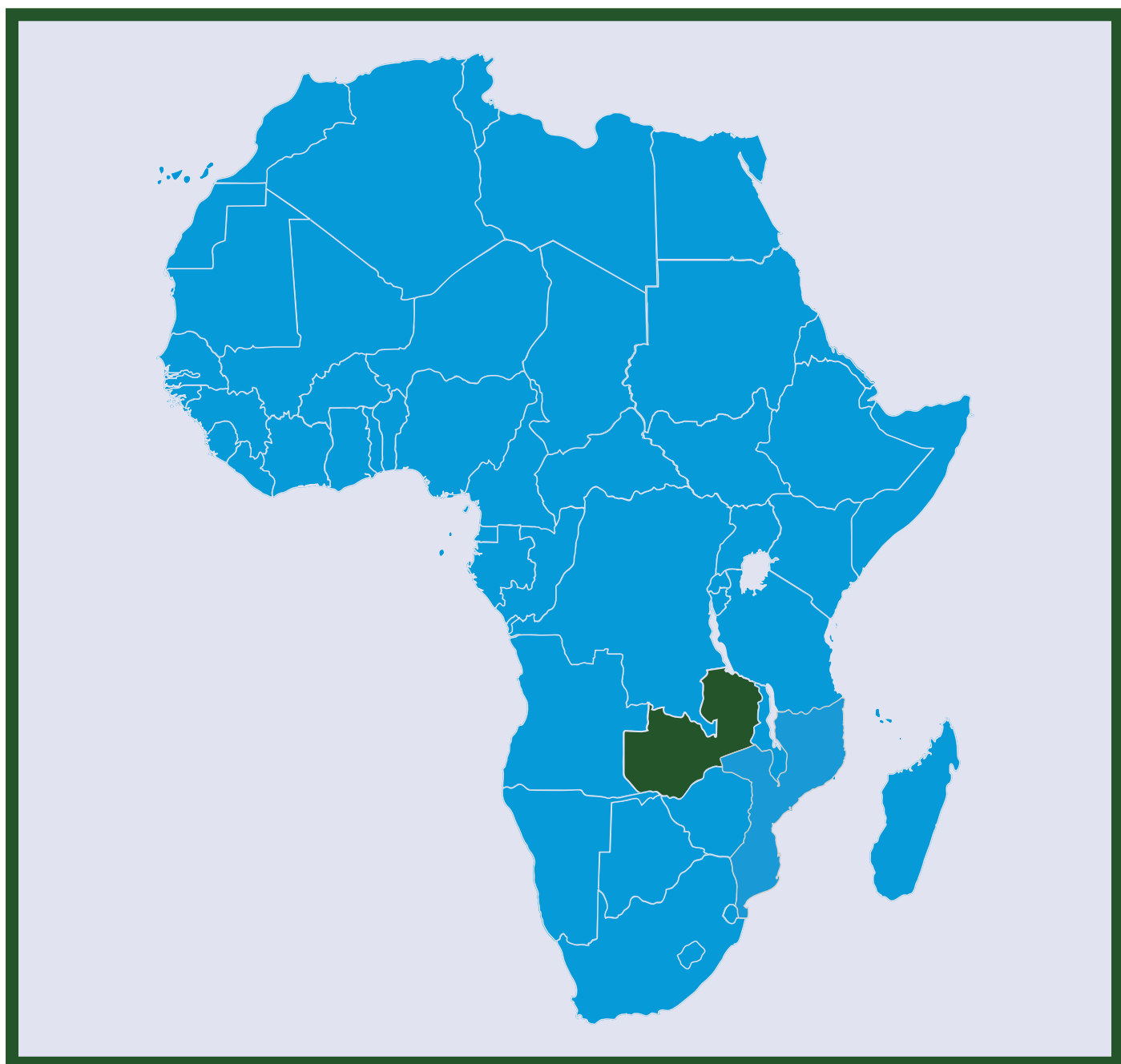


Mini-Grid Market Opportunity Assessment: Zambia

Green Mini-Grid Market Development Programme:
SE4ALL Africa Hub & African Development Bank

October 2018





The SEforAll Africa Hub has the mission to facilitate the implementation of the SEforAll initiative in Africa. It is part of a regional hubs network established with the multilateral development banks. The Africa Hub promotes African ownership, inclusiveness and a comprehensive approach to the initiative's implementation. Its main activities include provision of guidance for the SEforAll country action processes globally and in Africa, delivering of technical assistance to partner countries, networking and communication, and mobilisation of financing.



The African Development Bank has an overarching objective to spur sustainable economic development and social progress in its Regional Member Countries (RMCs), contributing to poverty reduction. The Bank Group aims to achieve this objective by mobilising and allocating resources for investment in RMCs, and providing policy advice and technical assistance to support development efforts.



The Carbon Trust wrote this report based on an impartial analysis of primary and secondary sources. The Carbon Trust's mission is to accelerate the move to a sustainable, low carbon economy. It is a world leading expert on carbon reduction and clean technology. As a not-for-dividend group, it advises governments and companies around the world, reinvesting profits into its low carbon mission.



SNV, the Netherlands Development Organisation, supported information gathering and analysis for this report. SNV's mission is to make a lasting difference in the lives of millions of people living in poverty. SNV is a leading development organisation working with local partners to find innovative solutions, empowering communities to break the cycle of poverty by guiding their own development.

The Carbon Trust would like to thank the following organisations for their interview contributions to this report: Africa-EU Renewable Energy Cooperation Programme (RECP), McKinsey & Company (of the Southern Africa Energy Programme, funded by USAID), and the World Bank (Zambia). We would also like to thank the following organisations for their publicly available literature which contributed to this report: Copperbelt Energy Corporation, Commonwealth Local Government Forum, ENEA Consulting, Energy Regulation Board, Great Lakes Africa Energy, Zambia Off-Grid Investor Forum, Office for Promoting Private Power Investment, Zambia Development Company, ZESCO Electricity Company.

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PREFACE

This paper, part of the Green Mini-Grid Market Development Programme (GMG MDP) document series, assesses the green mini-grid market in Nigeria. Green-mini grids include mini-grids powered by renewable energy resources – solar radiation, wind, hydropower or biomass – either exclusively, or in combination with diesel generation.

Mini-grids are not a new phenomenon in Africa. Almost all national utilities own and operate diesel-powered generating facilities not connected to the main grid, which supply electricity to secondary towns and larger villages. This solution to rural electrification often results in significant financial losses for the utility, needed to sell power at prices significantly below the cost of production and delivery. It also leaves the most remote towns and villages without electricity. The latest Sustainable Energy for All (SEforALL) Global Tracking Framework estimates that the urban-to-rural divide in access to electricity in Africa is as high as 450 percent, with 69 percent of the population in urban areas electrified compared to only 15 percent in rural areas.

There are three principal options for providing new connections to currently unserved populations in Africa, namely: extension of the national grid; installation of separate “mini” grids to operate independently from the main grid; and stand-alone generating systems that supply individual consumers. The most cost-effective approach for powering mini-grids is to use renewable energy sources, which are widely available across Africa.

However, the development of GMGs is not without its challenges, however. In addition to unfavourable policy and regulatory frameworks, barriers to growth of the private mini-grids sector in Africa include the lack of proven business models, market data and linkages, key stakeholder capacity, and access to finance.

In response to these challenges, the SEforALL Africa Hub at the African Development Bank (AfDB) designed and launched Phase 1 of the GMG MDP in 2015 with grant funding from the AfDB’s Sustainable Energy Fund for Africa (SEFA).¹ The GMG MDP is a pan-African platform that addresses the technical, policy, financial and market barriers confronting the emerging GMG sector. It is part of a larger Department for International Development (DFID) funded GMG Africa Programme, which also has GMG initiatives in Kenya and Tanzania; country-specific GMG policy development through SEFA; and an action learning and exchange component implemented by the World Bank’s Energy Sector Management Assistance Program (ESMAP). Phase 2 of the GMG MDP, greater in scope and scale as compared to Phase 1, was launched in November 2017.

In its Africa Energy Outlook 2014, the International Energy Agency (IEA) predicted that by 2040, 70 percent of new rural electricity supply in Africa will most affordably come from stand-alone systems and mini-grids. The GMG MDP, SEforALL, SEFA, ESMAP and similar programmes, which are contributing to falling costs, technological advances and more efficiencies in GMG development, will help ensure that up to two thirds of this supply is powered by renewables.

The goals of the GMG programme are central to AfDB’s mission of spurring sustainable economic development, social progress and poverty reduction in its regional member countries. Off-grid and mini-grid solutions are a key component of the AfDB’s New Deal on Energy for Africa, launched by the Bank’s president in January 2016. The New Deal, a transformative, partnership-driven effort, aspires to achieve universal access to energy in Africa by 2025.

This report was prepared by the Carbon Trust, and SNV at the request of the AfDB. It was written by Antoinette Gous and Kate Hooper of the Carbon Trust, and Michel Samake of SNV. Carbon Trust is a mission-driven organisation helping businesses, governments and the public sector accelerate the move to a low carbon economy. SNV is the Netherlands Development Organisation, with the mission of making a lasting difference in poverty alleviation through sustainable and locally led development.

The content of this report was reviewed by Daniel Rea on behalf of the AfDB’s GMG team and cleared by Brendan Coleman, Energy Specialist and Project Manager at the AfDB. It was edited by Ruth Lumley.

1 The SEforALL Africa Hub partnership includes the African Union Commission, the New Partnership for Africa’s Development (NEPAD), the United Nations Development Programme (UNDP), and the Regional Economic Communities (RECs), which are represented on a rotating basis. <http://www.se4all-africa.org>

Contents

PREFACE	3
EXECUTIVE SUMMARY	8
1. INTRODUCTION TO THE GREEN MINI-GRID MARKET DEVELOPMENT PROGRAMME	10
2. COUNTRY AND SECTOR OVERVIEW	11
2.1 Country Overview	11
2.2 Overview of the Energy Sector	13
2.3 Overview of the Power Sector	16
2.4 Overview of the Off-Grid sector	20
3. GREEN MINI-GRID POTENTIAL	28
3.1 Data Availability	28
3.2 Mini-Grid Potential Assessment	29
3.3 Renewable Energy Potential for Mini-Grids	32
4. DIRECTORY	34
4.1 Energy Sector Policies and Regulatory Frameworks Directory	34
4.2 Investment Incentives Directory	35
4.3 Data Sources Directory	36
4.4 Stakeholder Directory	36
BIBLIOGRAPHY	40



List of Figures

Figure 1: Population density per province across Zambia (Energy Access Africa, 2017)	11
Figure 2: Average monthly temperature and rainfall for Zambia 1991 to 2015 (World Bank, 2018)	12
Figure 3: Political Map of Zambia (Nations Online Project)	13
Figure 4: Institutional structure of Zambia's power sector (adapted from (IRENA, 2013))	14
Figure 5: National Electricity Installed Capacity by Technology in 2015 and 2016 (ERB, 2016)	15
Figure 6: Electricity access per province (Energy Access - Africa, 2017)	16
Figure 7: Current and planned grid network (Source : Carbon Trust analysis)	19
Figure 8: Map of Rural Growth Centres in Zambia, coloured by province, (REA, 2009)	21
Figure 9: Mobile subscriptions per 100 People (World Bank, 2018)	26
Figure 10: Existing electricity grid with planned network up to 2030 (dotted lines).	29
Figure 11: Regions best served by grid extension, mini-grid and standalone systems, shown with major and minor population centres. Dotted lines are planned grid extensions up to 2030 (Carbon Trust analysis)	30
Figure 12: Yearly Global Horizontal Irradiation (kWh/sq.m) 1994 to 2015 ave.	33
Figure 13: Mean wind speed at 100m height (m/s) 2015	33

List of Tables

Table 1: Installed generation capacity (MW) source (RECP, 2018)	17
Table 2: Zambian tariff schedule September 2017 (ERB, 2017)	20
Table 3: Population, Population Density, and Electrification by Province (Worldpop, 2015)	29
Table 4: Estimated household market size for off-grid solutions (analysis using existing network)	31
Table 5: Estimated household market size for off-grid solutions (analysis using planned network up to 2030)	31

LIST OF ACRONYMS

AEEP	Africa-EU Energy Partnership
AECF	Africa Enterprise Challenge Fund
AfDB	African Development Bank
CAPEX	Capital expenditure
CEEEZ	Centre for Energy, Environment, and Engineering
DBZ	Development Bank of Zambia
EIA	Environmental Impact Assessment
ERB	Energy Regulation Board
ESMAP	Energy Sector Management Assistance Program
EUEI PDF	European Union Energy Initiative Partnership Dialogue Facility
GIS	Geographic Information System
HEP	Hydro Electric Power (Limited)
HV	High Voltage
IAAZ	Impact Assessment Association of Zambia
LV	Low Voltage
MDP	Market Development Programme
MT	Metric tons
MV	Medium Voltage
NAMA	Nationally Appropriate Mitigation Action
NDCs	Nationally Determined Contributions
NEP	National Electrification Plan
NES	National Electrification Strategy
OPEX	Operational expenditure
OPPI	Office for Promoting Private Power Investment
PPA	Power purchase agreement
PPP	Private public partnership
PV	Photovoltaic
REA	Rural Electrification Authority
RECP	Africa-EU Renewable Energy Cooperation Programme
REF	Rural Electrification Fund
REFIT	Renewable Energy Feed-in Tariff

REMP	Rural Electrification Master Plan
RGC	Rural Growth Centre
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SE4ALL	Sustainable Energy for All
SE4ALL AA	Sustainable Energy for All Action Agenda
SEFA	Sustainable Energy Fund for Africa
SNV	Netherlands Development Organisation
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNZA	University of Zambia
USAID	United States Agency for International Development
ZABS	Zambia Bureau of Standards
ZAMSIF	Zambia Social Investment Fund
ZANACO	Zambia National Commercial Bank
ZARENA	Zambian Renewable Energy Agency
ZEMA	Zambia Environmental Management Authority
ZESCO	Zambia Electricity Supply Corporation
ZMW	Zambian Kwacha
ZPC	Zengamina Power Company
ZPPA	Zambia Public Procurement Authority
ZRA	Zambia Revenue Authority

EXECUTIVE SUMMARY

This country report is one of a series of country reports under the Market Intelligence business line of the African Development Bank's Green Mini-Grid Market Development Programme (GMG MDP). The MDP has the ultimate objective of fostering access to electricity across Africa by promoting the development of green mini-grids where they represent a technically and economically better option than the extension of the main grid. The Market Intelligence business line aims to provide comparable, actionable data on the potential for GMGs across countries in Sub-Saharan Africa (SSA). This report provides an analysis for Zambia. Previous country reports can be downloaded from the GMG Help Desk (<http://greenminigrid.se4all-africa.org>).

This report's methodology combines a high-level opportunity assessment with practical knowledge and information targeted at mini-grid practitioners. Information provided covers key stakeholders, raw data on physical and non-physical factors, a policy and regulatory analysis. Assessing the potential for mini-grids is challenging as such analysis requires plenty of data and assumptions. A thorough assessment must include several criteria that are driven by the particular business model and approach of the implementing agency for each case. This report therefore aims to capture available data and highlight general assessments that would be relevant to most mini-grid stakeholders. Raw data is provided with this report so stakeholders may further conduct their own specific analysis.

Zambia has a population of approximately 17 million people, the majority of whom (58%) live in rural areas. Zambia has a relatively low population density when compared with other East African countries, 23 people per square kilometre. The population has been growing at a steady rate of around 3% annually and by 2030 the population is expected to grow to more than 24.8 million people. According to the World Bank, 57.5% of the population were living on less than \$1.90 per day in 2015. The country was ranked 143rd in the Human Development Index in 2018 out of 189 countries, down from 139th in 2016.

Zambia's economy is the third largest in Southern Africa, after South Africa and Angola, with a GDP of \$25.8 billion and GDP per capita of \$1,510. After a number of years of high economic growth, Zambia experienced a slow-down in 2015 and 2016, due in large part to droughts, affecting crop yields and straining electricity supply (the country is highly dependent on hydropower). The largest consumer of electricity, the mining sector, on which Zambia's economy depends, was significantly affected. Since energy is a critical driving force behind the economy and development in Zambia, the Government committed to developing and improving energy infrastructure. In 2016, the Government set out its plan to diversify the economy and its energy mix to accelerate the country's development. Annual growth in GDP improved in 2017 and is expected to increase to around 4% in 2018. Politically stable, Zambia has sound democratic structures, independent judiciary, and many free and fair elections, offering an attractive investment environment. Zambia has strong foreign investment at 3.36% of GDP in 2016.

There are three key government agencies below the Ministry of Energy that play a role in the energy sector in Zambia. The Energy Regulatory Board (ERB) regulates licensing, sets standards and develops technical standards. The Office for Promoting Private Power Investment (OPPI) is responsible for promoting private investments in the electricity generation and transmission sector (mainly above 10MW) by reducing the complexity of procedures, rules and regulations, and red tape usually associated with obtaining the required approvals, permits or licences. The Rural Electrification Authority has the mandate to increase rural electrification rates through the development of electricity infrastructure and implementation of the Rural Electrification Plan. They also manage the Rural Electrification Fund.

Access to electricity is low in Zambia, with 31% of the population being electrified. There is a stark difference between electrification rates, and the progress being made between urban and rural areas. Urban populations are 67% electrified, and improving year on year, while rural populations are around 4% electrified, with little improvement in the last few years.

The National Energy Policy sets out the Government's intended actions in the energy sector, providing the vision and guiding principles, policy measures and strategies. The policy enabled an opening up in the market to private sector operators and paved the way for the Energy Regulation Board's (ERB) establishment, as well as the Office for Promoting Private Power Investment (OPPP). Overall the framework for the energy sector is positive and the Government is taking positive steps to develop the sector.

The Rural Electrification Master Plan of 2009 sets a target of 51% of the rural population being electrified by 2030. The plan guides planning and implementation to achieve 51% rural electrification by 2030 through the electrification of Rural Growth Centres (RGC), through either solar home systems, mini-grids or connection to the grid. A number of shortcomings of the report have been identified, including the strong focus on-grid connection despite it not being the most cost-effective solution, the lack of planning for non-RGC areas, and its need to be updated (published in 2009, it uses much data from 2006 which may no longer be accurate).

Zambia had 2,800MW of installed electricity generation capacity in 2016, nearly 2,400MW of which are from hydropower. Zambia's hydroelectric potential is 6,000MW, and numerous generation units are being planned. Opportunities for small hydropower in the northern provinces are particularly good, where much of the population remains unelectrified. Government intends to diversify the energy mix with solar, coal and biomass after little rain and low dam levels have significantly reduced electricity output.

Mini-grids of all sizes and technologies require a licence that will be approved by ERB. The procedures to obtain a licence for energy activities is set out in the Energy Regulation (Licensing) Regulations SI No.2 of 1998 and must be read together with the Energy Regulation Act Cap 436 of 2003. Once an application is assessed, an application fee of 0.1% of the cost of investment is payable. Upon being licensed, the licensee is also required to pay monthly licence fees of 0.7% of the monthly turnover of the business. Applicants for solar energy projects are exempted from the monthly licence fees.

The analysis estimates a total annual revenue market size of \$14.7 million, based on allowable tariffs of \$0.04/kWh. It is unclear whether higher tariffs are politically feasible in Zambia, given on-grid tariffs that have historically been very low. Existing mini-grids report significantly differing tariff regimes; this is therefore a conservative estimate. Fifty six percent of the mini-grid market is found in the Northern and Eastern Provinces due to their low electrification rates, limited grid coverage and population densities high enough to support mini-grids. The highest-potential province for mini-grid solutions is the Eastern Province, with an estimated market size of \$6.25 million and 210,834 people most economically served through mini-grids.

When considering planned grid extension up to 2030, this drops to a total market of \$12.1 million, a 17% reduction compared to the market for mini-grids under the current grid. Again, this is a conservative estimate. The largest market reduction when including these extensions is in the Eastern Province. This is due to grid extensions being more likely to occur in areas with higher population densities. The largest market remains in the Eastern Province at \$3.9 million.

1. INTRODUCTION TO THE GREEN MINI-GRID MARKET DEVELOPMENT PROGRAMME

The African Development Bank's (AfDB) Green Mini-Grids Market Development Programme (GMG MDP) aims to foster access to electricity across Africa. The MDP provides assistance to a range of stakeholders in overcoming the challenges for widespread and sustainable implementation of Green Mini-Grid (GMG) projects, by:

- Establishing a comparable, actionable understanding of the GMG market opportunity in Sub-Saharan Africa (SSA);
- Promoting the linkages between communities, public institutions, developers, financiers, and technology providers needed for successful mini-grid development;
- Strengthening capacity of developers to develop and operationalise GMG business models;
- Promoting a sound policy and regulatory environment; and
- Engaging project financiers and supporting the development of suitable financial solutions.

This country report is one of a series of country reports of the MDP's Market Intelligence business line, each of which provides an analysis of the GMG potential per country. These reports provide comparable, actionable data on the GMG potential across countries in SSA. GMG Opportunity Assessments for other countries can be downloaded from the GMG Help Desk (<http://greenminigrid.se4all-africa.org>).

The Market Development Programme is implemented by the Sustainable Energy for All (SEforALL) Africa Hub, through a grant of the Sustainable Energy Fund for Africa (SEFA). The SEforALL Africa Hub, hosted by the AfDB, is a partnership of African institutions dedicated to support the continent's progress towards the SEforALL initiative's three main objectives on energy access, renewable energies and energy efficiency.

The development of clean energy mini-grids is also the primary objective of the Mini-Grid Partnership for which the Bank is playing a lead role for Africa. The partnership will galvanize action on the barriers facing the sector, with the engagement of public, private and civil society expertise and resources. The Mini-Grid Partnership (formerly the Clean Mini-Grids HIO), including the co-ordination group, secretariat and wider membership, is the established forum for discussion and co-ordination of the efforts of development partners to advance the adoption of GMGs. The MDP was designed from the beginning to be integrated and closely co-ordinated with the activities carried out in the framework of the Partnership.

2. COUNTRY AND SECTOR OVERVIEW

2.1 COUNTRY OVERVIEW

Zambia has a population of approximately 17 million people, the majority of whom (58%) live in rural areas. Zambia has a relatively low population density when compared with other East African countries, of 23 people per square kilometre. The population has been growing at a steady rate of around 3% annually (World Bank, 2018) and by 2030, the population is expected to grow to more than 24.8 million people. According to the World Bank, 57.5% of the population were living on less than \$1.90 per day in 2015 (World Bank, 2018). The country was ranked 143rd out of 189 countries in the Human Development Index in 2018, down from 139th in 2016 (UNDP, 2018).

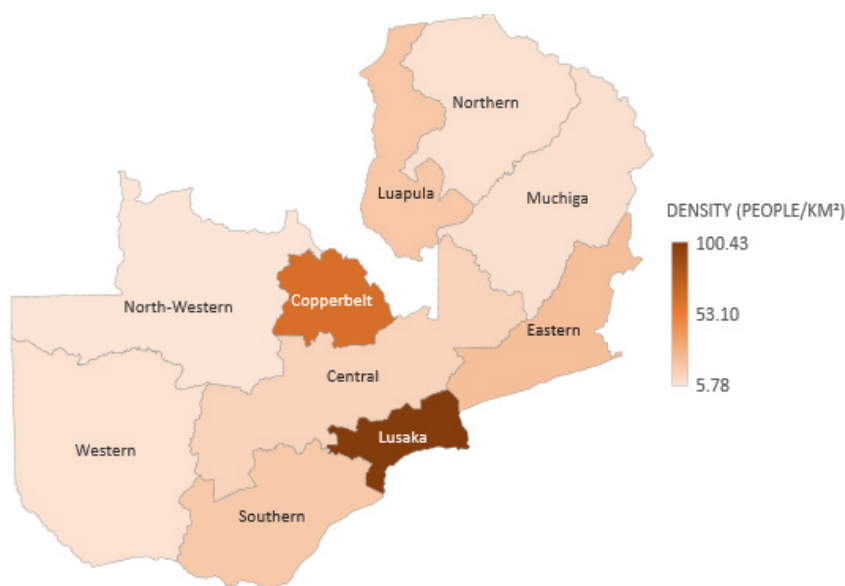


Figure 1: Population density per province across Zambia (Energy Access Africa, 2017)

Zambia is a landlocked country with a landmass of 743,390km² and has a humid sub-tropical climate. Zambia is bordered by the Democratic Republic of Congo to the north, Angola to the west, Tanzania and Malawi to the east, and Mozambique, Zimbabwe, Botswana and Namibia to the south. Although located in the tropics, Zambia's climate is modified by elevation. The terrain of Zambia is mostly high plateau, with some hills and mountains. Zambia's vegetation is made up of savannah woodlands and grasslands (CSO, 2010). It has three seasons, cold and dry (May to August), hot and dry (September to November) and hot and wet (December to April). Annual temperature variations are the greatest in the southern parts of the country, and smallest in the northern parts that are located closer to the equator. Rainfall in the northern parts of the country is 1250mm per year and decreases towards the southern parts of the country, where it is 750mm per year (Zambia Tourism, 2018). Average Global Horizontal Irradiance (GHI) in Zambia is around 2,100 kWh/m² (which is comparable to other very high yield sites around the world) (ESMAP, 2018).

Zambia is increasingly vulnerable to climate change, particularly droughts; the country has experienced an increase in the frequency and the intensity of drought events in recent years. Most notably, erratic rainfalls in 2015 and 2016 had a marked impact on the country's economy with both agricultural yields down, and the mining industry impacted by electricity shortfalls as the country is largely dependent on hydropower. Population health is also vulnerable: malaria may become more prevalent in certain areas, and increased flooding because of erratic rain can cause health and sanitation problems, in addition to malnutrition issues from lower agricultural yield (USAID, 2013).

Zambia has a relatively well connected road network. Zambia's primary and secondary road networks provide basic regional and national connectivity, despite low road density, and most of the roads are paved and in good condition. Rural roads in the outlying areas, however, tend to be in poorer conditions (Foster & Dominquez, 2010). The Government of Zambia recently launched the Link Zambia 8000 programme, aimed at rehabilitating and constructing roads to allow more efficient travelling, as well as linking international highways with neighbouring countries through the building of 8,000km of new roads (ZDA, 2018).

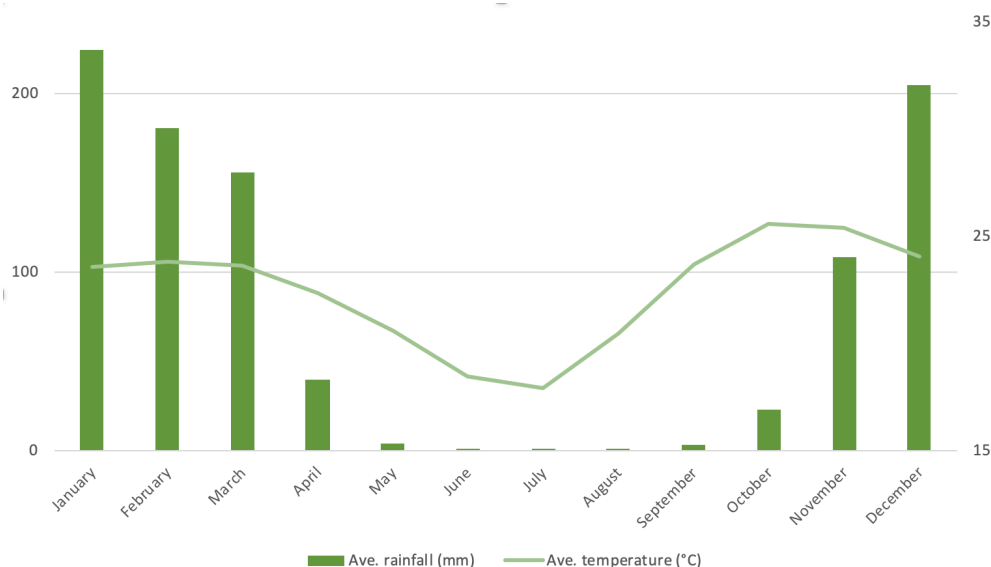


Figure 2: Average monthly temperature and rainfall for Zambia 1991 to 2015 (World Bank, 2018)

Zambia's telecommunication network provides relatively good coverage in areas that are densely populated. Telecommunication coverage is mainly in populated urban centres, along main road networks and selected rural areas, with national network coverage being 78% of the country's area, and 93% of the population (ZICTA, 2017).

Officially named the Republic of Zambia, the country is a presidential republic administratively divided into 10 provinces. These are Central, Copperbelt, Eastern, Luapula, Lusaka, Muchinga, Northern, North Western, Southern and Western provinces, each headed by a permanent secretary appointed by the president. Provinces are further divided into districts. Zambia has a multi-party democracy with distinct separation of powers between the three branches of government; the Legislature (Parliament), Executive (the President, Vice-President and Cabinet) and Judiciary (Courts of Law). The president is elected by the people during national elections that are held every five years and is limited to a maximum of two five-year terms. The next presidential election will be held in 2021 (ZDA, 2015). For much of Zambia's post-colonial history, the country has been politically stable, though a closely contested presidential race in 2016 saw President Lungu's main rival detained in 2017 and then released some months later owing to international pressure (World Bank, 2018).

Zambia's economy has been growing on average by 7.3% annually between 2000 and 2017, upgrading it to a Lower Middle Income Country in 2011 (World Health Organisation, 2016). However, growth has slowed in recent years, and public debt has risen as borrowings increased to such an extent that the country has been classified to be at a high risk of debt distress. Falling copper prices (the country is Africa's second-biggest producer), drought and depreciation of the local currency have contributed to a worsening financial situation (Index Mundi, 2018). This has been closely linked with the problems of the energy sector, with the drought severely reducing electricity generation; Zambia is dependent on hydropower for electricity generation (Rasmussen, 2018). As a consequence, inflation rates increased to more 20% in 2016. Growth has been recovering: at 4% in 2017, this is up from 2.9% and 3.4% in 2015 and 2016, respectively, much of which was attributed to a good rainfall in 2017 resulting in a bumper crop harvest and improved electricity supply (World Bank, 2018). The economy remains vulnerable to future fluctuations in copper prices and drought and has a big challenge managing rising external debt levels (World Bank, 2018). The country is rated BB by the Standards and Poors, but the economic outlook was revised in 2017 from negative to "positive with a stable outlook" (IMF, 2017).

In an effort to improve the economic environment, the Government launched the **7th National Development Plan 2017 to 2021**. Following the election in 2016, President Lungu called for a national transformation to address the country's high levels of poverty and a fundamental shift in the way resources were allocated. The National Development Plan presented the Government's strategic goal to create a diversified and resilient economy, focusing on economic diversification and job creation, poverty and vulnerability reduction, reduced developmental inequalities, enhancing human development, and a conducive governance environment for economic diversification (Ministry of National Development Planning, 2017). The GDP growth outlook is positive, expected to strengthen to about 4% in 2018 (World Bank, 2018).

Zambia's economic activity is concentrated in the corridor running from Lusaka to the Copperbelt. The services sector comprises 59% of GDP and includes government activities, communications, transportation and financial services. Industry comprises 35% of GDP and includes mining (the largest consumer of electricity), manufacturing, energy production and construction (Rasmussen, 2018).



Figure 3: Political Map of Zambia (Nations Online Project)

2.2 OVERVIEW OF THE ENERGY SECTOR

2.2.1 GOVERNMENT STRUCTURE AND AGENCIES

The Ministry of Energy is the overarching regulating authority responsible for the energy sector in Zambia. Its portfolio functions encompass energy policy, electricity, as well as biofuels, renewable and alternative sources of energy. As the overarching regulating authority, it is responsible for carrying out energy planning, formulation and implementation of national energy policies, strategies and plans, and the development of new energy programmes (RECP, 2018).

Other key organisations that make up the institutional structure of the energy sector in Zambia include:

- **The Energy Regulation Board (ERB)** which was established under the Energy Regulation Act in 1996 and is responsible for the licensing of Independent Power Producers (IPPs), setting electricity tariffs and the development of technical standards. (Mudenda, et al., 2013). In January 2017, the ERB began regulating the import of solar components (RECP, 2018).
- **The Office for Promoting Private Power Investment (OPPPI)**, established in 1999 and responsible for promoting private investments in the electricity generation and transmission sector by reducing the complexity of procedures, rules and regulations, and red tape usually associated with obtaining the required approvals, permits or licences (OPPPI, 2018). OPPPI deals primarily with projects that are 10MW and above (Bowa, et al., 2017).

- **Rural Electrification Authority (REA)**, which was established by the Rural Electrification Act of 2003. REA's mandate is to increase rural electrification rates through the development of electricity infrastructure, and manages the Rural Electrification Fund. The REA is responsible for the development, implementation and revision of the Rural Electrification Master Plan (REMP) (REA, 2017).
- **Zambia Electricity Supply Corporation (ZESCO)** is the state-owned vertically integrated utility company, established in 1970. It is responsible for generation, transmission and distribution of electricity (ZESCO, 2018).

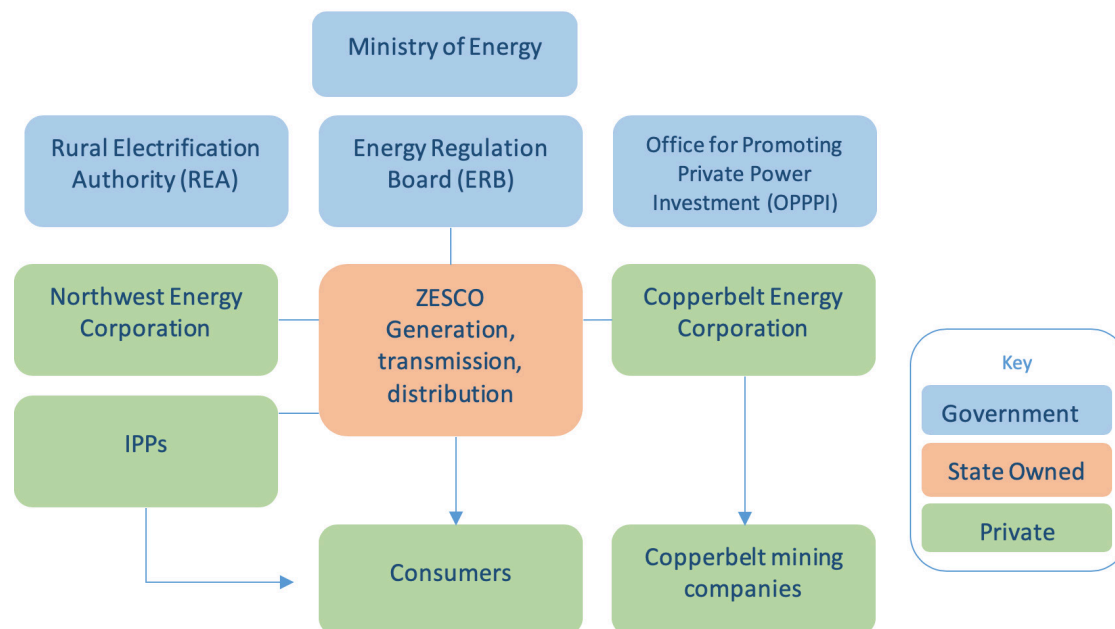


Figure 4: Institutional structure of Zambia's power sector (adapted from (IRENA, 2013))

2.2.2 ENERGY MIX, EMISSIONS AND TRENDS

Zambia's primary energy supply is dominated by biofuels at 8,826ktoe or nearly 80% of production (IEA, 2018). Zambia is nearly self-sufficient in energy, importing only oil and petroleum (World Bank, 2018). Seventy four percent of cooking energy is from biomass, compared with 16% from electricity. Woodfuel use is increasing with a growing population and is one of the key drivers in deforestation in the country (Ng'andwe, 2015).

The average electric power consumption per capita was 707kWh in 2014, higher than the sub-Saharan average of 484kWh and neighbouring countries such as Zimbabwe, Mozambique, Angola and Tanzania (World Bank, 2018). This is mostly attributable to a strong mining sector. Electricity consumption on the whole was around 11.2TWh in 2016, which decreased from a high of 11.8TWh in early 2015. Despite the dip in 2015/16, consumption has increased significantly from a low of 7.5TWh in 2009 (IEA, 2018). The mining industry accounts for nearly 70% of the country's demand, benefiting from subsidised electricity tariffs (RECP, 2018). Electricity demand has been estimated to be growing between 150MW and 200MW, or around 3%, annually (ZDA, 2014).

CO₂ emissions in Zambia have nearly tripled since the mid-2000s, from 1.3Mt of CO₂ to 3.6Mt of CO₂ in 2016 (IEA, 2018), still only representing around 0.01% of global annual emissions. The energy sector is the second largest contributor to emissions in Zambia, although the primary source of emissions, forestry and land-use change is a significantly greater contributor, accounting for 86% of emissions in 2014 (WRI, 2018).

Government aims to diversify Zambia's electricity sector that is largely dependent on hydropower. Zambia had approximately 2,800MW of installed electricity generation capacity in 2016, of which nearly 2,400MW is from hydropower (Power Africa, 2017)). National electricity generation was reduced by 13% from 13,400GWh to 11,696GWh owing to poor

rainfall and consequently low dam levels in 2015 and 2016 (ERB, 2016). The erratic rains in the past few years coupled with increasing demand has prompted the Government to move towards diversifying the energy mix with solar, biomass and coal, and investigate the possibilities of wind, nuclear and geothermal energy. Hydropower's contribution to the country's energy mix has decreased in the last three years with other energy sources being connected to the grid, namely coal fired power plants (see Figure 5). This notably includes the 300MW Maamba coal-fired power plant (RECP, 2018). A second 340MW coal-fired plant is planned to come online in 2019, developed by ZEMCO (ZDA, 2017).

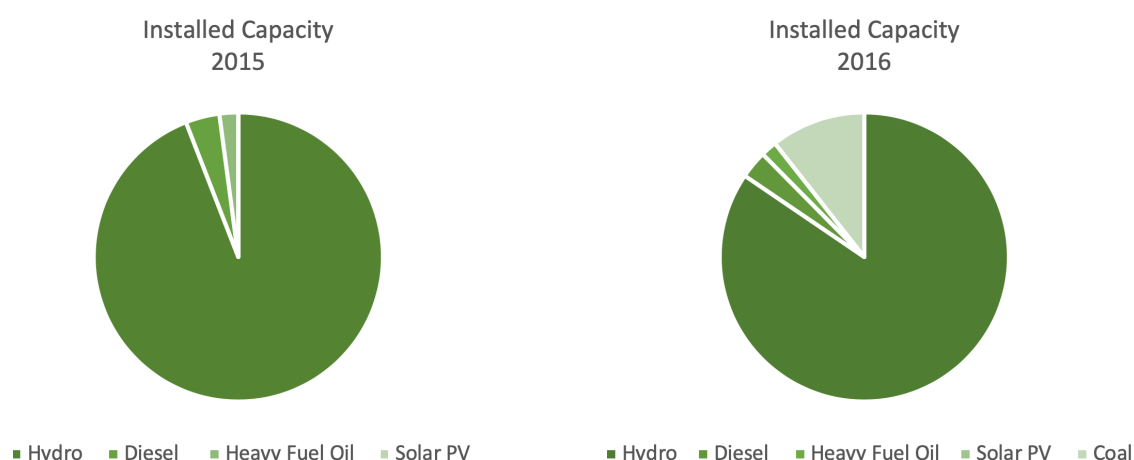


Figure 5: National Electricity Installed Capacity by Technology in 2015 and 2016 (ERB, 2016)

2.2.3 GOVERNMENT ENERGY POLICIES, STRATEGIES, TARGETS, ROADMAPS, PLANS AND PROGRAMMES

There are clear priorities in Zambia to diversify the energy mix and increase access to energy. The country's Vision 2030, the 7th National Development Plan and the National Energy Policy, all recognise the need to diversify electricity generation and enhance access. Overall, the framework for the energy sector is positive and the Government is taking positive steps to further develop the energy sector.

The National Energy Policy (revised in 2008) sets out Government's intended actions in the energy sector, providing the vision and guiding principles, policy measures and strategies. The policy enabled the opening up of the market to private sector operators and paved the way for the Energy Regulation Board's (ERB) establishment, as well as the Office for Promoting Private Power Investment (OPPI).

Vision 2030 provides the vision for the energy sector to achieve 'Universal access to clean, reliable and affordable energy at the lowest total economic, financial, social and environmental cost consistent with national development goals by 2030'. This is further broken down into four goals:

1. Abundant and reliable supply of affordable energy to both urban and rural areas;
2. Increased renewable alternative sources of energy;
3. Export led energy industry; and
4. Reduce the share of wood fuel to 40% by 2030.

Universal access to energy should not be made synonymous with universal electricity access in this case. Vision 2030 is operationalised by five-year national development plans. The 7th National Development Plan will take effect for the five-year period of 2017 to 2021. The 7th National Development Plan sets at a high-level the goal to improve access to electricity in rural and peri-urban areas as a strategy, but does provide further detail such as electrification targets or detailed plans.

The National Electrification Strategy (NES) and Rural Electrification Master Plan (REMP) provide specific electrification targets and the detailed roadmaps to achieve electrification targets. The REMP sets electrification targets for 2030 at a national level at 66%, 90% in urban areas and 51% in rural areas. Both the NES and REMP are discussed in more detail in section 2.4.

Zambia's mitigation programmes, as part of their NDC, support the use of green mini-grids to achieve NDC goals. The implementation of Zambia's Nationally Determined Contribution (NDC) programmes aims to achieve a reduction of between 20,000GgCO₂e and 38,000GgCO₂e or 25% and 47% reduction against 2010 baseline conditions, dependent on international finance support. Zambia's mitigation programmes cover Sustainable Forest Management, Sustainable Agriculture and Renewable Energy and Energy Efficiency. The objective of the Renewable Energy and Energy Efficiency programme is to promote switching from conventional and traditional energy sources to sustainable and renewable.

The EU, SIDA and the World Bank, are currently supporting the Government to improve the enabling environment for private sector investment in renewables. The EU is providing technical assistance support to the Government to enhance policies, and the legal and regulatory framework around rural electrification, with the aim of supporting market entry for private sector players. The EU is also working with the Government around tariffs, and tariff settings. Sida is working to develop a collaborative market platform involving a broad range of stakeholders to support information sharing on the off-grid market (RECP, 2018).

2.3 OVERVIEW OF THE POWER SECTOR

2.3.1 CONTEXT

Zambia has low rates of electricity access nationally, and there is a stark difference between urban and rural areas. The most recent estimates of the percentage of the urban and peri-urban populations with electricity access is 67%, while those in rural areas only have a 4% access rate. The national electrification rate is estimated at 27% (CSO, 2015). Access to electricity is highest in the Copperbelt and Lusaka provinces and decreases in provinces located further away from the central economic corridor and main roads (Figure 6) (CSO, 2015). Whilst overall electricity access rates have slowly been increasing, rural electrification rates have stagnated (World Bank, 2017). According to the Living Conditions Monitoring Survey Report published in 2015 by the Central Statistics Office, flashlights are still the primary source of lighting for almost half of all households nationally, or more than 70% of households in rural areas. Solar PV is the main source of lighting for less than 5% of households, most of which are located in the Eastern Province (CSO, 2015).

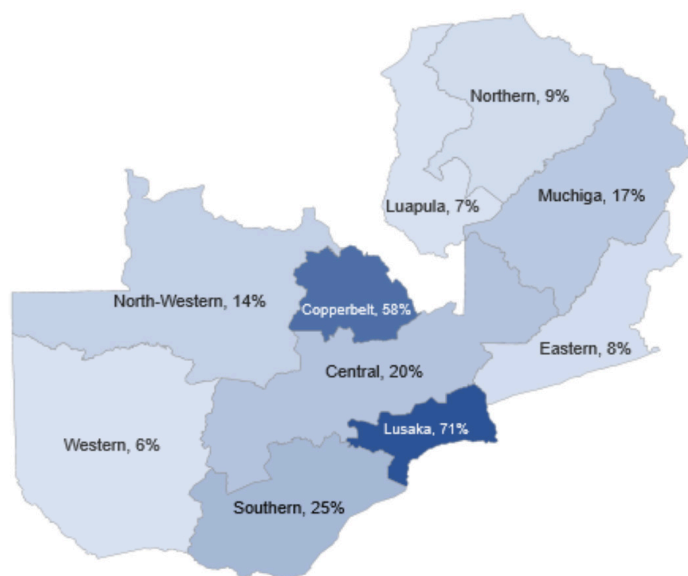


Figure 6: Electricity access per province (Energy Access - Africa, 2017)

Zambia has a regulated and liberalised power sector that is open to IPPs for the generation and transmission of electricity. The power sector was liberalised in 1995 to allow the private sector to participate in the generation, transmission and distribution of electricity. OPPPI, along with ERB was established to promote private sector involvement. The vertically integrated utility company, ZESCO, is regulated by the Ministry of Mines, Energy and Water Development, the Rural Electrification Authority and the Energy Regulatory Board. The Government of Zambia is the sole shareholder in ZESCO (ZESCO, 2015). The Copperbelt Energy Corporation (CEC) is a private company that buys almost 50% of the electricity generated by ZESCO and distributes and sells it to the copper mines. CEC also has 80MW of its own generation power on standby (CEC). Zambia is a member of the Southern African Power Pool and operates within international operating guidelines (Mudenda, et al., 2013)

2.3.2 GENERATION

Power supply is largely centralised and state owned. The state-owned utility, ZESCO operates the national grid, and is responsible for the generation of much of the electricity supplied in Zambia. Although there has been an opening up of the market to Independent Power Producers since regulations allowed IPPs to feed electricity into the grid in the 1995, only four IPPs did so. They collectively contribute to 7% of installed capacity (RECP, 2018).

Zambia has a total installed capacity of approximately 2,848MW. ZESCO owns the majority of the generation stations and has an approximate installed capacity of 2,363MW. More than 50% of electricity generated through ZESCO is purchased by the Copperbelt Energy Company, which organises the distribution of electricity to copper mines. Zambia's electricity mix is primarily made up of hydro generation accounting for approximately 83% of installed capacity in the country (RECP, 2018). Noteworthy Independent Power Producers (IPP) are Lunsemfwa Hydro Power Company (56MW), Copperbelt Energy Company (CEC) (80MW), Ndola Energy (105MW) (HFO) (GL Africa Energy, 2017) and Maamba Collieries (300MW) (Coal-fired) (GL Africa Energy, 2017) .

Zambia has several future generation projects planned. Large-scale hydro projects to be completed in the next four years include a 40MW hydropower plant (HPP) at Kabompo Gorge, a 750MW HPP at Lower Kafue Gorge (both to be completed in 2019), a 250MW project on the Kalungwishi river in Luapula province, a 80MW project at Ngonye falls and a 2,400MW project at Batoka Gorge (shared between Zimbabwe and Zambia) (ZESCO, 2018).

Table 1: Installed generation capacity (MW) source (RECP, 2018)

Power Station	Owner	Installed Capacity (MW)	Type
Kafue Gorge	ZESCO	990	Hydro
Kariba North Bank	ZESCO	1,050	Hydro
Itezhi-Tezhi	ZESCO and Itezhi Tezhi Power Corporation	120	Hydro
Victoria Falls	ZESCO	108	Hydro
Lunzua	ZESCO	15	Hydro
Lusiwasi	ZESCO	12	Hydro
Chisimba Falls	ZESCO	6	Hydro
Musonda Falls	ZESCO	5	Hydro
Shiwa Ng'andu	ZESCO	1	Hydro
Lunsemfwa	Lunsemfwa Hydro Power Ltd.	31	Hydro
Mulungushi	Lunsemfwa Hydro Power Ltd.	25	Hydro
Gas Turbine (Standby)	CEC	80	Gas
Ndola Energy Heavy Fuel Oil (HFO)	Ndola Energy	105	HFO
Maamba Thermal Power Plant	Maamba Collieries Limited	300	Coal
TOTAL		2,848	

Zambia faces an ongoing power deficit owing to climate variability of the hydropower resources it relies upon and lack of planning for future electricity demand. Zambia has struggled since mid-2015 to meet increasing electricity demand, attributed to heavy reliance on hydropower with droughts during 2015 and 2016, reducing the country's electricity capacity to half of peak demand, with lack of planning to construct new power plants. Output for the sector is estimated

at less than one third of installed capacity (RECP, 2018). Demand has been growing at an average rate of 3% annually (or between 150MW and 200MW), largely driven by the mining sector, consuming approximately 53% of the country's power supply (ZDA, 2014). Peak demand is projected at 3,000MW by 2020 and 3,525MW by 2030 (Ministry of National Development and Planning, 2017). The power crises of 2015 to 2016 prompted the Government to fill the gap in the short term through electricity imports from South Africa's Eskom (Eskom, 2015) and to invest in coal-fired power plants (RECP, 2018).

Efforts to increase the share of solar within the generation capacity have ramped up in recent years by launching programmes such as GET-FiT and IFC's Scaling Solar. The Global Energy Transfer Feed-in-Tariff (GET-FiT) programme aims to fast-track the generation of smaller projects and bring 200MW of renewable energy onto the grid within the next three to five years. This includes 100MW of solar PV in the first round of tenders, expected to be concluded in early 2019 (GET-FiT Zambia, 2018). Through round one of the Scaling Solar initiative, a 54MW and 34MW solar PV plant is planned to be built in the Kafue District (Neoen, 2017) (ESMAP, 2018). In round two of the programme, Zambia's Industrial Development Corporation (IDC) recently signed an agreement with the IFC to develop 500MW of solar energy (Scaling Solar, 2018).

Other renewable energy technologies that may hold energy generation potential but require additional research and feasibility assessments are wind and geothermal energy. Wind power remains a relatively unexploited resource with moderate potential in Zambia. Feasibility studies are being performed to develop Zambia's first windfarm to the size of 130MW (Access-Power, 2018). Historic studies have identified that Zambia has more than 80 geothermal sources, of which 35 are viable (Kachapulula-Mudenda, et al, 2018). The Zambian geothermal development company, Kalahari GeoEnergy, received a grant from the US Trade and Development Agency in 2017 to perform feasibility studies for the development of a geothermal power plant. Historically, two x 100kW geothermal generators were installed in Kapisya at Lake Tanganyika, but are currently dormant (Think Geoenergy, 2017).

2.3.3 TRANSMISSION AND DISTRIBUTION

Limited investment in infrastructure has resulted in deficiencies in transmission and distribution assets. No new power plants were built between 1977 and 2014, transmission infrastructure is limited and the network is aged with obsolete equipment. ZESCO had limited ability to support the development of the national grid, maintain its assets and invest in new generation capacity due to highly subsidised and unreflective cost tariffs (RECP, 2018). Zambia's quality of electricity supply is also low. Zambia was ranked 121st of 137 countries for quality of electricity supply in the World Economic Forum's 2017/18 Global Competitive Index (Schwab, 2018). This has been attributed to regular power failures (apart from load shedding due to the droughts in 2015/16) and fluctuations in voltage (Mudenda, et al., 2013).

ZESCO operates and maintains a high and low voltage distribution system. Voltage lines range from 11kV to 330kV with a large concentration of high voltage lines running along the economic corridor between Lusaka and Copperbelt provinces. ZESCO's transmission grid is made up of 330kV (2,241km), 220kV (571km), 132kV(202km), 88kV (734km) and 66kV (1,037km) as well as 33kV and 11kV voltage lines. The backbone of the grid is built on 330kV transmission lines that run from the southern part of the country where the major generating stations are, through Lusaka and Central provinces to the Copperbelt Province, where the mines are located Figure 7 (ZESCO, 2015).

ZESCO is rolling out several grid extension projects, particularly in the North West Province. Notable expansion projects that are in progress by ZESCO are connecting the North Western Province to the National Grid and the Kalumbila Transmission Project. ZESCO operates diesel-fired power stations in the North Western Province districts of Mwinilunga, Mufumbwe, Kabompo and Chavuma and plans to connect the districts to the grid. First Quantum Mine Limited is in the process of establishing a new copper mine in Kalumbila and has requested ZESCO to supply electricity to the mining area (ZESCO, 2015). No date of completion has been provided for these projects. The Transmission Development North (TDN) and Transmission Development South (TDS) technical departments within the Transmission Development Directorate are

responsible for expanding the transmission system (ZESCO, 2015). The Government plans to increase rural electrification to 51% by 2030, although the target seems unfeasible since rural electricity access has been stagnating around 4% due to a lack of funds available.

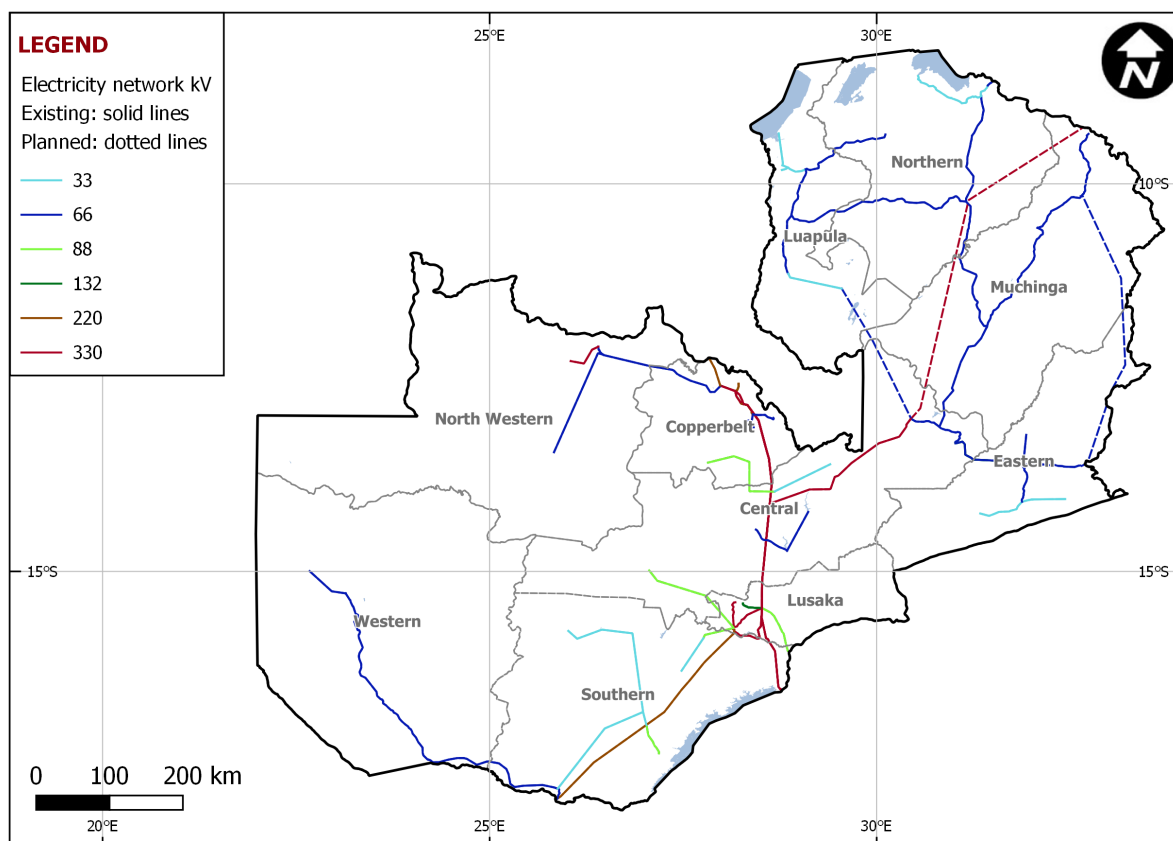


Figure 7: Current and planned grid network (Source : Carbon Trust analysis)

2.3.4 TARIFFS

Zambia has commenced migrating from its previously low and heavily subsidised electricity tariffs to cost-reflective tariffs. Prior to 2008, Zambia enjoyed the lowest electricity tariff in Southern Africa, with an average tariff of USD 0.027 per kWh (IRENA, 2013). The heavily subsidised tariffs led to challenging commercial environments for both private developers and ZESCO, resulting in very little investment in power infrastructure and new generation capacity from late 1970s to early 2000s. Since 2009, the country started to migrate towards cost-reflective tariffs that are in line with the objective of the Southern African Development Community (SADC). Tariffs were increased by around 75% over a period of five months in 2017, with the aim being to have cost reflective electricity tariffs by 2019. The approved electricity tariffs as of 1 September 2017 are summarised in Table 2 (ERB, 2017).

Table 2: *Zambian tariff schedule September 2017 (ERB, 2017)*

Customer category	Energy charge per kWh (US\$)	Fixed Monthly Charge
Metered residential (Prepaid): Up to 200kWh per month	0.15	18.23
Metered residential (Prepaid): More than 200kWh per month	0.89	18.23
Commercial	0.54	96.41
Social services: Schools, hospitals, orphanages, churches, water pumping and street lighting	0.49	83.84

**The rate provided is exclusive of 3% government excise duty and 16% VAT.*

REFiT and GET-FiT initiatives have both launched in Zambia. Zambia's Renewable-Energy Feed-in-Tariff (REFiT) strategy, developed with support from USAID, was officially launched in October 2017. The strategy allocates 200MW of small- to medium-scale projects (maximum size of 20MW) to be procured over three years. Eligible technologies include solar PV, hydro, geothermal, biomass, waste energy and wind power, with 100MW specifically reserved for hydro and the remaining 100MW for non-hydro (Ministry of Energy, 2017). In addition to the REFiT strategy, the GET-FiT Zambia programme, which aims to procure an additional 200MW of renewable energy projects over three years, has received €31 million funding from the German Government (through the German Development Bank, KfW) (GETFiT Zambia). Round one of the GET-FiT Zambia programme launched in early 2018 and allocated 100MW specifically to Solar PV projects of up to 20MW, and at time of writing, the framework for round two of the programmes, the 100MW small hydropower tender, was being created. The REFiT and GET-FiT programmes are only applicable to grid connected generation (Enea, 2016).

2.4 OVERVIEW OF THE OFF-GRID SECTOR

2.4.1 ENERGY ACCESS POLICY AND PLANNING

Off-grid renewable capacity contributes little to generation capacity in Zambia, although penetration of off-grid technology is increasing. Recent years have seen solar portable lighting products proliferate in the country, being now widely available (Carbon Africa & RECP, 2018). GOGLA has estimated around 16,500 solar home system kits and solar lanterns were sold in the first half of 2017 (GOGLA, 2017). There is uncertainty about the actual number of operational mini-grids in Zambia, though it is estimated that at the end of 2017, around 20 mini-grids were installed, operated by public, private and non-profit entities, with more mini-grids planned in future. ZESCO operates eight diesel-based mini-grids, and has done so for many years. ZESCO has little experience in the development and operation of renewable energy mini-grids, running one hydro and no solar PV mini-grids. Of the installed mini-grids, the remainder are comprised of solar PV, solar-diesel hybrid, mini-hydro, and biomass. These include solar mini-grids being developed by REA in Chunga and Lunga of 200kW and 300kW capacity respectively, a solar PV mini-grid operated by the Kafita Cooperative Society in Mpanta (initially supported by UNIDO), and micro-hydro plants in Nyangombe, Sachibondu, Mutanda, Mporokoso and Luena ranging from 5kW to 73kW capacity.

The 2009 Rural Electrification Master Plan (REMP), developed by the REA to advance rural electrification, serves as an important plan for rural electrification, but is largely outdated. The plan guides planning and implementation efforts to achieve 51% rural electrification by 2030 (REA, 2009) (JICA, 2008). It sets out electrification methods and budget to achieve the target. The REMP clusters rural areas with a high concentration of residential settlements and economic activity into Rural Growth Centres (RGC), with 1,217 RGCs identified and prioritised for electrification (Figure 8). The REMP analysed which electrification technology would be best suited to electrify each RGC, and estimated costs to achieve the 51% rural electrification target by 2030 at US\$1.1 billion or US\$50 million per year (REA, 2009). The REMP estimates the least cost options for electrification of the RGCs as:

- 79.9% grid extension;
- 19.8% solar home systems;
- <1% mini-grid.

Case study: Zengamina

A noteworthy mini-grid is Zengamina, a 700kW run-of-river mini hydropower plant, and 800 connection grids in the Ikelenge district of North West Province. It was founded by local community members/stakeholders who formed the North West Zambia Development Trust (NWZDT) and has been successfully operated by Zengamina Power limited since 2007. The Zengamina mini-grid was originally built to power the historic Kalene Mission Hospital and staff but rapidly expanded to a 30km diameter HV grid with other off-takers include a commercial farm, cell phone towers, stone crushing plant, pineapple drying business, other small businesses and market centres, maize mills, welding workshops, schools and clinics, as well as residential customers.

The mini-grid consists of a generation and distribution network system, and as it expands to more than 1,000 customers. Proposed expansions to Zengamina will include the addition of solar PV to supplement electricity generation during the dry season, a second hydro turbine, and another hydro site upstream.

Zengamina tariffs include a non-metered as well as a metered residential tariff with a fixed charge and stepped prices according to consumption. Peak and off-peak rates apply to businesses. Tariffs have been non-cost reflective for the entire 12 years of operation and a submission to adjust this is pending. A few key areas that have ensued the success of Zengamina are committed local management, securing productive uses and baseload anchor clients, tariff structure suitable to end users needs and mobilising grant funding.

A number of shortcomings of the report have been identified, including the strong focus on on-grid connection despite it not being the most cost-effective solution, the lack of plan for non-RGC areas (60% of the rural population are therefore not considered), and its need to be updated (published in 2009, it uses much data from 2006 which may no longer be current) (Enea, 2016), (World Bank, 2017), (USAID, 2018) (Kachapulula-Mudenda, et al., 2018).

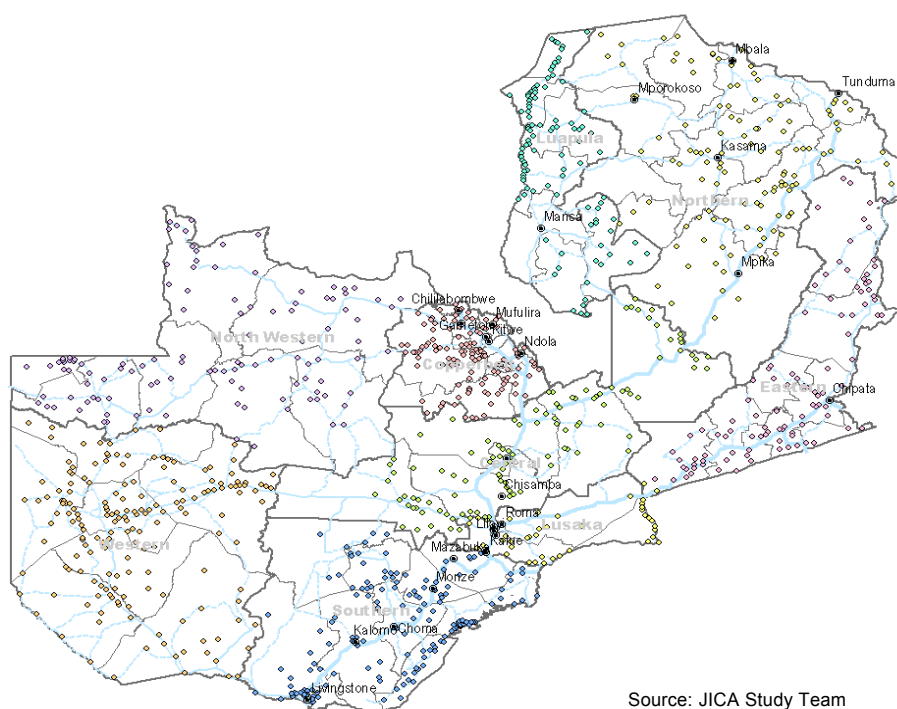


Figure 8: Map of Rural Growth Centres in Zambia, coloured by province, (REA, 2009)

A revised National Electrification Strategy (NES) in Zambia is currently under development, which intends to address the shortcomings of the REMP with support from the USAID geospatial model. The World Bank, through its Electricity Service Access Project (World Bank, 2017) intends to support the Government of Zambia in developing a more comprehensive, and up-to-date NES to support the scaling up of energy access. It is intended that a NES would provide a framework for planning and for policy, address ongoing financial support and allow for better co-ordination of efforts. It would address urban, RGC and non-RGC areas, and would be informed by regularly updated geospatial planning. The recently public USAID geospatial model will support the Ministry of Energy and REA to develop the NES.

The USAID geospatial model estimates there is potential for around 1,450 mini-grids as a least-cost option. The geospatial model determined the best electrification solution to achieve universal electricity access by 2030 following a least cost option (USAID, 2018). The geospatial model defines universal access as access to either a SHS, mini-grid or on-grid connection and not necessary to other forms of energy, as opposed to the Vision 2030. The results of the geospatial model therefore is also inconsistent with the REMP electrification targets. The tool suggests 7.3 million people live in 'stand-alone areas', areas where population is <0.5 persons per hectare. In these areas, it is assumed that due to isolation and low population densities, SHS is the least cost option. However, USAID also estimates that there are around 300 settlements in these areas with sufficient agricultural and productive use activities to support demand for mini-grids (that is, greater than 17,250kWh p.a.) (USAID, 2018).

The ERB developed a new enabling regulatory framework for mini-grid development focusing on licensing, economic and technical requirements. The proposed mini-grid regulatory framework was approved by the Board in October 2018 on the basis that it would be 'road-tested' and the lessons learnt would be incorporated into the final regulation that will be gazetted. Changes that the new mini-grid regulatory framework will possibly introduce include:

- The size of the mini-grid will determine the way it will be regulated i.e. 'very light-handed' regulation for mini-grids below 100kW and 'light-handed' regulations for mini-grids between 100kW-1MW;
- All mini-grid licences be issued as combined generation, distribution and sales licences, with the option to also only apply for a separate licence;
- Better protection from grid encroachment through issuing fixed term licences, defining the geographical area set out for the mini-grid within the licence, and giving exclusive supply rights in a green-field area for a pre-defined period; and
- Simplifying process type issues.

The 'road-testing' is expected to be completed during the second half of 2020 (ERB, 2018).

2.4.2 LICENSING

Mini-grids of all sizes and technologies require a licence to be approved by the ERB. However, it is unknown if smaller, older, and non-commercial grids have been exempted from this, and there have been reports of inconsistencies in the application of licensing for mini-grids (RECP, 2018). The private sector can obtain a licence for generation, distribution and supply, which have a 30-year, 15-year and five-year period of validity respectively (ERB, 2018). The procedures to obtain a licence for energy activities is set out in the Energy Regulation (Licensing) Regulations SI No.2 of 1998 and must be read together with the Energy Regulation Act Cap 436 of 2003.

The licensing fees are based on a percentage of the total investment cost and is payable as a one off application fee as well as a monthly licence fee. Once an application is assessed, an application fee of 0.1% of the cost of investment is payable. Upon being licensed, the licensee is also required to pay a monthly licence fee of 0.7% of the monthly turnover of the business. Applicants for solar energy projects are exempted from the monthly licence fees (ERB, 2018).

The following should accompany an application when applying for a generation licence using renewable energy:

- Five year business plan;
- Latest audited accounts/financial,
- Statement [if company is already operational];
- Proof of funds i.e. six months bank statement;
- Letter of commitment from sponsors accompanied with board resolutions of sponsor company;
- Latest annual returns from PACRA;
- Latest tax clearance certificate from ZRA;
- Residence permits for foreign, directors/shareholders; certified copies of NRCs for Zambian directors;
- Copy of Investment Endorsement;
- Proof of residence for directors, i.e. utility bill or tenancy agreement; and
- Technical detail of the infrastructure to be used.

An application can also be made for an Investment Endorsement to ERB. An Investment Endorsement is a precursor to a licence and can be procured to guarantee the issuance of a licence for new energy generation or transmission projects and assure investors that the tariff advised by the ERB as part of the Investment Endorsement will be applicable to the licence. An Investment Endorsement is only valid for a specific period but is renewable if a valid motivation is provided. Generation, distribution and supply licences are applied for once all other approvals are in place and the project has been built. This is valid for a specific geographical area, with a provisional licence provided in the first instance. (ERB, 2015). The following is required when applying for an Investment Endorsement:

- Detailed project description;
- Estimated cost and economic justification of the project;
- Decision letter on an Environmental Project Brief from the Zambia Environmental Management Agency;
- Draft Power Purchase Agreement (PPA) if power is to be sold by the Developer to ZESCO Limited (as off-taker).

Environmental Authorisations, water permits and land use authorisations may also be required. EIA requirements must be done in accordance with the Environmental Management Act of 2011. Environmental impact studies are mandatory most of the time, but can be simplified for small scale projects with, for example, an Environmental Project Brief (EPB) which essentially is a simplified EIA. Both EIAs and EPBs require the approval of the Zambia Environmental Management Agency (ZEMA). Water use authorisations for hydropower plants are managed by Zambia's Water Resources Management Authority (WARMA). Fees and charges for hydropower projects are based on the amount of electricity generated, however, this may change in the future to base it on the amount of water used (WARMA, 2018). Water works dam construction permit and diversion canal fees may also apply, but dam storage fees do not apply. Hydropower projects under 500kW exporting to the national grid are exempt from the water permit requirement and all the prescribed fees. Land use authorisations for the power plant can be obtained through receiving a long-term lease from the Government. Agreements with the local communities may be required to install the distribution network (Enea, 2016).

2.4.3 MINI-GRID TARIFFS

Off-grid energy projects can charge a different tariff from the national rate. The tariff is usually based on the cost of investments, operations and maintenance costs, type of customer, the level of output of electricity generated by the plant as well as socioeconomic factors such as the willingness/ability of customers to pay. ERB must approve the proposed calculated tariff, which needs to be based on the methodology provided in its guidelines and must be supported by a business plan (ERB, n.d.).

Off-grid energy tariffs in Zambia tend to be subject to much social pressure and it can therefore be a challenge to set financially sustainable and politically feasible tariffs. Many mini-grid developers are therefore dependent on grants and other financial support to ensure profitability.

Other tariff schemes, apart from fixed tariffs, can be implemented to allow increased profitability. These include customer-based tariffs (household or business) and peak and off-peak tariffs (Enea, 2016). A recent draft RECP report (RECP, 2018) provides examples of different tariff models implemented by private mini-grids. In 2017, a private hydro mini-grid had a monthly fixed tariff of around US\$6 up to 1.5 amps, and a monthly stepped tariff for the first 150kWh of US\$7.7, and between \$0.06 and 0.11 for each kWh thereafter. One private solar PV mini-grid had time-based tariffs ranging from US\$0.43 to 0.68 per day, while a public solar mini-grid of the same size had an approved monthly charge of US\$3.41.

2.4.4 SUBSIDIES AND INCENTIVES

The Rural Electrification Fund (REF) can grant subsidies to qualifying developers, although funding of the REF has been poor. The REF's sources of funding are a 3% electricity levy from ZESCO, funds appropriated by Parliament annually, and other sources such as loans and donations. There is a provision under the Rural Electrification Act for REA to support rural electrification projects with a capital subsidy aimed at leveraging tariffs. In response to this, REA developed the REF Operational Manual, which states that publicly-led rural electrification projects can receive a capital subsidy of up to 100%. Privately-driven rural electrification projects can receive a subsidy of up to 50% of capital costs, with remaining funds to be secured by the developer with a minimum level of 20% of equity, and a minimum internal rate of return of 10% before grants (IRENA, 2013). Unfortunately, the estimated US\$50 million per year funding requirement calculated by REA has not been achieved to date, and the levy from ZESCO is not always remitted in full, limiting REA's operations (World Bank, 2017).

Through the Electricity Service Access Project, the World Bank intends to work with the Government to develop subsidies to scale up electricity access. The National Electrification Strategy in Zambia, to be developed with support through this programme, will identify incentives for private electricity service providers. The World Bank intends that this document would also support "removing bottlenecks for private sector participation". The Government has been in discussions with the World Bank and others to explore options for stimulating private sector involvement, including, in addition to subsidy revisions, through the revision of REA's role to become more of a 'facilitator', enhancing the REF financing model, and clarifying the role of ZESCO (World Bank, 2017).

Tax, import duty and other non-fiscal incentives have been created to attract investments in renewable energy technologies. The tax and import duty exemptions are defined in the Statutory Instrument (SI) no. 32 and no. 33 of 2008. A tax waiver was introduced for all imported goods for the purpose of supply, install and maintenance of solar systems, regardless of investment size (Bowa, et al., 2017). Investors that invest more than \$500,000 in a priority sector (which includes the energy sector) can also receive tax and import duty incentives such as:

- Zero per cent import duty will be charged on capital goods, and machinery
- VAT deferment on import of eligible capitals goods, machinery and equipment
- Zero per cent tax charged on dividends for five years
- Zero per cent tax charged on profits for five years (IRENA, 2013).

There are a number of incentives which are available to smaller projects. Where the project investment is between \$250,000 and \$500,000, incentives may include investment guarantees and protection against nationalisation and facilitation of an investor work permit. In addition, micro and small enterprises will be exempted from income tax for the first three years in urban areas and for the first five years in rural areas (RECP, 2018).

2.4.5 POWER PURCHASE AGREEMENTS

Power Purchase Agreements (PPA) are drawn up on a case by case basis as there is a lack of a standardised PPA (Danish Energy Management & Esbensen, 2017). There have been cases where it has taken IPPs up to a decade to negotiate PPAs. A consultative process is required to develop a standardised PPA to increase the profitability of renewable energy power projects (IRENA, 2013). The REFiT and GET-FiT strategies will include technology specific PPA's (Ministry of Energy, 2017). The ERB has published guidelines to guide stakeholders when reviewing PPA's (ERB, n.d.).

2.4.6 ARRIVAL OF THE GRID

There is no updated or singular plan with respect to grid extension projects. Future grid extension projects to be executed from 2006 are set out in the REA's Rural Electrification Master Plan (REA 2009). While this plan covers the period 2006 to 2030, as previously mentioned, the REMP requires revision. The REMP assumes a number of RGCs in remote areas (namely in Eastern, Northern, Luapula, North-Western and Western Provinces) are not easily accessible by distribution lines, and areas outside of RGCs are not considered at all. As current grid expansions are being carried out using equipment intended for urban applications, there has been a tendency for overspecification of voltage levels in rural areas, and the World Bank has highlighted a need for the rural grid-expansion approach to be revised as part of the development of the NES (World Bank, 2017). Analysis done through the USAID geospatial tool project indicates that off-grid solutions, mainly through mini-grid and stand-alone solar PV systems are the least-cost options for most rural areas given the low population density and high connection fees (USAID, 2018), (World Bank, 2017).

Since 2006, the REA has implemented nearly 160 grid extension projects in rural areas across all 10 provinces. These had initially focused on schools and rural community health centres, and household connections were targeted later. There are several transmission and distribution initiatives being implemented by ZESCO, on their website, including projects connecting the North Western Province to the national grid (ZESCO, 2018). REA is receiving support from donors, including through the World Bank's Electricity Service Access Project (ESAP), for grid extensions initiatives. The ESAP would support finance network reinforcements, extensions and subsidise connection costs. Around 22,000 low income households and 1,000 SMEs in rural areas would be targeted for electrification by 2022 (World Bank, 2017).

There is no provision for protection for grid-stranded mini-grids. There is a regulatory gap regarding the procedure for grid interconnection and the application of any compensation mechanism if ZESCO were to take over the mini-grid network. Should a mini-grid become grid-connected, a developer may need to adhere to the Distribution Grid Code of 2016 (see Technical Rules section below) and other standards. If a mini-grid operator wishes to become a bulk electricity buyer from ZESCO for onward distribution, this will require an ERB-approved PPA. In addition, a mini-grid developer may incur the interconnection facility costs, as well as load flow study costs. The Grid Connection Guidelines of 2016, as well as the Distribution Code and the Model Grid Connection Agreement provide information that will likely apply for interconnection or integration of the mini-grid (ERB, 2016).

2.4.7 TECHNICAL RULES

Where off-grid systems will be integrated into the grid, the *Zambian Distribution Grid Code (2016)* provides the minimum technical, design and operational criteria that renewable energy plants should meet (ERB, 2016).

The Zambian Bureau of Standards (ZABS) sets out various technical standards for the electricity sector, most of which are not available online and must be purchased from ZABS. These include the draft standards such as:

- DZS 1191-8
- DZS 1191-9
- DZS 1205-1
- DZS 1205-2

Other regulations with technical requirements that may need to be adhered to include:

- The Electricity (Grid Code) Regulations of 2013;
- The Electricity (Supply) Regulation of 1995;
- The Power Quality Management Framework for the Electricity Supply Industry in Zambia (2014).

2.4.8 MOBILE SERVICES

Zambia has mobile network coverage across populated areas and all service providers run mobile payment services. There are four mobile service providers: Airtel, MTN, Vodafone (data only) and Zamtel. Coverage and access of mobile services are present in all 10 provinces including most of the districts. National geographical network coverage is 78% of the country and network coverage by population is 93% (ZICTA, 2017). All service providers are currently running mobile payment services on all their networks. Coverage aligns to densely populated areas such as urban areas, main road networks and selected rural areas. Zambia has 13.4 million active mobile phone subscribers with a mobile penetration rate of 82 per 100 inhabitants (Figure 9) (ZICTA, 2017). The number of mobile internet users in the country is estimated at 7.7 million, representing approximately 45% of the population (Malakata, 2018).

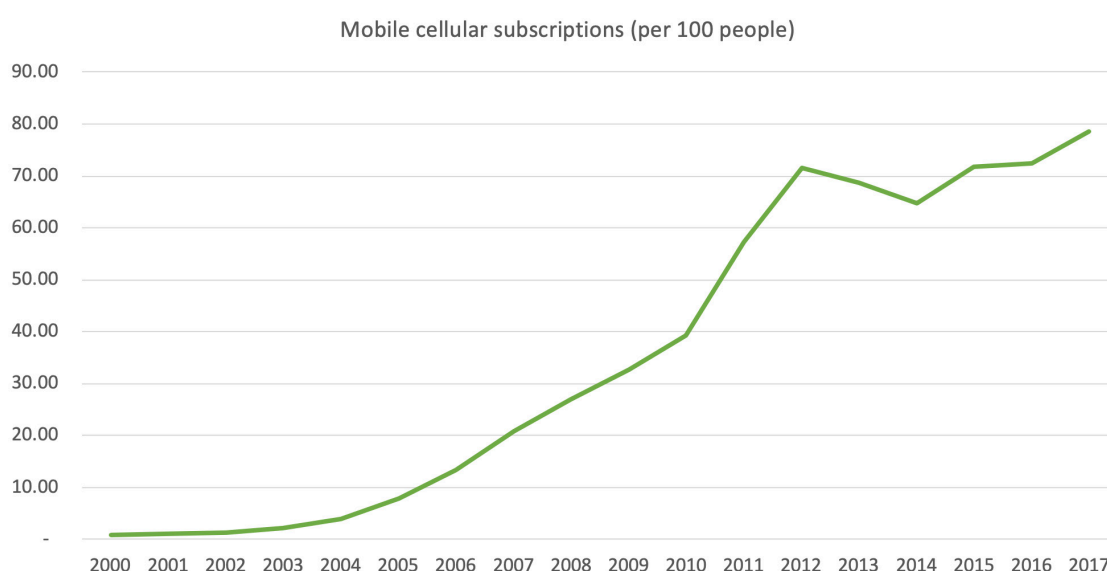


Figure 9: Mobile subscriptions per 100 People (World Bank, 2018)

2.4.9 BARRIERS TO MINI-GRID DEPLOYMENT

Most rural areas in Zambia have low population densities and servicing these customers may not be financially viable. Building up a customer base to increase the load factor and revenue stream is challenging in areas of low population density where economies of scale are lacking. Areas with low population densities also have high distribution costs, which further increases the costs to develop the off-grid systems. To achieve a sufficient load factor and to increase revenue streams, many anchor businesses such as telecom towers, commercial farms and other energy intensive business needs to be included in the customer base in areas of low population density (USAID, 2018).

Off-grid tariffs in Zambia are subjected to much social pressure, and willingness and ability to pay far lower than cost-reflective rates. These tariffs are set on a case-by-case basis (RECP, 2018). Setting tariffs at a financially sustainable price can be difficult. Willingness or the ability of customers to pay is a large factor that determines what the upper limit of an off-grid system tariff can be. Poverty and low disposable income of households in rural areas creates a challenging environment to justify financially viable tariffs. Mini-grid developers are therefore many times reliant on grants and subsidies to leverage tariffs. There is a risk that once the grants and other financial support ends, that the projects cease because they become financially unsustainable.

The existence of clear strategies and policies for rural electrification in Zambia is limited. The National Energy Policy of 2008, despite seeking to address barriers to renewable energy uptake, places heavy emphasis on grid-connected hydropower at the expense of other technologies (Kachapulula-Mudenda, et al., 2018). REA is guided by the REMP as it administers the REF and develops and implements rural electrification plans and tenders projects. The REMP however, published in 2009, uses much data from 2006, much of which requires revision. There are no also rural electrification programmes for providing access to the population outside of the RGCs (REA, 2009). Through the Energy Services Access Project (ESAP), the World Bank will support REA in developing a National Electrification Strategy to cover both RGC and non-RGC areas, informed by geospatial planning updated on a regular basis (World Bank, 2017).

There is a lack of sufficient private financing, and tenures tend to be short (five to seven years). Zambia's history of renewable energy IPP projects is limited, and much of this has been done through DFI financing. The limited capacity of local commercial banks and in the financial industry more broadly and lack of experience in the sector, contributes to high risk perceptions. This lack of appetite, the high cost of capital and limited experience presents as a barrier for financial institutions to participate in the sector (ODI, 2016).

3. GREEN MINI-GRID POTENTIAL

3.1 DATA AVAILABILITY

Estimating the potential for mini-grids is a challenging task that requires substantial data and assumptions. Some physical factors, such as resource availability and geographic features, can be collected remotely through satellite data, but other factors require the availability of local datasets and surveys. Certain non-physical factors, such as demand and consumption patterns, require precise settlement-level data to be collected. This data is often unavailable, out of date, or is highly resource intensive to obtain. An opportunity assessment relies upon a number of assumptions and criteria that are driven by the particular business model and approach of the implementing agency for each case. For example, a private developer may consider purely financial metrics, whereas a community scheme could focus more on the level of service provided. A detailed assessment in this report will not address the needs of all stakeholders for which it is intended. Therefore, this report aims to capture available data and highlights general assessments that would be relevant to most mini-grid stakeholders. Raw data is provided with this report to allow stakeholders to conduct their own further analyses as required.

The availability and quality of GIS data in Zambia is increasing rapidly with donor assistance. USAID launched a geospatial tool for Zambia's electricity sector in May 2018, collaborating with the Ministry of Energy and the Rural Electrification Authority (REA). The tool identified areas without power, and presents the lowest-cost electrification options. The tool will be used by REA and the Ministry of Energy to update the NES on a regular basis. A geospatial analysis model has been developed through the Electrification Pathways project. (ESMAP, 2018) The World Bank, ESMAP and KTH Division of Energy Systems Analysis have developed the National High Resolution Dynamic Least Cost Options Plan for Universal Access to Electricity in Nigeria, Tanzania and Zambia. The GIS based application presents options for least cost electrification for settlements of 1km by 1km in these countries. ESMAP also provides renewable energy resource potential assessments. The World Bank has been working with the Government of Zambia since 2013 to improve the assessment and mapping of solar and wind resource potential, and the 'Global Solar Atlas' and 'Global Wind Atlas', funded by ESMAP have provided free and easy access to solar and wind resource data and mapping.

The 2015 Living Conditions Monitoring Survey contains the most relevant population, development and electrification data at both the national and sub-national levels. The survey was produced by The Central Statistical Office of Zambia which is responsible for the production of national statistics on behalf of all government departments and agencies (CSO, 2015). The survey includes relevant socioeconomic statistics such as population projections, the breakdown of annual household expenditure and proportional use of different energy sources. However, it does not provide an estimate of household expenditure on energy alone, but rather groups it within non-food, household expenses. The next census is planned for 2020.

Government electrification and planning data is not current, and limited. The Rural Electrification Authority published the Rural Electrification Master Plan (REMP) in 2009, which is the latest publicly available rural electrification planning document. Some of the data from this plan is from 2006, and there is no information on demand estimates outside of RGCs. Ability to pay (ATP), and willingness to pay (WTP) information is included, but is based on older data and is likely no longer representative. There is no database that we are aware of that lists operational or planned mini-grids. OPPPI, ZESCO and REA have hydropower site databases, however this is not publicly readily available (it may be requested). The Water Resources Management Authority (WARMA) provides hydrological data where it is available, but this is limited due to low numbers of river gauging stations.

The high-level analysis performed as part of this study defines grid and off-grid areas based on their distance from the power network. Grid regions are defined as those areas within 15km of the grid, in keeping with the methodology for all country reports under the Market Development Programme. Off-grid population centres are then mapped, enabling an analysis of the potential for mini-grid projects. Analysis has been conducted using both the current power network and planned power network up to 2030. The planned network extensions were sourced from the Renewable Energy Master Plan (REA, 2009)

3.2 MINI-GRID POTENTIAL ASSESSMENT

The latest population figures for Zambia indicate a low population density of 23 people per km² (World Bank, 2018). The last official census was performed in 2010, with the next expected to take place in 2020. The Central Statistical Office projects population growth to 26.9 million in 2030, with a 77% increase in the population in rural areas between 2011 and 2035 and populations in urban areas more than doubling in that same period (CSO, 2013).

Table 3 Population, Population Density, and Electrification by Province (Worldpop, 2015)

Province	Total population	Population Density (per km ²)	Electrification rate	Electrified population
Central	1,515,086	16	20%	311,048
Copperbelt	2,362,207	75	58%	1,354,777
Eastern	1,813,445	35	8%	149,073
Luapula	1,127,453	22	7%	77,856
Lusaka	2,777,439	127	71%	1,915,956
Muchinga	895,058	10	17%	151,443
North Western	1,304,435	10	14%	116,990
Northern	833,818	11	9%	114,005
Southern	1,853,464	22	25%	464,439
Western	991,500	8	6%	61,655

The Northern, North Western and Western provinces of Zambia are furthest from the grid as shown in Figure 8. ZESCO operates and maintains a high and low voltage distribution system. The transmission grid operates on five levels: 330kV (2,241km), 220 kV (571km), 132kV (202km), 88kV (734km) and 66kV (1,037km). Its distribution network operates at two voltage levels: 33kV (2,100) and 11kV (1,037) (the latter not shown in Figure 10). Supply lines are 400V supply lines, with the exception of high-level consumers, these tend to supply 240V to end users. Electricity access rates were lowest in Western, Luapula, Eastern, Northern and North Western provinces (see Table 4).

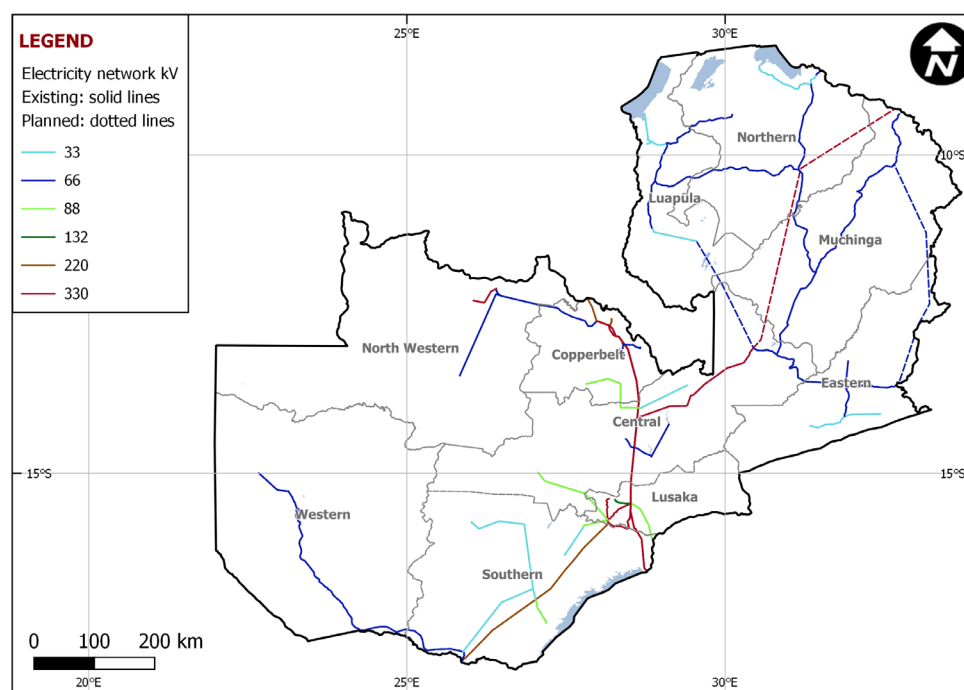


Figure 10: Existing electricity grid with planned network up to 2030 (dotted lines).

For this analysis, High Voltage (HV) and Medium Voltage (MV) mapping was overlaid with nightlights data. Zambia's grid data consists of nearly all HV and just a few 33kV lines. There is limited grid extension data available.

Recent data on average monthly spending on energy in Zambia was unavailable, so willingness to pay estimates were used. The data implies a potential tariff of only \$0.04/kWh. The Living Conditions Survey of 2015 provides a breakdown of average expenditures by province, and rural and urban populations on monthly household expenditure on non-food items, which includes energy. For our assessment, we used a World Bank estimate of a household's willingness to pay for basic lighting, radio, communication, and television services at US\$12.6 per month for a mini-grid project (World Bank, 2017). These estimates were derived from an Electricity Supply Board study conducted in 2015, which surveyed 200 households and 38 small businesses in the Central and Eastern Province in Zambia. These provinces tend to represent average values in terms of monthly spending on non-food household items in Zambia according to the Living Conditions Survey (CSO, 2015). The market size estimate shown in Table 5 assumes the willingness to pay of US\$12.60 per month as used by the World Bank, or US\$151.20 annually, and US\$29.65 annually per capita based on the average household size of 5.1. The World Bank ESAP report also suggests the average household will consume around 91.03kWh monthly (though this rate may be lower for rural households). Using ZESCO current tariffs, annual household expenditure on electricity before tax, would be around US\$38. This data implies a potential tariff of only \$0.04/kWh.

The 2009 Rural Electrification Master Plan suggests that monthly expenditures on electricity per household was around US\$5, or US\$60 annually. However, the ability and willingness to pay information in this plan is based on older data and is likely no longer representative. Similarly, World Bank data from 2010 on household expenditure on energy in rural areas shows an average spend of US\$84.51 annually (World Bank, 2010).

The draft, 2018 RECP report estimates that households in rural areas have a willingness to pay off between US\$5.97 and US\$10.67 per month (RECP, 2018).

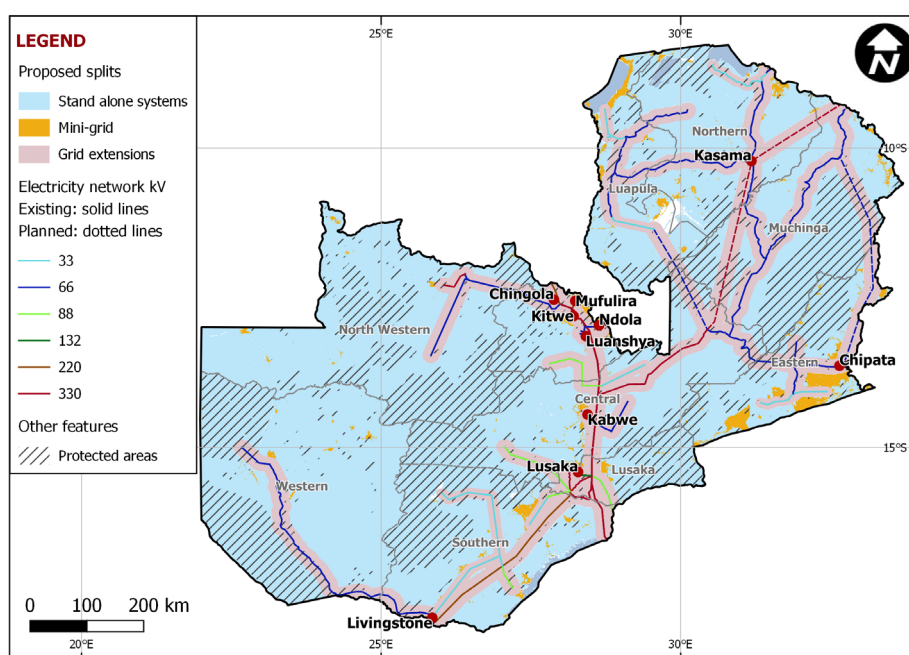


Figure 11: Regions best served by grid extension, mini-grid and standalone systems, shown with major and minor population centres. Dotted lines are planned grid extensions up to 2030 (Carbon Trust analysis)

Our analysis estimates that 494,655 people (3% of the unelectrified population) would be best served by mini-grid solutions. A further 4.2 million people will be best served by solar home systems (SHS) and 10.7 million people will be best served by grid extension, based on proximity to the existing grid. This calculation is based on the current grid coverage. When including planned grid extensions up until 2030, 409,111 people will be best served by mini-grids, four million people by SHS and 11 million people by grid extension (Figure 11).

The analysis estimates a total annual revenue market size of \$14.7 million, based on allowable tariffs of \$0.04/kWh. It is unclear whether higher tariffs are politically feasible in Zambia, given on-grid tariffs have historically been very low. Existing mini-grids reported significantly differing tariff regimes; this is therefore a conservative estimate. Fifty-six per cent of the mini-grid market is found in the Northern and Eastern Provinces due to their low electrification rates, limited grid coverage and population densities high enough to support mini-grids. Figures show that 210,834 and 69,436 people will be best served by mini-grids in the Eastern Province and Northern Province, respectively (Table 4).

When including planned network extensions up to 2030, this analysis suggests a total market of \$12.1 million, a 17% reduction compared to the market for mini-grids under the current grid. Again, this is a conservative estimate. The largest market reduction when including these extensions is in the Eastern Province. This is due to grid extensions being more likely to occur in areas with higher population densities. The largest market remains in the Eastern Province at \$3.9 million (Table 5).

Table 4: Estimated household market size for off-grid solutions (analysis using existing network)

Province	Current grid network				
	Electrification rate	Population (thousands)			Mini-Grid Market (\$,m)
		< 15km of grid	Mini-Grid	SHS	
Central	20%	1,128,738	2,606	423,896	77,266
Copperbelt	58%	2,251,889	10,040	73,895	297,643
Eastern	8%	1,199,163	210,834	453,416	6,250,607
Luapula	7%	641,114	65,937	405,174	1,954,835
Lusaka	71%	2,574,801	4,326	119,403	128,262
Muchinga	17%	387,257	43,055	460,527	1,276,461
North Western	14%	226,266	19,827	589,550	587,804
Northern	9%	593,576	69,436	603,708	2,058,575
Southern	25%	1,396,028	48,415	413,311	1,435,367
Western	6%	341,401	20,179	665,997	598,237
Total		10,740,233	494,655	4,208,878	14,665,058

Table 5: Estimated household market size for off-grid solutions (analysis using planned network up to 2030)

Province	Planned grid network to 2030			
	Population (thousands)			Mini-Grid Market (\$,m)
	< 15km of grid	Mini-Grid	SHS	
Central	1,156,081	2,584	396,576	76,610
Copperbelt	2,251,889	10,040	73,895	297,643
Eastern	1,341,247	131,599	390,568	3,901,517
Luapula	673,705	61,901	376,619	1,835,183
Lusaka	2,574,801	4,326	119,403	128,262
Muchinga	453,365	42,808	394,667	1,269,142
North Western	226,266	19,827	589,550	587,804
Northern	644,221	67,432	555,067	1,999,159
Southern	1,396,028	48,415	413,311	1,435,367
Western	341,401	20,179	665,997	598,237
Total	11,059,003	409,111	3,975,653	12,128,924

3.3 RENEWABLE ENERGY POTENTIAL FOR MINI-GRIDS

3.3.1 HYDRO

Zambia has strong potential for both large and small-scale hydropower, though it is subject to drought-related risks. Zambia's hydro energy potential is estimated to be 6,000MW. It has a large untapped potential for small scale hydropower, specifically in rural areas (RECP, 2018). The North Western, Northern, Luapula and Eastern provinces have the highest potential for mini-hydro plants due to the rainfall and topography in the area. The REA has identified 29 small and mini-hydro sites and has completed feasibility studies for several projects such as the Chikata falls, a 3.5MW mini-hydropower plant in the Kabompo district.

Noteworthy existing off-grid small hydro plants apart from the 700kW run-of river Zengamina hydropower plant is the 1MW Shiwang'andu hydropower plant owned by ZESCO. Construction of the \$8.6 million 0.64MW mini-hydro power station in Kasanjiku falls in the Mwinilunga districts has been completed in October 2019. The project will electrify 11 schools, one Mission hospital, four Rural Health Centres, one Local Court and one Chief's Palace (REA, 2018).

3.3.2 BIOMASS

Zambia has a biomass resource of 2.2 million tonnes and an economic bioenergy potential of 498MW. It is estimated that 90% of biomass feedstock can be derived from agricultural wastes (animal manure and crop residues from sugarcane, dairy, livestock and poultry farming). The country has sufficient feedstock sources (agricultural, forest and sawmill waste) and has the potential to produce biomass-based electricity. However, further exploration and research is required as the success of energy from biomass requires good policies, frameworks, strategies, and technical expertise, etc. (Shane, et al., 2015).

Existing bioenergy plants are at Nakambala Sugar factory and Kafue Sugar. Nakambala Sugar factory uses bagasse to generate 17MW of electricity and Kafue Sugar produces 3MW of electricity (IRENA, 2013). Other uses of biomass for energy includes using biogas to power milk chillers in rural areas (SNV, 2016).

3.3.3 SOLAR

Zambia has great solar potential as high solar irradiation values creates a promising environment for the development of solar PV plants. The country has average GHI values of 2,000kWh/m² and higher across the country (Figure 12). The country has an average of up to 3,000 hours of sunshine per year with an output of 5.5kWh/m²/day (IRENA, 2013).

Solar energy is widely used in Zambia and will be further developed over the next decade, given its high potential. The Mpanta Solar Mini-grid Project (60kW) in the Luapula province (owned by Kafita Cooperatives) was completed in June 2013 and provides electricity to 480 households, a school, a health centre and the harbour. After the success of the Mpanta project, the development of two additional solar mini-grids, Chunga (300kW) and Lunga (200kW), started in 2016 in the Central and Luapula provinces, respectively (REA, 2018). The Government has received tenders to install a total of 30MW solar PV using a Build-own-operate model. There will be 10MW installed in each of the Eastern, North Western and Luapula provinces (Bowa, et al., 2017).

A Pay-As-You-Go (PAYG) system has been employed by Muhanya Solar Limited as a pilot project. The project is a 30kW mini-grid solar system in Sinda. The project was launched as a pilot project to attract private investment, and also to scale up the project through building a business case and proving the economic and technical feasibility. The PAYG concept is being tested on 60 houses. The tariff structure is based on a monthly fixed rate according to the estimated demand and ability to pay of different classes of consumers (Danish Energy Management & Esbensen, 2017).

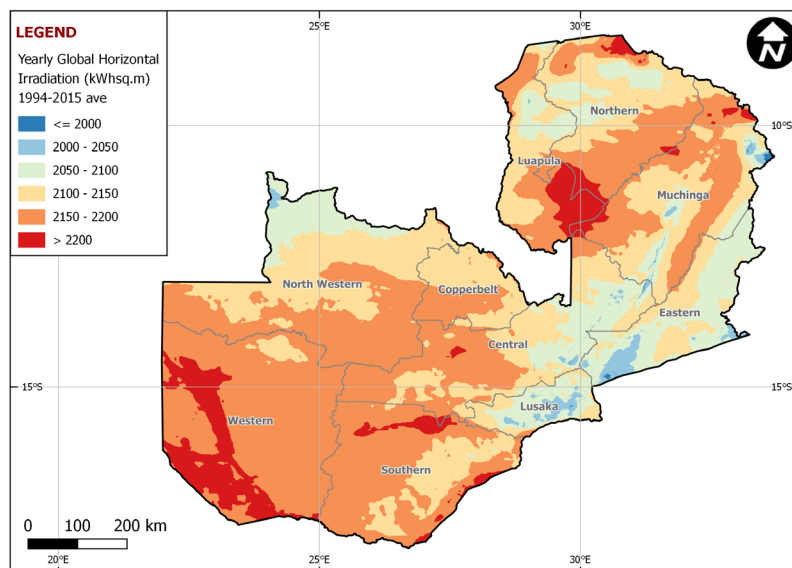


Figure 12: Yearly Global Horizontal Irradiation (kWh/sq.m) 1994 to 2015 ave.

3.3.4 WIND

Zambia has a moderate to low wind energy potential and the focus of feasibility studies and research has only recently moved to wind power. Majority of wind speeds at 100m above the ground are between 4 to 7m/s (Figure 13). Most of the south-western area of the country, as well as along selected areas on the escarpment in the western part of the country, has wind speeds of between 5 to 7m/s, which may have electricity generating potential. The north western and low lying area may be best suited for water pumping rather than electricity generation. The average wind speed at 10m height is 3m/s and is only suitable for water pumping. The two large red areas as indicated in the figure below in the northern and southern parts are both waterbodies. ESMAP and the World Bank produced a Wind Resourcing Map of Zambia in May 2018 (World Bank, 2018). The US Trade and Development Agency approved a \$1 million grant to Access Power and EREN Renewable Energy to support a feasibility study for a 130MW wind plant. This will be Zambia's first wind farm (Access-Power, 2018).

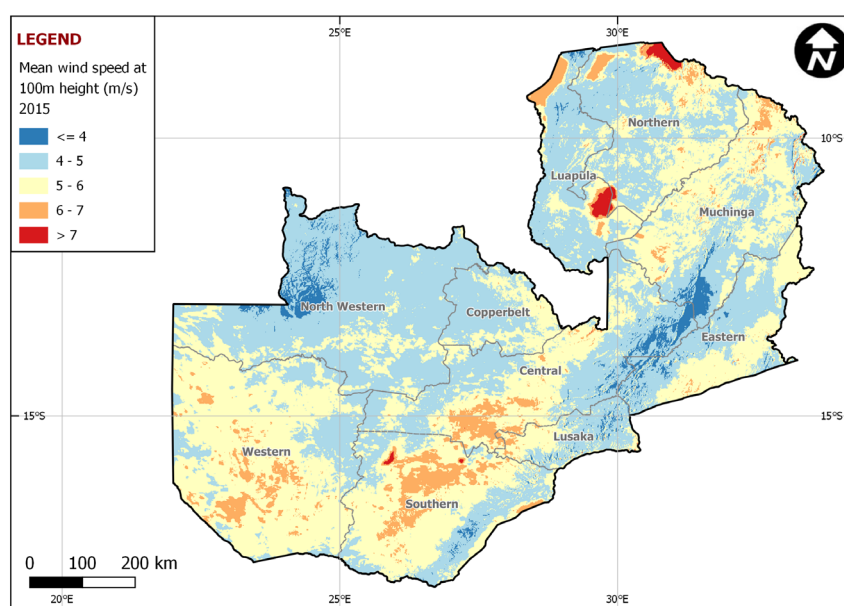


Figure 13: Mean wind speed at 100m height (m/s) 2015

4. DIRECTORY

4.1 ENERGY SECTOR POLICIES AND REGULATORY FRAMEWORKS DIRECTORY

National Energy Policy (revised in 2008)

<https://static1.squarespace.com/static/58c95e0c5016e18d705d710a/t/58ee21f0ebbd1a718d26a06d/1492001282630/National+Energy+Policy+2008.pdf>

The National Energy Policy is a guide for policy makers, investors and development managers on the Government of Zambia's intended actions in the energy sector. The Policy provides the vision and guiding principles for the energy sector, and the policy measures and strategies for implementation to ensure the availability and adequate supply of energy.

Energy Regulation Act 1995 (amended 2003)

<http://www.parliament.gov.zm/sites/default/files/documents/acts/Energy%20Regulation%20Act.pdf>

The Energy Regulation Act recognises solar, wind and biofuels as viable energy sources and also establishes licences and guidelines to facilitate the adoption of renewable technologies, including for solar power and bio-energy, as well as setting off-grid tariffs. This act established the ERB.

Rural Electrification Act No. 20 of 2003

<http://admin.theiguides.org/Media/Documents/Rural%20Electrification%20Act.pdf>

An Act to establish the Rural Electrification Authority and to define its functions (the REA being responsible for implementing the Rural Electrification Master Plan (REMP), and to establish the Rural Electrification Fund.

7th National Development Plan

<http://www.mndp.gov.zm/download/7NDP.pdf>

The 7th National Development Plan 2017 to 2021 (NDP) sets out the strategy to improve energy production and distribution for sustainable development by enhancing generation, transmission and distribution of electricity, promoting renewable and alternative energy, and improving electricity access to rural and peri-urban areas.

Rural Electrification Master Plan 2008

http://open_jicareport.jica.go.jp/pdf/11871019.pdf

The Rural Electrification Master Plan provides a systematic implementation plan (including a financial plan and policy recommendation) to achieve rural electrification of 51% by 2030 in Zambia.

Vision 2030

<http://unpan1.un.org/intradoc/groups/public/documents/cpsi/unpan040333.pdf>

The National Long-term Vision 2030 (Vision 2030) expresses Zambia's aspirations for the year 2030. The vision will be operationalised through the five-year development plans, starting with the 5th National Development Plan, and annual budget.

Zambia NDC

http://www4.unfccc.int/ndcregistry/PublishedDocuments/Zambia%20First/FINAL+ZAMBIA%27S+INDC_1.pdf

This document outlines Zambia's Intended Nationally Determined Contributions (INDCs), which aims for a reduction of between 20,000GgCO₂e and 38,000GgCO₂e or 25% and 47% against 2010 baseline conditions.

Zambian Distribution Grid Code

<http://www.erb.org.zm/downloads/gridcode/ZambiaDistributionGridCode.pdf>

The Grid Code provides the minimum technical, design and operational criteria that renewable energy plants should meet to be integrated with the grid.

ReFIT (and GET-FiT) Scheme

<https://www.getfit-zambia.org/about/>

The Renewable Energy Feed-in-Tariff (REFIT) mechanism was developed by ERB with support from USAID and KfW. The scheme allocated 200MW of electricity capacity supply from renewable sources (of small to medium scale) to be connected with the grid.

The Environmental Management Act No. 12 of 2011

<http://www.parliament.gov.zm/sites/default/files/documents/acts/Environmetal%20Mangement%20Act%2012%20of%202011.pdf>

This Act makes provision for integrated environmental management, the protection and conservation of the environment, and the sustainable management and use of natural resource and related matters. In Part I it sets out the principles governing environmental management.

The Standards Act Cap 416

<http://www.parliament.gov.zm/sites/default/files/documents/acts/Standards%20Act.pdf>

An Act to provide for standards of quality control for certain commodities; to continue the Zambia Bureau of Standards and to redefine its powers and functions; to establish the Standards Council of Zambia; to repeal the Zambia Bureau of Standards Act; and to provide for matters connected with or incidental to the foregoing.

Companies Act No. 26 of 1994

<http://www.parliament.gov.zm/sites/default/files/documents/acts/Companies%20Act.pdf>

An Act to provide for the formation, management, administration and winding-up of companies; to provide for the registration of charges over the undertakings or properties of companies; to provide for the registration of foreign companies doing business in Zambia; and to provide for matters connected with or incidental to the foregoing.

4.2 INVESTMENT INCENTIVES DIRECTORY

Zambia Development Agency Act

<http://extwprlegs1.fao.org/docs/pdf/zam97277.pdf>

Zambia Development Agency Act provides a wide range of incentives, allowances, and exemptions and concessions to companies. It defines investor protections and additionally governs issues related to land use, development, and ownership.

Customs and Excise Act Cap 322

<http://www.parliament.gov.zm/sites/default/files/documents/acts/Customs%20and%20Excise%20Act.pdf>

An Act to provide for the imposition, collection and management of customs, excise and other duties, the licensing and control of warehouses and premises for the manufacture of certain goods; the regulating, controlling and prohibiting of imports and exports; the conclusion of customs and trade agreements with other countries, forfeitures and for other matters connected therewith or incidental thereto.

Value Added Tax Act

<http://www.parliament.gov.zm/sites/default/files/documents/acts/Value%20Added%20Tax%20Act.pdf>

An Act to impose a tax on the supply of goods and services in Zambia and the importation of goods into Zambia.

4.3 DATA SOURCES DIRECTORY

This methodology was developed during the second phase of this project, the Green Mini-Grids Market Development Programme - Market Intelligence business line, which is also available via the African Development Bank.

This analysis, the results of which are provided in Section 3, considers the potential for mini-grids by segmenting the countries into two areas: grid and off-grid areas. This split is based on the distance of 15km from the power network. We have used the planned power network for up to 2030. The GIS sources used in this analysis are detailed below.

Source:

Zambia - Electricity Transmission Network (2014)

<https://ifc.ds.io/dataset/zambia-electricity-transmission-network-2014>

Combination of the following data sources: 1) data collected and prepared for a project of the World Bank Group in April 2014 2) The Africa Infrastructure Country Diagnostic (AICD) study 3) OSM data OpenStreetMap contributors

Global Atlas: IRENA

<http://www.irena.org/globalatlas>

Solar Irradiation and Wind atlas - Irena

LandScan 2015 Global Population Database

<http://web.ornl.gov/sci/landscan/>

World Pop

<http://maps.worldpop.org.uk/#/map/layers/ppp-2015>

Population Growth: IMF WEO database: <https://www.imf.org/external/pubs/ft/weo/2017/01/weodata/index.aspx>

4.4 STAKEHOLDER DIRECTORY

4.4.1 GOVERNMENT AND AGENCIES

Ministry of Energy

Email: ministry.energy@moe.gov.zm

Link: <https://www.moe.gov.zm/>

Brief description: The Ministry of Energy (until 2016, the Ministry of Energy and Water Development (MEWD)) is responsible for carrying out energy planning, the formulation and implementation of national energy policies, strategies and plans, and the development of new energy programmes.

Office for Promoting Private Power Investment (OPPPi)

Email: oppipi@zamnet.zm

Telephone: +260 211 253970

Link: <http://www.oppipi.gov.zm/>

Brief description: OPPPI was set up to be a 'One Window Operation' to reduce the complexity of procedures, rules and regulations and red tape usually associated with obtaining the required approvals, permits and licences for investors in the electricity sector.

Energy Regulation Board (ERB)

Email: erb@erb.org.zm

Telephone: +260 211 258844 – 49

Link: <http://www.erb.org.zm/viewpage.php?page=news>

Brief description: The mandate of the ERB is to regulate the energy sector in accordance with the Energy regulation Act Cap 436 of the Laws of Zambia. The ERB is responsible for the licensing of Independent Power Producers (IPPs), setting electricity tariffs and the development of technical standards.

Rural Electrification Agency (REA)

Email: info@rea.org.zm

Telephone: +260 211 241296/98

Link: <http://www.rea.org.zm/>

Brief description: REAs mandate is to increase rural electrification rates by providing electricity infrastructure. It is responsible for the management of the Rural Electrification Fund as well as the development, implementation and revision of the Rural Electrification Master Plan.

Zambia Electricity Supply Corporation (ZESCO)

Email: zesco@zesco.co.zm

Telephone: +260 211 361111

Link: <http://www.zesco.co.zm/home>

Brief description: ZESCO Limited is a vertically integrated electricity utility, which generates, transmits, distributes and supplies electricity in Zambia. It is a public utility, with the Government of the Republic of Zambia being a sole shareholder. The only utility, it is responsible for the construction and operation of the grid, and runs nine mini-grids (one hydro, eight diesel).

Zambia Development Agency (ZDA)

Email: <http://www.zda.org.zm/?q=content/contact-form>

Telephone: +260 211 220177 / 223859

Link: <http://www.zda.org.zm/>

Brief description: The ZDA supports investors with market entry, providing information and services to help promote trade and investments. The agency can support with applications for licences land acquisition

Zambia Renewable Energy Agency (ZARENA)

Email: <http://zarena.org/contact/>

Telephone: +260 211 255174

Link: <http://zarena.org/>

Brief description: The mission of ZARENA is to promote and advocate for the increased use of Renewable Energy by developing an effective network of members and stakeholders, emphasising the need for quality and best practice throughout the sector.

4.4.2 MINI-GRID PRACTITIONERS AND PRODUCT DEVELOPERS

Name: Suntech

Email: info@suntech-zambia.com

Telephone: +260 963 399333

Name: Vitalite

Email: contact@vitalitegroup.com

Telephone: +260 976 147432

Name: I'D solar solutions

Email: sales@idsolutions.com

Telephone: +260 978 676937

Name: Standard Microgrid

Email: info@standardmicrogrid.com

Name: Zengamina Power Company

Email: dr@zambezipstar.com

4.4.3 BILATERAL AND MULTILATERAL DONOR ORGANISATIONS

Name: DFID Zambia

Email: enquiry@dfid.gov.uk

Telephone: +260 211 423200

Brief description: In February 2017, the UK's Department for International Development signed a partnership agreement with Zambia, including Zambia in the UK's Energy Africa programme focused on accelerated household solar solutions across sub-Saharan Africa.

Name: World Bank/IFC

Email: chambuba@worldbank.org

Telephone: +260 211 252811 / 253219

Brief description: The World Bank is implementing a number of projects for electricity access in Zambia. The "Electricity Service Access Project" is designed to provide up to USD 26.5 million (EUR 22.3 million) for last-mile connections, private sector support and national electrification planning. Through the "Lusaka Transmission and Distribution Rehabilitation

Project” the World Bank is providing up to USD 105 million (EUR 88 million) to support ZESCO in the rehabilitation of networks within Lusaka Division. The World Bank is currently implementing a national multi-tier household energy access survey in Zambia.

Name: EU-RECP

Email: recp@euei-pdf.org

Brief description: RECP produced the report “Mini-Grid in Zambia: A Guide for Developers and Investors in Solar PV and Hydro Mini-Grids”, in 2018 (in draft format at time of writing).

Power Africa and USAID

Brief description: Power Africa and USAID Zambia have provided USD 2 million (EUR 1.7 million) supporting the IFC’s Scaling Solar programme (Power Africa, 2017). Through the Scaling Off-Grid Energy Grand Challenge, USAID provided Fenix International and VITALITE USD 750,000 (EUR 635,000) and USD 300,000 (EUR 252,000) of financing respectively to scale solar home solutions in the country. Power Africa has supported the development of a Renewable Energy Feed in Tariff (REFIT) and standardised Power Purchase Agreement (PPA), and is currently providing technical assistance to the ERB. KfW is managing the GET-FiT Zambia programme to support government implementation of the REFIT.

Swedish International Development Cooperation Agency (Sida)

Email: sida@sida.se

Brief Description: Sida is financing the ‘Beyond the Grid Fund for Zambia’ that aims to bring clean energy access to one million Zambians and accelerate private-sector growth in energy generation and distribution in the country (REEEP, 2017). The fund will operate from 2016 to 2018, with a maximum funding level of EUR 20 million. Within that period, it intends to provide one million Zambians with access to clean electricity.

Name: KfW Office Lusaka – German Development Organisation

Email: kfw.lusaka@kfw.de

Telephone: +260 211 29 22-71

KfW have been supporting the Zambian government with the development and implementation of the ReFIT and GET-FiT strategy for Zambia

Other relevant organisations and initiatives

Company: Copperbelt Energy Corporation

Tel: +260 212 244956

Link: <https://cecinvestor.com/>

Company: Western Power Company Ltd

Email: info@eleqtra.com

Link: www.westernpower.org

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