the timeline specified by the government, a least cost geospatial electrification planning exercise was carried out. A five-year horizon was assumed, aligned with the government's goal of universal access by 2022. The outcome of the analysis is the KNES implementation plan that employs various supply options (grid expansion, grid intensification and densification, mini-grids and stand-alone systems) to achieve universal access.

The electrification planning exercise determined that there is potential for (figure S1):

- 269,000 connections to the grid through grid expansion (within 15 km of the 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 meters 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.

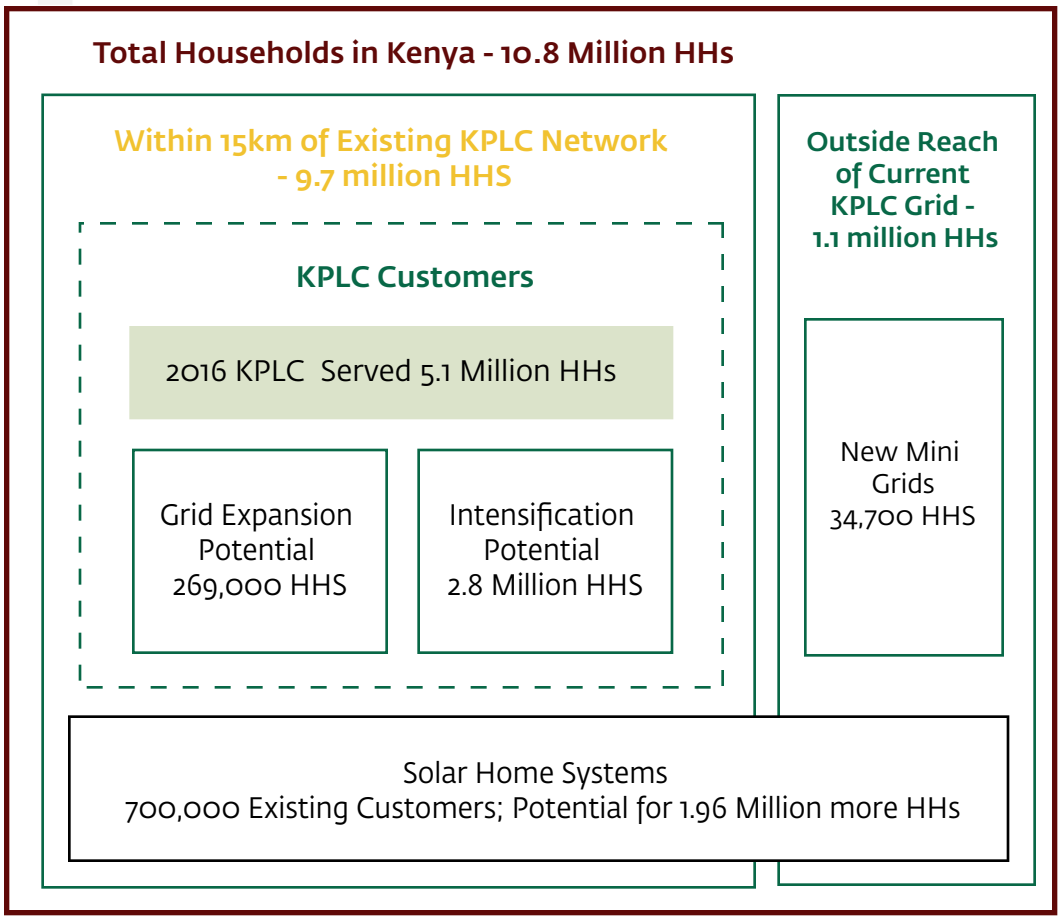
These figures take into account 2016 population projections, which suggest that 300,000 new households will be created each year of program implementation.

INVESTMENT PLAN

To achieve universal access to electricity by 2022, the national electrification program requires almost $2.75 billion of investment over the next five years—$2.3 billion of public investment in grid and mini-grid expansion implemented with donor-financing and $458 million of private investment in solar home systems (table S1).[2]

Assuming that the access targets for years 1–5 are achieved, additional investment averaging $58 million a year should be made in years 6–10 to keep pace with population growth.

Figure S1: Least-Cost Household Distribution in Grid and Off-Grid Areas for Current Population

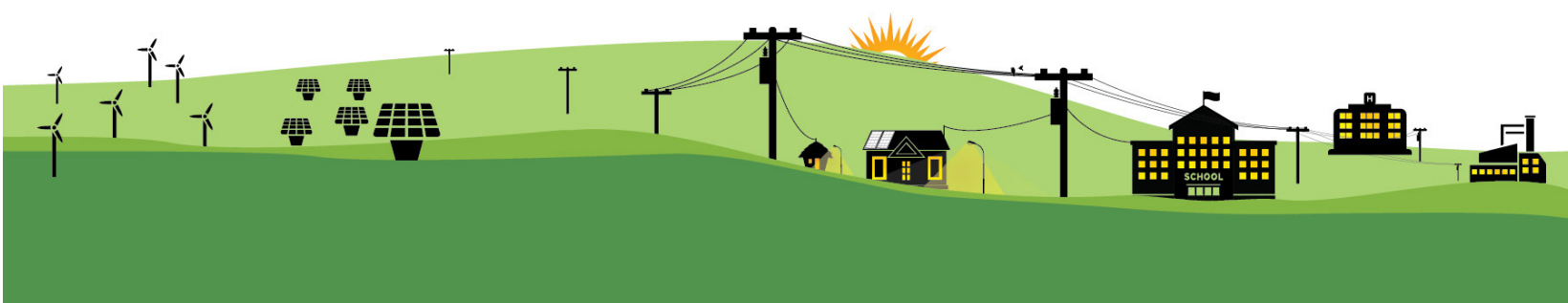


2 This does not include the investment needed for grid substations or for strengthening medium voltage distribution network, which are equally important to ensure adequate and reliable supply of electricity.

Table S1: Investment Plan Requirements in Years 1–5, by Intervention ($, millions)

Intervention	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Grid Expansion	$36.4	$61.6	$62.0	$110.5	$111.0	$381.5
Grid Densification	$23.9	$141.0	$340.3	$294.8	$442.4	$1,242.4
Grid Intensification	$82.2	$340.4	$154.6	$34.0	$22.2	$633.4
Mini-Grids	$5.8	$3.1	$8.4	$7.5	$8.3	$33.1
Solar Home Systems	$91.5	$91.5	$91.5	$91.5	$91.5	$457.5
Total	$239.8	$637.6	$656.8	$538.3	$675.4	$2,748.9

Note: Components may not sum to totals because of rounding.



Section 1

COUNTRY OVERVIEW

Kenya, with its roughly 48 million people, is a leader in economic growth in Sub-Saharan Africa. Its dynamic economy boasts a gross domestic product (GDP) of $70 billion that has grown an average of 5 percent over the past several years, outperforming the average for Sub-Saharan Africa. Kenya aspires to be a newly industrialized middle-income country providing a high quality of life to all its citizens by 2030 (Vision 2030). Electricity is critical to achieving the economic and productive sector objectives defined in Vision 2030.

The level and intensity of commercial energy use in a country are key indicators of socioeconomic development. As incomes increase and urbanization intensifies, household demand for energy rises. Realizing the Vision 2030 objectives is feasible only 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.

In a 2017 Jamhuri Day speech, President Uhuru Kenyatta identified food security, affordable housing, manufacturing, and affordable healthcare for all—all of which he expects to achieve by 2022—as responses to the challenges facing the country (the Big Four Agenda). He elaborated that the Big Four Agenda will be achieved by building on the foundation laid in his first term, which included electricity distribution. As manufacturing-led economic growth accelerates, electricity demand will increase manifold, requiring sustained efforts to ensure adequate and reliable supply. By targeting universal access to electricity by 2022, the Kenya National Electrification Strategy (KNES) will facilitate achieving the Big Four Agenda.

The KNES 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 strategy ensures that the energy required by projects expected to accelerate economic growth to 10 percent a year will be available and that schools, hospitals, polytechnics, markets, administrative centers, and rural households will have access to modern energy services.

Key Indicators

- Population: 48 million.
- GDP: $70 billion.
- Annual GDP growth: 5 percent.
- Composition of the economy: primarily agriculture, forestry, tourism, mining, and energy.
- GDP per capita: $1,750.
- Area: 569,140 square kilometers.

1.1. KENYA'S ELECTRICITY SECTOR

Kenya has a vibrant power sector and has strived to improve the efficiency of its utilities, with the objective of opening the energy sector to increased private capital and optimizing the use of public resources.

Kenya boasts a continually evolving low-carbon, affordable, and diverse energy mix. Generation capacity stands at a comfortable 2,670 megawatts (MW), with peak demand of 1,841 MW. As of June 2018, renewable energy accounts for 65 percent of total installed capacity and 78 percent of total electricity generation (7.9 terawatt-hours). Geothermal represents more than 40 percent of electricity generated making Kenya one of the global leaders in the use of this low-cost renewable energy resource. Lower generation costs, thanks to geothermal's prominent role, have contributed to lowering the costs of supply to consumers.

SECTOR INSTITUTIONAL STRUCTURE

The Ministry of Energy is the lead institution for energy policy development and planning. It is mandated with overall leadership, policy authority, and oversight of the national energy plan. But several other institutions are also involved in formulating and implementing energy policy (Table 1 and Figure 1).

Table 1: Kenya Electricity Stakeholders

Level	Institution	Role
Lead Institution	Ministry of Energy	Formulates policies; oversees sector planning, electrification of rural areas, and exploration of indigenous energy resources; promotes renewable energy development; and mobilizes financial resources for the public sector.
National Government	Energy Regulatory Commission	Regulates energy subsectors, protects consumer interests, ensures a reasonable return on investment for developers and utilities, oversees licensing, reviews and approves power purchase agreements, and reviews and approves tariffs.
	Rural Electrification Authority	Implements rural electrification through grid extension and off-grid projects, manages the Rural Electrification Fund, mobilizes funds to support rural electrification, finances project preparation studies for rural electrification, and recommends suitable policies to the government.
	Kenya Electricity Generating Company	Develops and manages all public power generation facilities.
	Kenya Power and Lighting Company	Transmits, distributes, and sells electricity to end users.
	Kenya Electricity Transmission Company	Plans, designs, builds, and maintains electricity transmission lines and associated substations.
	Kenya Nuclear Electricity Board	Fast-tracks the development of nuclear electricity generation.

Table 1: *Continued*

Level	Institution	Role
	Geothermal Development Company	Fast-tracks development of geothermal resources, including providing steam to power plant developers for electricity generation.
County Governments	47 County Governments	Prepare county energy plans for the Cabinet Secretary. Some counties provide supplementary funding for rural electrification.
Private Electricity Suppliers	11 Independent Power Producers	Provide 1,000 MW of capacity (30 percent of total capacity) and $2.4 billion in investment.
	30 Private Companies Involved in Off-Grid Solutions	Provide mini-grids and standalone renewable energy systems to more than 700,000 consumers.
Independent Entities	Energy Tribunal	Arbitrates disputes between parties in the sector.

1.2 SECTOR INVESTMENT PROSPECTUS, 2018–2022

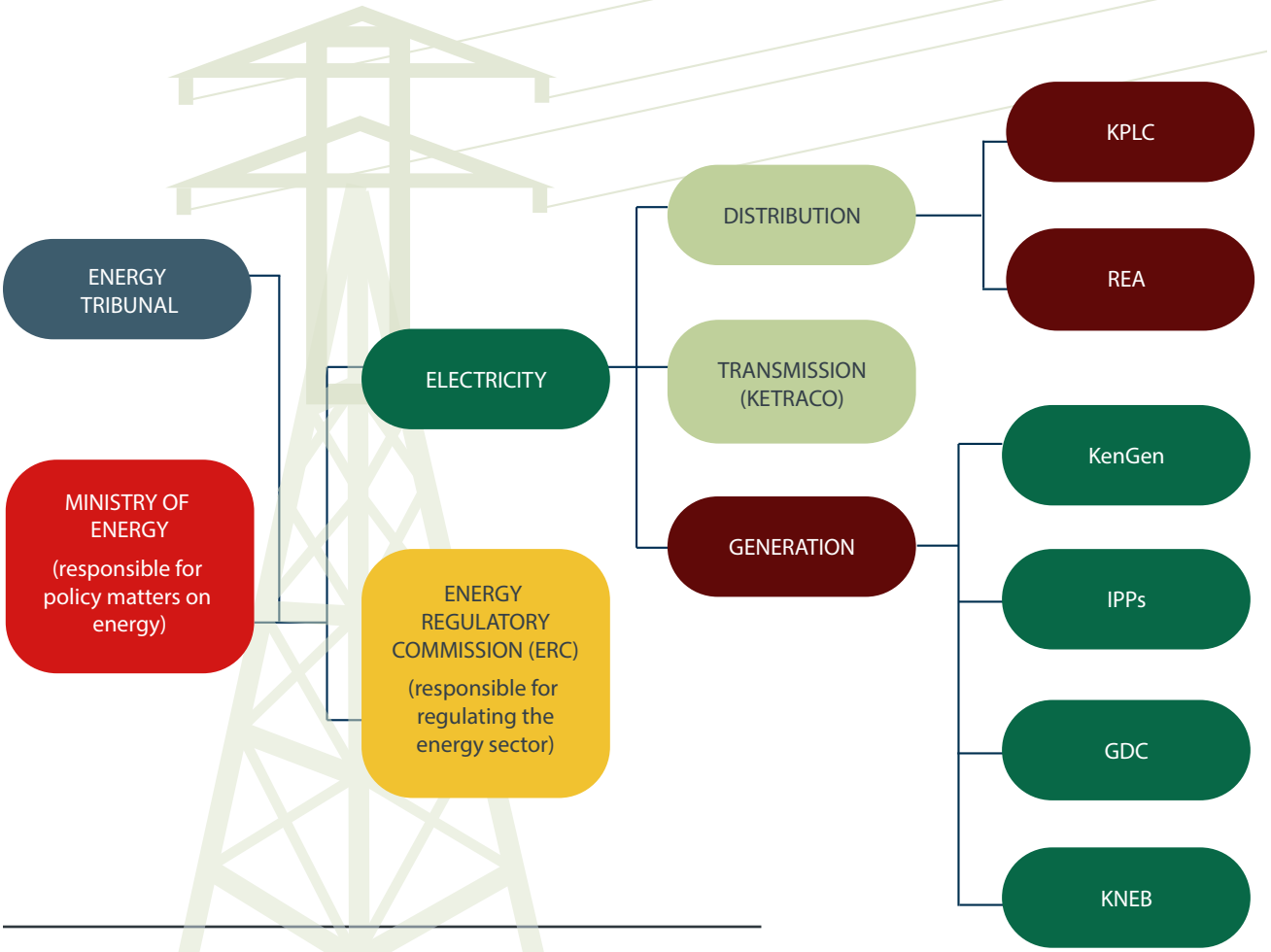
Kenya's industrialization agenda is set in the Vision 2030 development program and implemented through five-year Medium-Term Plans (MTPs). MTP III covers 2018–22.

This investment prospectus identifies the electricity investment needed from development partners and private investors and presents the electricity projects proposed under MTP III.

The total investment cost for MTP III is $14.8 billion. The prospectus covers six subsectors:

- ***Geothermal development.*** Investment in drilling, steam development, and electricity generation by the Geothermal Development Corporation, the Kenya Electricity Generating Company, and independent power producers ($5.2 billion).
- ***Power generation.*** Investment in areas other than geothermal development, including those by the Kenya Electricity Generating Company and independent power producers ($2.9 billion).
- ***Power transmission.*** Investment in new transmission lines and high-voltage substations, including interconnector projects with neighboring countries, by the Kenya Electricity Transmission Company ($2.9 billion).
- ***Power distribution.*** Investment in grid intensification and expansion to achieve universal access to electricity, expand the distribution network, and improve the reliability of the power supply by Kenya Power and Lighting Company (KPLC) ($2.9 billion).
- ***Off-grid electrification.*** Investment in mini-grids, solar home systems, and institutional solar photovoltaic systems by the Rural Electrification Authority, the Ministry of Energy, KPLC, and private companies ($0.9 billion).
- ***Energy efficiency.*** Investment by the government's Energy Efficiency and Conservation Programme and a few planned public and private energy efficiency initiatives (such as those for Nairobi city) ($23.5 million).

Figure 1: Institutional Framework of Kenya's Power Sector



New energy bills being enacted to align the sector to the New Constitution, Vision 2030 and Global Trends...

Section 2

UNIVERSAL ACCESS TO ELECTRICITY IN KENYA

Vision 2030 aspires to universal access to electricity by 2030, but in 2013 the government aimed to accelerate achievement of this goal and revised the target year to 2022. Connectivity has been scaled up tremendously over the past several years, with the access rate more than doubling between 2014 and 2018. As of February 2018, access is estimated at 75 percent from both grid and off-grid options,[3] thanks to the collaborations between the government, development partners, and the private sector through programmess like the Last Mile Connectivity, electrification of all public primary schools, results-based financing through the Global Partnership for Output-Based Aid, the Rural Electrification Programme, and the private sector-led market-based approaches in the off-grid space. Despite the accelerating growth in access in recent years, a quarter of Kenyans still lack access to a modern source of energy.

In 2014 the government realized that universal access to electricity would not be possible by 2022 without a paradigm shift. A new national electrification strategy was needed to address existing challenges and emerging issues.

The key challenges included:

- High connection costs.
- High costs of supplying electricity to rural and peri-urban households.
- Lack of appropriate incentives to attract private investors.
- Inappropriate technical standards given the nature of settlements.
- Difficulties and delays in obtaining wayleaves consents and rights of way and demands for high compensation.
- Weak implementation capacity.

To address these challenges, the government developed the Kenya National Electrification Strategy (KNES). Its principal objective is to define a strategy to achieve electricity access for all households and businesses in Kenya over the shortest timetable and at acceptable quality of service. With the help of a geospatial planning tool, KNES identified the least cost technology options (grid extension, grid intensification, mini-grids, and standalone systems) and the associated investments required for reaching the remaining population with affordable and reliable electricity by 2022 (see chapter 4).

3 Multi-Tier Framework Survey Report: February 2018; World Bank.

2.1 ELECTRIFICATION SUCCESS

2.1.1. INCREASED GENERATION CAPACITY

After decades of shortages, Kenya now has surplus capacity to meet demand—including a peak reserve margin of 30 percent—and supply is predominantly from renewable energy sources. The government has invested heavily in geothermal production and partnered with the private sector to develop geothermal (figure 2), small hydro, wind, and solar (figure 3) while reducing dependency on liquid fuel and large hydroelectric power plants. Generation capacity has already been considerably increased to accelerate and accommodate access expansion, making universal access by 2022 achievable.

Figure 2: Olkaria 280 MW Geothermal Plant

Figure 3: Garissa Solar Photovoltaic Power Plant

2.1.2. INCREASED ELECTRICITY ACCESS

Kenya Power and Lighting Company (KPLC) connections have grown an average of 22 percent a year over the past five years, almost tripling the number of customers served (Table 2).

The Rural Electrification Authority's (REA) investment program has focused on expanding access to electricity for community loads, including government offices, health centers, markets, and schools (Table 3).

Approaches to achieving universal access to electricity

Table 2: Number of customers with a Kenya Power and Lighting Company connection, 2009/10–2016/17

Type of Customer	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Domestic	1,262,141	1,524,784	1,776,973	2,059,340	2,481,856	3,305,934	4,565,907	5,839,865
Small Commercial	198,451	225,174	244,323	267,263	281,657	299,675	316,851	328,586
Other	3,047	3,390	17,329	4,359	4,470	6,295	7,615	4,485
Total	1,463,639	1,753,348	2,038,625	2,330,962	2,767,983	3,611,904	4,890,373	6,172,936
Increase		289,709	285,277	292,337	437,021	843,921	1,278,469	1,282,563
Percentage Increase		20	16	14	19	30	35	26

Table 3: Electrified and Unelectrified Institutions Assisted by the Rural Electrification Authority

	Electrified		Unelectrified		Total	
Facility	**2014**	**2016**	**2014**	**2016**	**2014**	**2016**
Trading Centers	9,174	12,263	2,868	3,178	12,042	15,441
Secondary Schools	8,195	7,845	19	1,586	8,214	9,431
Health Centers	4,673	4,876	0	1,671	4,673	6,547
Primary Schools	15,157	23,375	6,065	0	21,222	23,375
Water Projects	1,967	2,093	1,784	4,298	3,751	6,391

2.2 APPROACHES TO ACHIEVING UNIVERSAL ACCESS TO ELECTRICITY

2.2.1. BALANCING CONSUMER INTENSIFICATION WITH SERVICE BEYOND THE GRID

This challenge is twofold:

- To expand grid electric power to areas where expansion costs are below a reasonable ceiling ("grid compatible") at an accelerated pace.
- To identify off-grid solutions that can meet the energy needs of lower income remote population centers and housing clusters at reasonable costs and within the government's timeframe.

2.2.2. INTEGRATING PLANNING PROCESSES

Both KPLC and REA have planning processes, but the processes do not focus on systematically expanding grid and off-grid coverage. KPLC focuses on meeting load growth within its footprint, which is both extremely important and in line with its primary responsibilities to its consumers and shareholders. REA focuses on extending electricity service to public facilities. The KNES is based on an integrated planning for both grid and off-grid areas.

2.2.3. DEVELOPING A GEOSPATIAL PLATFORM TO FOCUS INVESTMENT ON EQUITABLE EXPANSION OF ACCESS

A geospatial platform would allow KPLC and REA to identify opportunities for grid intensification and expansion and to coordinate deployment of mini-grids and solar photovoltaic systems. In particular, effective geospatial planning for electrification enables countries to achieve economic efficiency and to systematically and equitably expand service to community facilities, households, small businesses, and other demand centers. A common geospatial platform would enable both KPLC and REA to systematically evaluate:

- The costs and benefits of grid expansion versus off-grid services to rural and remote communities.
- How to expand coverage beyond the grid through mini- and micro-grids and standalone systems.

2.2.4. SCALING UP OFF-GRID SERVICE

Off-grid service plays a key role in rural and remote areas. Scaling up off-grid service has proved very challenging in many countries because of high cost of service and low affordability, inadequate customer financing, low-quality projects, and lack of enabling frameworks for off-grid services, among other reasons. However, pay-as-you-go photovoltaic systems that provide basic lighting and cell-phone charging have achieved high market penetration, especially in Kenya, proving the critical role that this technology can play in helping Kenya achieve universal access to electricity by 2022. The main challenge is to devise a strategy for systematic service delivery to off-grid areas that can achieve scale (that is, reach many consumers efficiently) and at the approved level of energy delivery.

Section 3

ELEMENTS OF THE KENYA NATIONAL ELECTRIFICATION STRATEGY

The Kenya National Electrification Strategy (KNES) focuses on six key themes that outline the means and processes by which electrification expansion can be better coordinated during the period of rapid investment and accelerated implementation:

- Designating service levels for off-grid projects by defining an electrified household or small business.
- Developing strategies for identifying projects and prioritizing them for implementation.
- Defining the technical aspects of future electrification investment, including modification of design and construction standards and quality of service standards.
- Defining the roles and responsibilities of the key participating institutions.
- Defining procurement arrangements to optimize future electrification program results.
- Evaluating financial requirements and how they can be satisfied by local and external sources of financing.

3.1 PILLARS OF THE KENYA NATIONAL ELECTRIFICATION STRATEGY

The six themes are organized into three pillars: the planning and technical pillar, the institutional pillar, and the financial pillar (Figure 4).

3.1.1. THE PLANNING AND TECHNICAL PILLAR

Successfully implementing the KNES will depend on clearly defining:

- How grid and off-grid expansion will be planned.
- Which technology solutions will be used to address grid expansion to areas with low population density.
- How and when to use micro-grids.
- How standalone solar photovoltaic systems will be used to provide service where grids and micro-grids are not viable.

Defining these items involved the following activities:

- The World Bank Multi-Tier Framework was used to define service levels and, through extensive sector consultations, determine that Tier 1 provides the basic level of service for a household to receive electricity access in off-grid areas (Table 5).
- Willingness-to-pay analyses provided critical information for evaluating the economic benefits of grid versus off-grid technologies. They also informed the analysis of lifeline electricity tariff requirements.

Figure 4: Pillars and Strategic Elements of the Kenya National Electrification Strategy

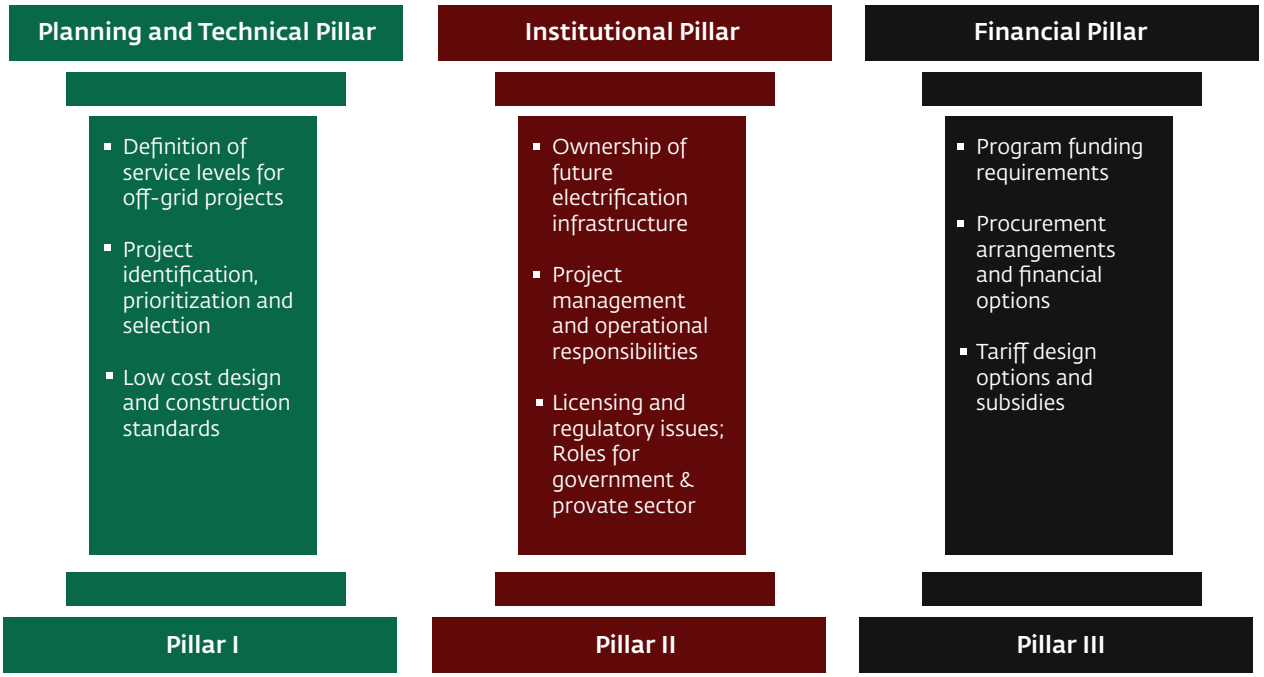


Table 4: Attributes of the Multi-Tier Framework for Electricity Access

Attribute	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Available Peak Power	At least 3 W	At least 50 W	At least 200 W	At least 800 W	At least 2 kW
Monthly Consumption per Consumer	At least 12 Wh	At least 200 Wh	At least 1 kW	At least 3.4 kW	At least 8.2 kWh
Daily Availability	At least 4 hours	At least 4 hours	At least 8 hours	At least 16 hours	At least 23 hours
Evening Availability	At least 1 hour	At least 2 hours	At least 3 hours	At least 4 hours	At least 4 hours
Reliability (Outages per Week)	NA	NA	NA	At most 14	At most 3 (with total duration of less than 2 hours)

Note: NA is not applicabale

- Geospatial platforms and master planning have been and will be employed as a principal input to more comprehensive program planning and coordination across stakeholders and used to track progress.
- Low-cost grid and off-grid solutions were identified and assessed. Rapidly expanding electricity connectivity will require several billion dollars of investment. But optimizing design and construction practices for medium- and low-voltage distribution systems could bring substantial efficiencies.
- Scaling up the off-grid program requires multiple interventions: leveraging the knowledge and capacity of existing market participants and stimulating investment by offering incentives for service provision in difficult-to-reach areas, among others. Such approaches will be employed to achieve universal access in Kenya.

3.1.2. THE INSTITUTIONAL PILLAR

Table 5 defines the roles and responsibilities for the principal stakeholders in Kenya's electricity sector.

Table 5: Sectoral Roles and Responsibilities in Kenya's Electricity Sector

Pillar	Ministry of Energy	Kenya Power and Lighting Company	Rural Electrification Authority
Planning and Technical	Establishing the EPMU, hosting the geospatial planning platform, and developing a monitoring and evaluation plan and annual investment plans.	Coordinating with EPMU for expansion planning, implementing programs to expand access to the grid, and leading the development of low-cost technical standards.	Collaborating in project reviews and evaluation results to prioritize investments.
Institutional	Developing procurement packages for on- and off-grid prioritized projects and implementing outreach programs to engage county electrification offices.	Developing and operating larger mini-grids and overseeing management contractors responsible for operation and maintenance of smaller mini-grids.	Developing the capabilities required to operate mini-grids (if the Rural Electrification Authority wishes to become an electric service provider).
Financial	Coordinating with donors and multilaterals to finance prioritized projects.	Collecting subsidies and levies from customers to finance electricity expansion funds and subsidies.	Financing a portfolio of high-priority projects that is commensurate with its budgetary resources (grid extension for public facilities and mini-grids for remote housing clusters).

Continued on the next page

Table 5: *Continued*

Pillar	Energy Regulatory Commission	County Electrification Offices	Kenya Electricity Transmission Company
Planning and Technical	Issuing quality of service standards.	Providing inputs to EPMU for the prioritization of identified projects deemed feasible.	Coordinating with EPMU planning teams on investment in grid substations.
Institutional	Reviewing and acting on license applications by potential electric service providers.	Receiving training to enable county electrification officers to use geographic information systems for future planning and program monitoring.	NA
Financial	Responding to requests for tariff modifications by Kenya Power and Lighting Company and other service providers.	NA	NA

3.1.3. THE FINANCIAL PILLAR

The financial pillar addresses tariffs and subsidies as well as investment requirements for the KNES.

3.1.3.1. TARIFFS AND SUBSIDIES

The Ministry of Energy favors a uniform national tariff. Extending the Kenya Power and Lighting Company (KPLC) tariff to off-grid systems will require a clear mechanism to allocate and manage subsidies. For example, subsidies could be financed through an intrasector mechanism such as a levy. With KPLC annual sales of 7,000 gigawatt-hours, a $19.5 million annual subsidy would add $0.0028 per kWh to KPLC grid-connected consumers' cost (Table 6).

Target: 1,105,000 unelectrified households in 14 off-grid counties located more than 15 kilometers from KPLC service.

Determination: Approximately 35,000 households are likely to be served by mini-grids, and 1,070,000 householdswill be served by solar home systems.

Table 6: Subsidies Required for Off-Grid Technologies

System	Households	Annual Subsidy ($)
Mini-Grids	35,000	$3,377,500
Solar Home Systems	1,070,000	$16,050,000
Total	1,105,000	$19,427,500

Table 7: Estimated Investment Required to Achieve Universal Access to Electricity by 2022

Program	Impact (Connections)	Projected Cost ($, millions)
Grid Intensification & Densification	3,133,308[a]	$1,875.8
Grid Expansion	299,601	$381.5
Mini-Grids	38,661	$33.1
Solar Home Systems	2,179,730	$457.5
Total	5,651,300	$2,747.9

a. Includes 100,000 additional consumers through intensification of existing mini-grids.

3.1.3.2. INVESTMENT REQUIREMENTS

More detailed information is provided in section 4, but Table 7 presents a snapshot of the investment required to achieve universal access to electricity.

3.2 SUPPLY SOLUTIONS TO ACHIEVE UNIVERSAL ACCESS TO ELECTRICITY

In January 2017, KPLC served 5.1 million customers and was adding 100,000 new connections a month. In addition, 700,000 households were equipped with quality-certified solar home systems. But based on projections from the 2009 census, there were 10.8 million total households in January 2017, leaving 5 million households unelectrified.

To determine how best to connect the remaining households, small business, and public facilities and achieve universal access to electricity in the most cost-efficient manner in the timeline specified by the government, a least cost geospatial electrification planning exercise was carried out and an investment plan prepared. A five-year horizon was assumed, aligned with the government's goal of universal access by 2022. Similarly, the KNES implementation plan will employ multiple modalities to achieve universal access in the coming years. So various electricity supply options were considered.

The evaluation of supply options and preparation of the investment plan consisted of three-phases:

- A countrywide integrated electrification planning exercise was conducted using a geospatial platform populated with extensive data such as population distribution, location of public facilities, distribution system infrastructure, roads, water bodies, and other terrain. In addition, satellite imagery was processed to locate clusters of households to be electrified.
- Multiple technology delivery modalities were analyzed:
    1. *Grid expansion*. Extending the medium-voltage distribution network to connect housing clusters located within 15 kilometers of the KPLC distribution system.
    2. *Grid intensification and densification*. Installing additional transformers on existing KPLC medium-voltage feeders and laterals to connect housing clusters within 600 meters of existing KPLC distribution transformers (grid densification). Housing clusters more

than 600 meters from existing transformers that can be served by new transformers along existing lines and extending short (up to 2 kilometer) medium-voltage lines to connect housing clusters that are beyond the reach of existing transformers and the medium-voltage system (grid intensification).

3. *Mini-grids*. To serve housing clusters too distant from the network or too small to be interconnected. These clusters are beyond the area that is served by the existing KPLC distribution service and beyond the area to which KPLC service could be expanded.

4. S*tandalone solar photovoltaic systems*. All remaining housing clusters and individual houses that cannot be served by the above three modalities were highlighted for standalone solar photovoltaic systems. Kenya's energy market has included off-grid service providers for more than two decades, and the role of these providers has grown in recent years. Where grid extension and mini-grid service are not viable, off-grid standalone energy systems such as solar photovoltaic systems will be employed. Minimal service (Tier 1, as defined by the Multi-Tier Framework) is the baseline that the KNES will recognize for standalone energy service.

- A preliminary technical design and a cost–benefit analysis were conducted for each identified project within the delivery modalities for evaluation and prioritization in the investment plan.

Figure 5: Community Celebrating Electricity Access through Solar Photovoltaics

3.2.1. GEOSPATIAL PLANNING PLATFORM AND ANALYSIS

The purpose of developing a geospatial framework was to create a mechanism that provides objective planning data with which national and county policy makers can make informed decisions regarding grid and off-grid investment for electricity service to communities, households, small businesses, and public facilities across the country. The geospatial platform will be used for planning, for coordinating private investment in off-grid electrification services, for program monitoring, and for sharing infrastructure development data and information with other government agencies and stakeholders. The platform includes multiple datasets that have been integrated on a national scale for the first time. Publicly providing these data have substantial value to parties in multiple sectors.

3.2.2. GEOSPATIAL PLATFORM DEVELOPMENT

The development of the geospatial platform started with data collection to create the geographic base map for expansion planning.

To address the multiple technology options, the geospatial team began by downloading and processing satellite imagery to identify and locate all structures throughout Kenya (Figure 6). Census data were used to evaluate population and housing density on an individual constituency basis for the entire country. Data were also collected from various sources to locate all public facilities.

A team visited county officials in an effort to update data on schools, vocational training centers, water supply sources, and other public facilities, but county governments were not equally responsive to data requests (Figure 7). Those data were combined with data from Kenya Open Data, the government's centralized data clearinghouse.[4]

KPLC also provided a copy of the facilities database, which includes all medium-voltage (11 and 33 kilovolt) lines, primary substations, and distribution transformers as of December 2016. In addition, the KPLC distribution master plan was reviewed to identify new grid substations, primary substations, and medium-voltage feeder projects (Figure 8). All data were added to the geospatial platform.

In addition, the Kenya Electricity Generating Company and Kenya Electricity Transmission Company master plans were reviewed to locate power generation stations as well as existing and planned grid substations and transmission corridors. Locations of existing and planned mini-grid stations were requested and received from KPLC, the Rural Electrification Authority, the German Corporation for International Cooperation, and the World Bank.

Finally, the Kenya National Bureau of Statistics provided a geographically referenced file of Kenya's international, primary, secondary, and tertiary road network and political boundaries.

After all information was validated and populated in the geospatial platform, the analysis considered each technology option.

3.2.3 DENSIFICATION AND INTENSIFICATION

Grid densification is the connection of all consumers within 600 meters of existing distribution transformers where there is no need to add additional distribution transformers. Grid intensification is the addition of distribution transformers and short (up to 2 kilometer) medium-voltage extensions to capture more consumers.

The analysis indicates how many more consumers can be served by installing service drops and short low-voltage extensions (densification) and by intensifying the load on existing feeders and lateral medium-voltage lines (intensification). It did not consider the upstream impact of adding significant load to distribution transformers,

4 http://www.opendata.go.ke.

Figure 6: Existing Structures in Kenya

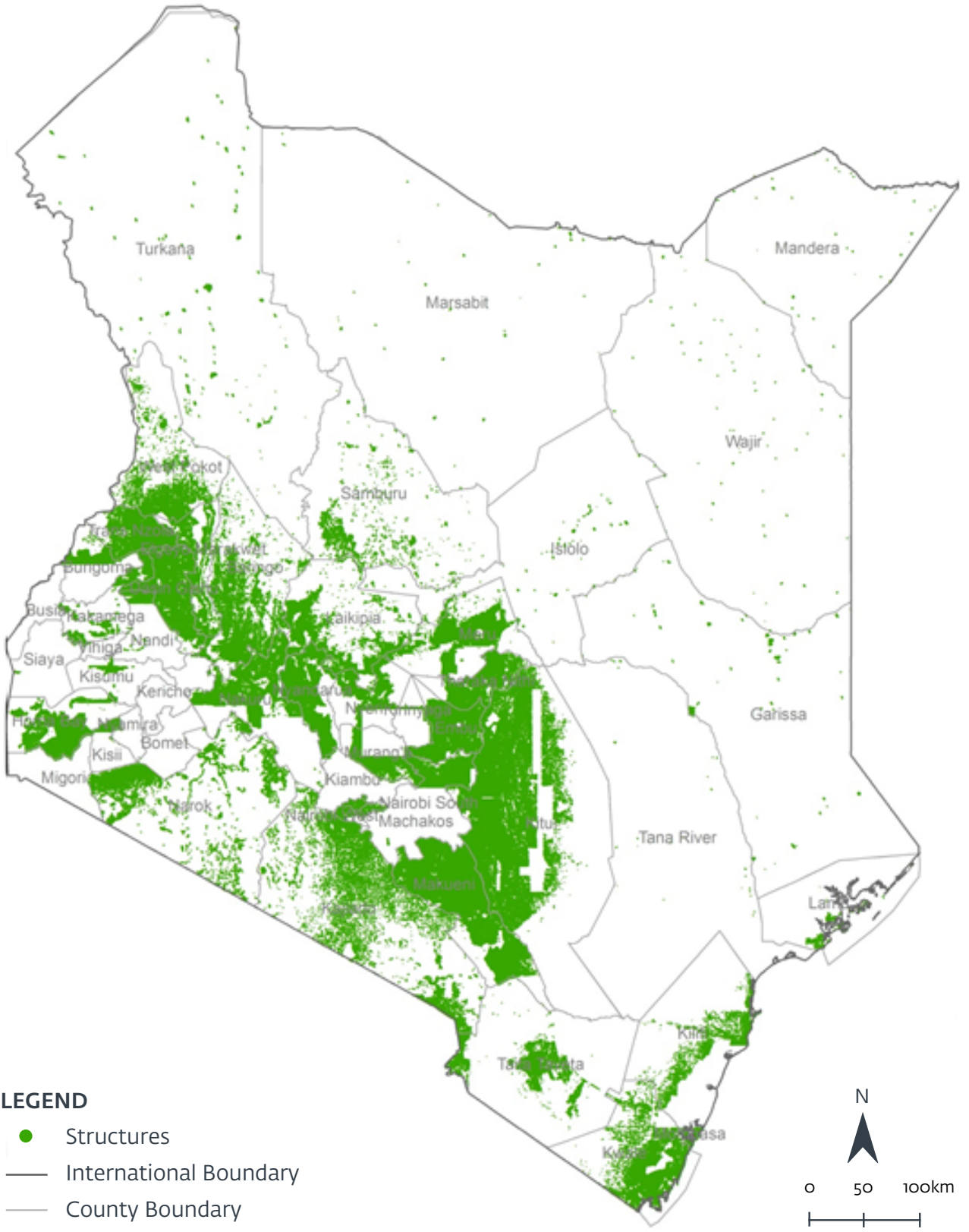


Figure 7: Location of Public Facilities in Kenya

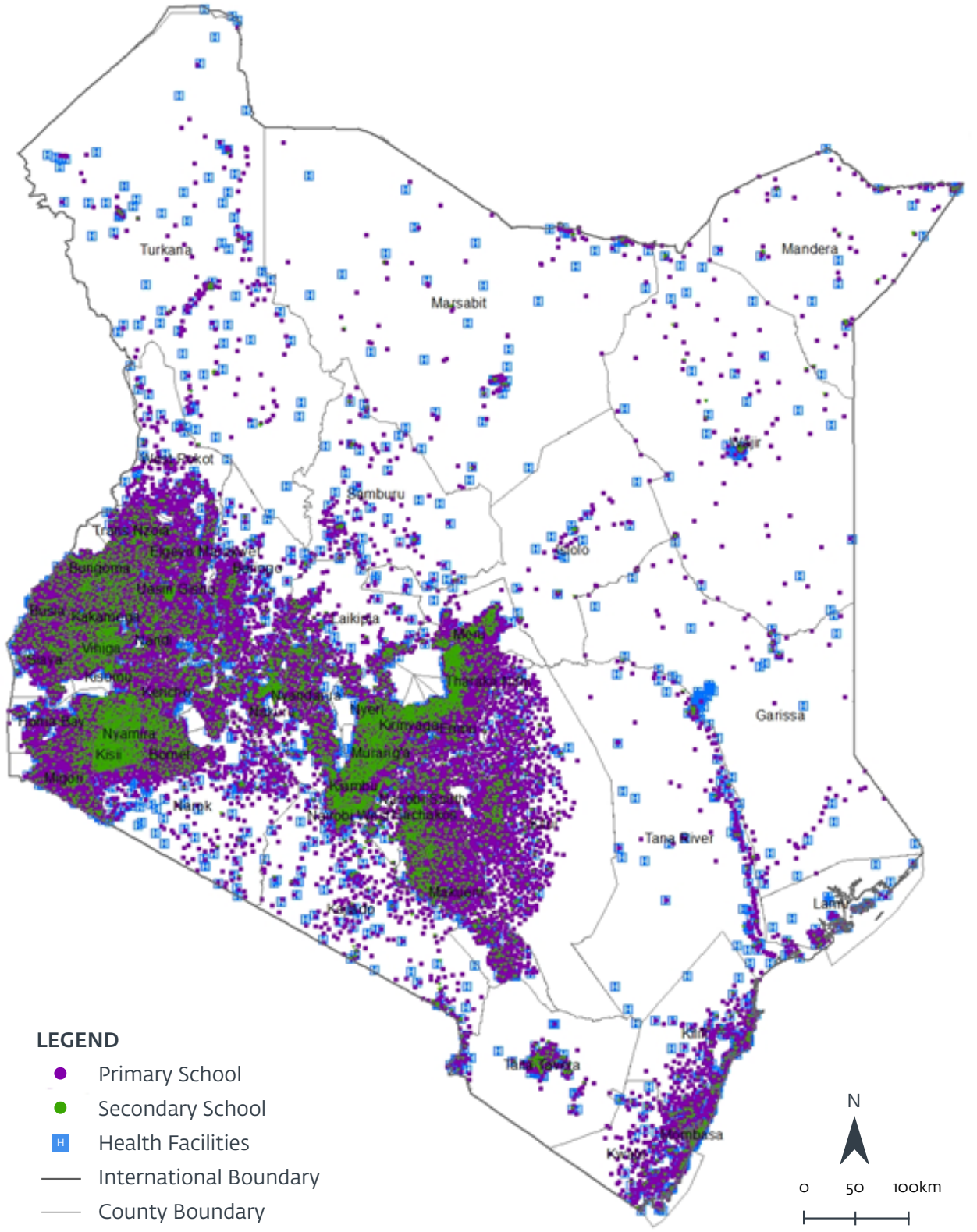
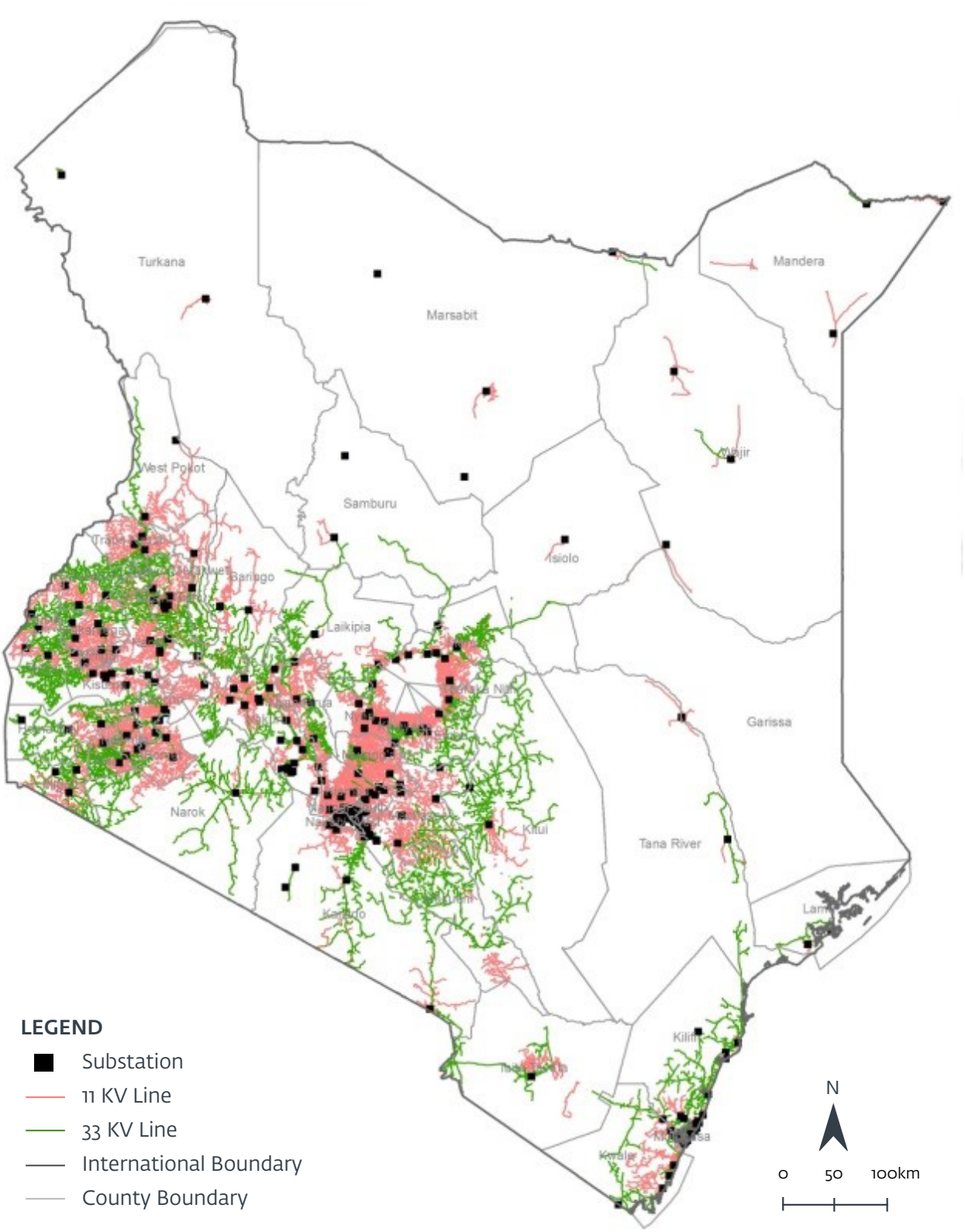


Figure 8: Existing Distribution (KPLC MV) Infrastructure in Kenya



medium-voltage laterals and feeders, and primary and grid substations.

The intensification analysis began by filtering out all structures in the structure dataset that are within 600 meters of existing distribution transformers (because those structures would be connected through densification). The analysis then defined the clusters of households in the filtered dataset that would make good candidates for installing a transformer and low-voltage network. This was done by grouping closely packed points (points with many nearby neighbors) and excluding outliers that are situated in low-density areas whose nearest neighbors are too far away. Then the low-voltage network was defined using a geoprocessing function to lay out lines following road networks wherever they exist. The algorithm determines the shortest path to interconnect houses to each distribution transformer.

This methodology was used for each county in which KPLC offers service (most of the 47 counties in Kenya). Grid densification and intensification are very low in some counties and much higher in counties where KPLC has a prominent presence.

3.2.4. MINI-GRIDS

The analysis indicates where mini-grid service is likely to be the most practical and pragmatic approach to providing energy service to households, businesses, and public facilities in rural and remote areas.

Evaluating mini-grid potential involved identifying communities and housing clusters that are beyond the limits of expected grid expansion and big enough to justify investment in a small generation-distribution system. First, all KPLC and REA mini-grids that are already in operation and are under development were identified. Then the communities and housing clusters that are candidates for mini-grid development were identified. The geospatial team used satellite imagery to evaluate all housing and business structures, identify housing clusters, and design distribution networks for each of the identified mini-grids (figure 9).

For all housing clusters with fewer than 500 structures, the team used only low-voltage distribution networks, sometimes designing multiple networks to cover housing clusters as efficiently as possible. For larger mini-grids with more than 500 structures, the team designed medium-voltage networks. The networks were designed using the most likely line alignments, and systems were modeled to evaluate expected residential and commercial loads. To model other point loads such as schools, grain mills, and water supply, the mini-grid model evaluated the number of schools per mini-grid based on the number of residential consumers, the number of grain mills per village by assuming one mill per 200 households, and water supply based on World Health Organization minimum daily water requirements. The load data for each mini-grid were combined to evaluate total power requirements and dimension the solar photovoltaic array, battery storage, and inverter. Mini-grid distribution alignments were used to dimension low-voltage network lengths.

3.2.5. LEAST COST SOLUTIONS

The electrification planning exercise determined that there is potential for:

- 269,000 connections to the grid through grid expansion.
- 2.77 million connections to the grid through grid densification and intensification (including 100,000 connections through intensification of existing mini-grids).
- 35,000 connections through 121 new mini-grids.
- 1.96 million connections through standalone solar home systems.

These figures take into account 2016 population projections, which suggest that 300,000 new households will be created each year of program implementation.

Figure 9: Potential Mini-Grid Locations

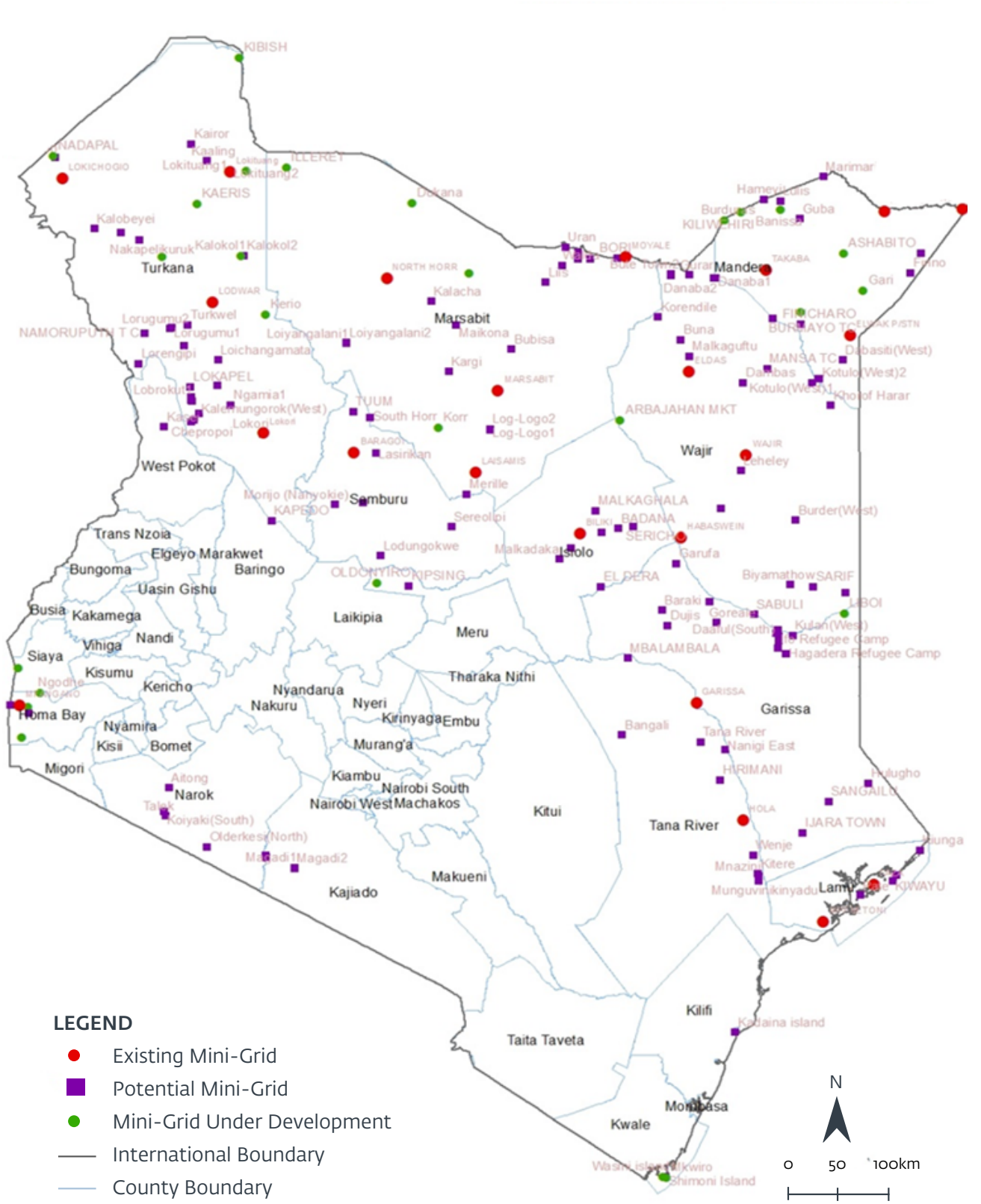
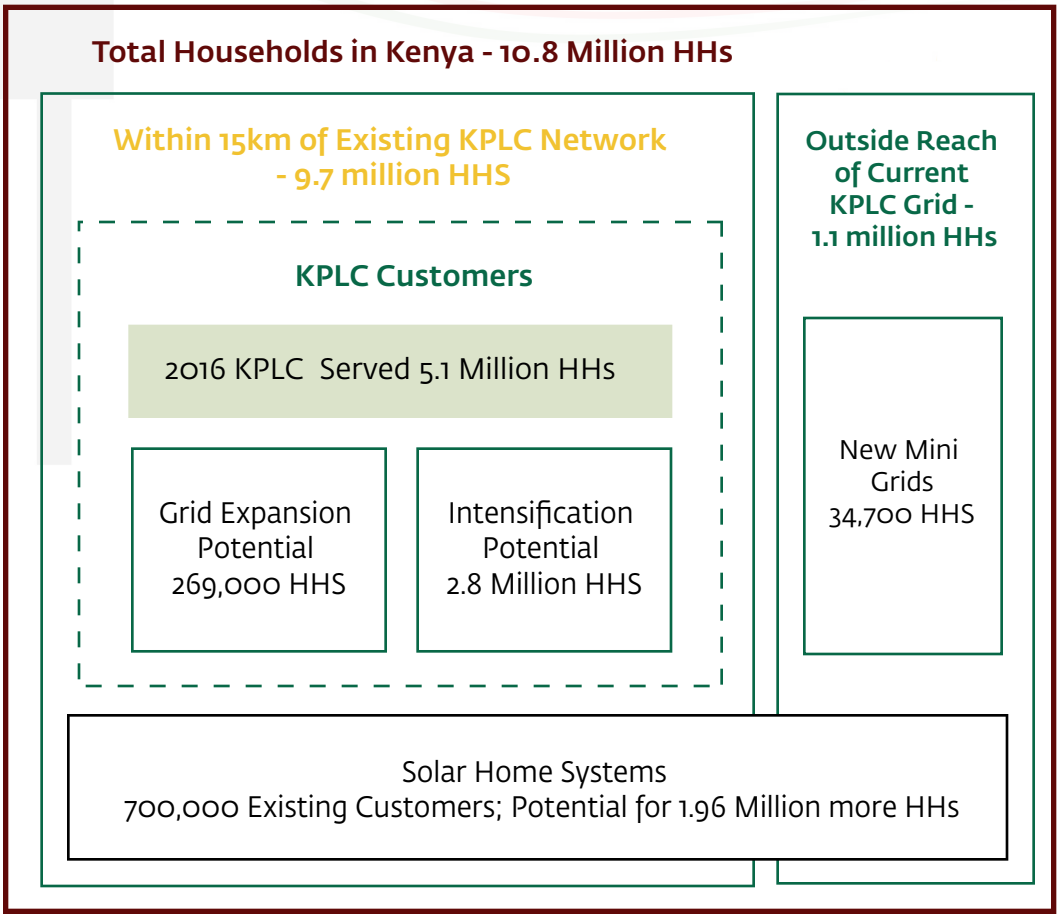


Figure 10: Least-Cost Household Distribution in Grid and Off-Grid Areas for Current Population



Section 4

INVESTMENT PLAN

4.1 FIVE-YEAR INVESTMENT PLAN FOR UNIVERSAL ACCESS TO ELECTRICITY

The government has committed to universal access to electricity by 2022. To achieve this ambitious goal, the national electrification program requires almost $2.75 billion of public and private investment (Table 8). This does not include investment needed for grid substations or for strengthening medium voltage distribution network.

The country has made great strides toward universal access to electricity through the Last Mile Connectivity Programme where the connection costs are subsidized by the Government. Achieving universal access will require $2.3 billion of public investment in distribution infrastructure and donor support will be critical to meet the investment needs. With the rapid expansion of consumers, service reliability and quality will suffer – and in some places significantly if grid strengthening investments are not included in the investment plan. Considering the fact that these investments in grid substations and medium voltage feeders are essential elements for the Last Mile Connectivity Program to work, such investments should also be treated in the same manner as the Last Mile and be eligible for subsidy by the Government.

In addition, $458 million of private investment in solar home systems is required for the households scattered throughout the country that are unlikely to be served by the national grid or small mini-grids.

Table 9 presents the estimated number of connections that will be made each year if the needed investment capital is available.

Table 8: Investment Plan Requirements in Years 1–5, by Intervention ($, millions)

Intervention	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Grid Expansion	$36.4	$61.6	$62.0	$110.5	$111.0	$381.5
Grid Densification	$23.9	$141.0	$340.3	$294.8	$442.4	$1,242.4
Grid Intensification	$82.2	$340.4	$154.6	$34.0	$22.2	$633.4
Mini-Grids	$5.8	$3.1	$8.4	$7.5	$8.3	$33.1
Solar Home Systems	$91.5	$91.5	$91.5	$91.5	$91.5	$457.5
Total	$239.8	$637.6	$656.8	$538.3	$675.4	$2,748.9

Note: Components may not sum to totals because of rounding.

Table 9: Connections made Available During Years 1–5 of the Expansion Program, by Intervention

Intervention	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Grid Expansion	44,153	50,329	53,015	74,105	77,999	299,601
Grid Densification	47,773	282,094	680,552	589,666	933,910	2,533,995
Grid Intensification	69,953	281,933	134,942	68,010	44,475	599,313
Mini-Grids	6,384	3,625	9,564	8,897	10,191	38,661
Solar Home Systems	435,946	435,946	435,946	435,946	435,946	2,179,730
Total	604,209	1,053,927	1,314,019	1,176,624	1,502,521	5,651,300

4.2 ONGOING ELECTRIFICATION INVESTMENT PLAN

Assuming that the access targets for years 1–5 are achieved, additional investment should be made in years 6–10 to keep pace with population growth. Table 10 presents the ongoing investment cost of the program each year, assuming that the population growth rate is uniform in grid and off-grid areas, and Table 11 presents the distribution of new connections each year in years 6–10.

4.3 SUMMARY OF 10-YEAR INVESTMENT PLAN

Figure 11 shows the investment requirements by year, disaggregated by intervention. After the initial five years, investment is driven mainly by population growth, averaging $58 million a year. Figure 12 shows the cumulative number of connections that will be financed by the plan. There is a very sharp increase in years 1–5, followed by a much shallower increase each year thereafter.

Table 10: Investment Plan Requirements in Years 6–10, by Intervention ($, Millions)

Intervention	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Grid Expansion	1.1	1.2	1.3	1.3	1.3	6.3
Grid Densification	33.5	34.5	35.4	36.3	37.3	177
Grid Intensification	8.1	8.3	8.5	8.8	9	42.7
Mini-Grids	0.2	0.2	0.2	0.2	0.2	1
Solar Home Systems	12.4	12.7	13.0	13.4	13.7	65.2
Total	55.4	56.9	58.4	60	61.5	292.2

Table 11: Connections Made Available During Years 6–10 of the Expansion Program, by Intervention

Intervention	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Grid Expansion	8,089	8,308	8,532	8,762	8,999	42,690
Grid Densification	36,080	68,903	70,763	72,674	74,636	323,056
Grid Intensification	16,181	16,618	17,067	17,528	18,001	85,395
Mini-Grids	1,044	1,072	1,101	1,131	1,161	5,509
Solar Home Systems	58,853	60,442	62,074	63,750	65,741	310,860
Total	120,247	155,343	159,537	163,845	168,538	767,510

Figure 11: Investment Plan Requirements for Years 1–10, by Intervention ($, Millions)

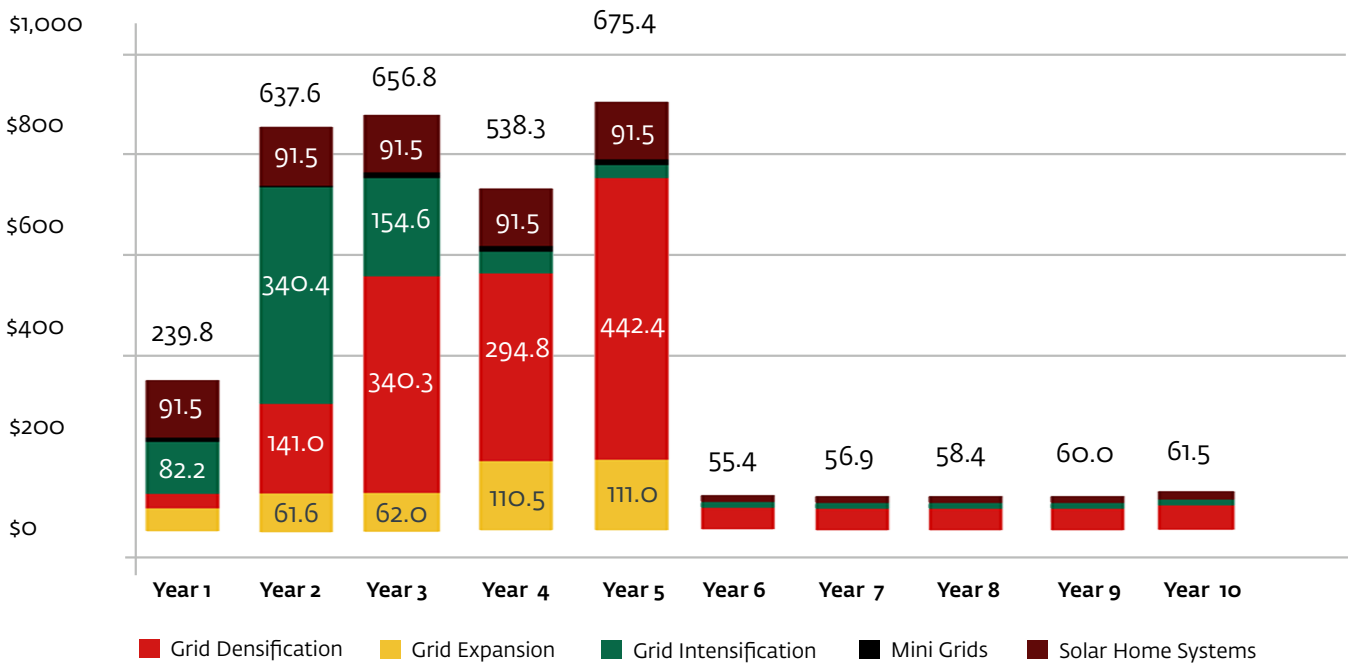
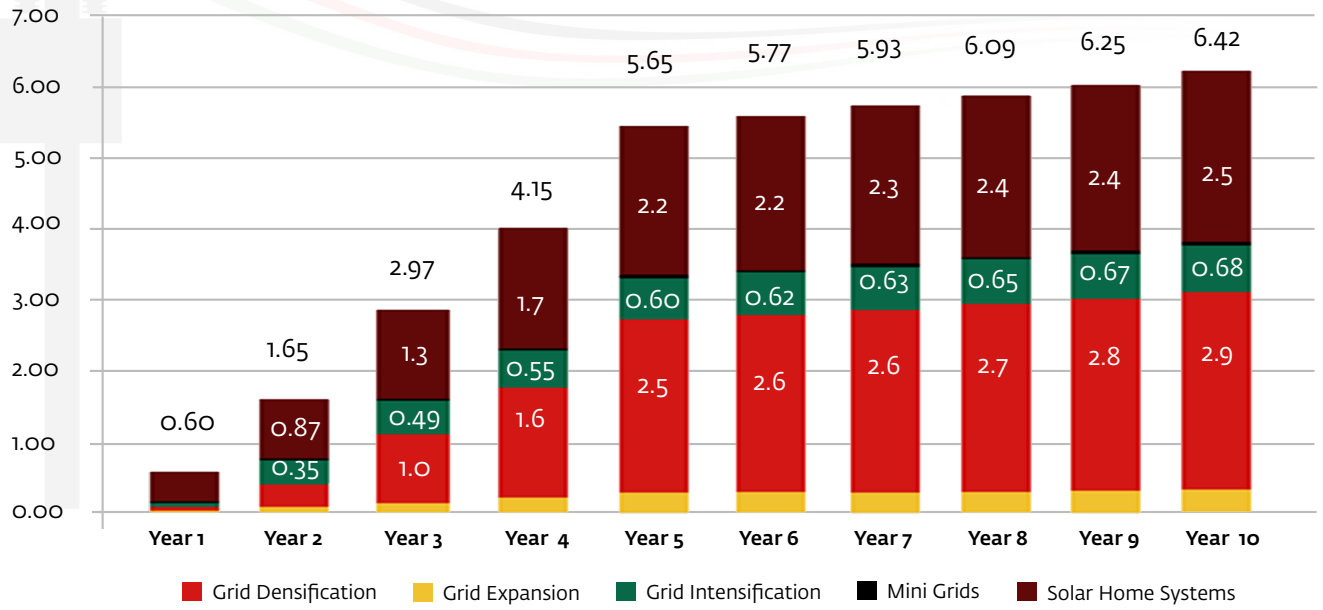


Figure 12: Cumulative Number of Connections Financed in Years 1–10, by Intervention (Millions)



4.4 CONCLUSION

The Kenya National Electrification Strategy (KNES) provides a roadmap to universal electricity access by identifying the least cost and most effective solutions for electrification coverage given available supply options and demand for energy service. The supply options considered are grid intensification and densification, grid expansion, and off-grid supply solutions (both mini-grids and standalone systems).

To reach universal electrification by 2022, public investment of $2.3 billion is required. This assumes a cost per grid connection of $1,000. At a cost per connection of up to $1,500, the investment requirement increases to $3.5 billion and decreases demand for solar photovoltaic home systems from 2.2 million to 1.2 million.[5]

Achieving universal coverage by 2022 is an ambitious goal and will require much more funding than has been pledged to date. But there is great potential, as the success of the Last Mile Connectivity Programme demonstrates significant program management capacity in the Kenya Power and Lighting Company and effective program coordination among the Ministry of Energy, the Kenya Power and Lighting Company, the Rural Electrification Authority, and stakeholders.

The KNES is particularly important to Kenya as an economy in transition. The national electrification program has the potential to transform rural areas and support Kenya's transition to a middle-income country as quickly as possible.

5 See KNES Investment Plan, Final Report 2018.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ETHIOPIA
UGANDA
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TANZANIA
INDIAN OCEAN
TURKANA
MARSABIT
MANDERA
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SAMBURU
ISIOLO
TRANS NZOIA
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