Mini-Grid Market Opportunity Assessment: Angola

Green Mini-Grid Market Development Programme: African Development Bank (Sustainable Energy Fund for Africa, SEFA)

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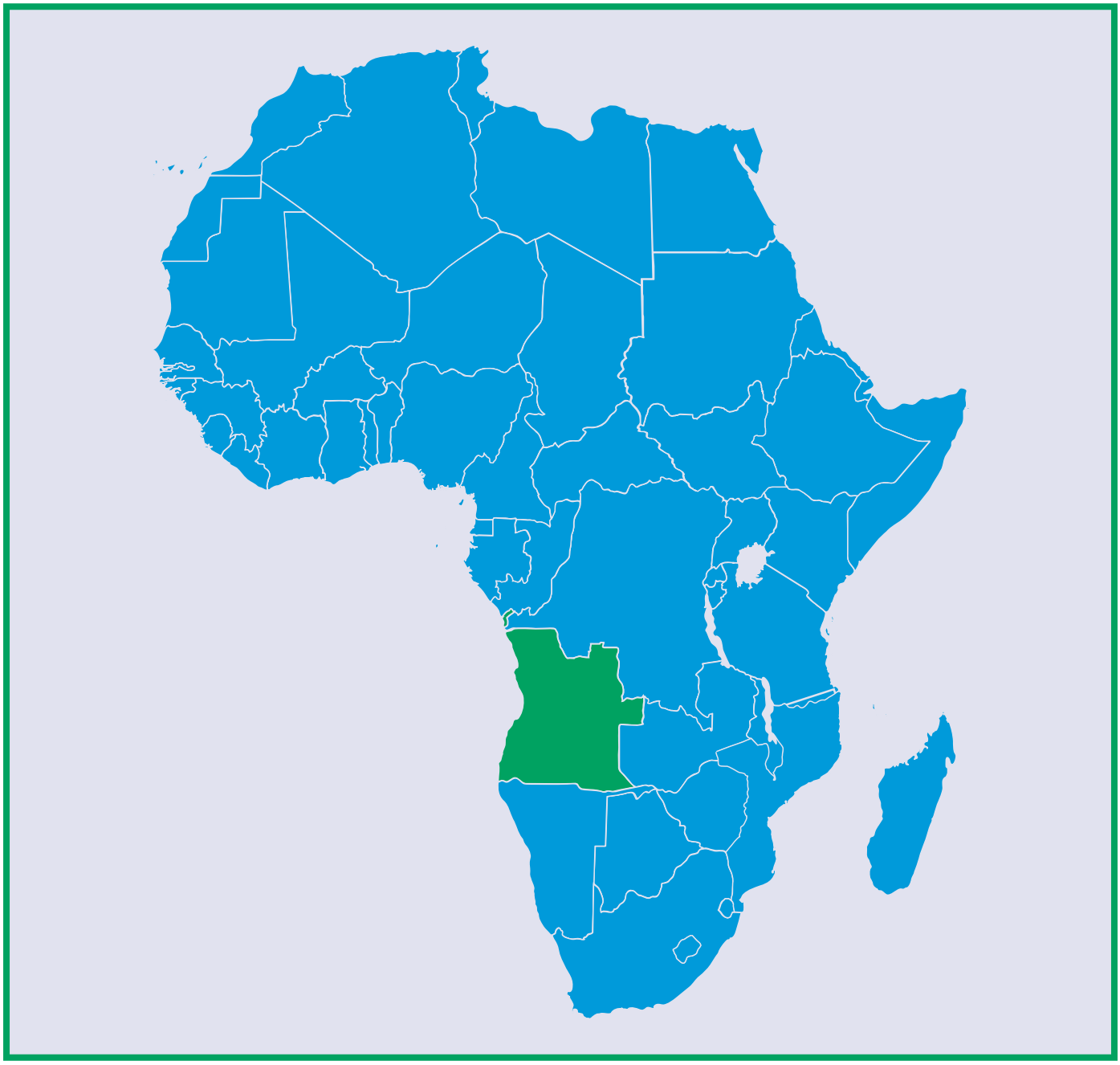

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The Sustainable Energy Fund for Africa (SEFA) is a special fund administered by the African Development Bank to support to African countries to accelerate the transition towards greener and more sustainable power systems. SEFA supports small and medium-scale renewable energy and energy-efficiency projects through early stage interventions that enhance project bankability and unlock private sector investments in new technologies and businesses. SEFA focus its interventions on three thematic areas: (1) green mini-grids to accelerate energy access to underserved populations; (2) green baseload to support clean generation capacity; and (3) energy efficiency to optimize energy systems and reduce energy intensity.

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.

The Carbon Trust would like to thank the Angola's Ministry of Energy and Water, their contributions which made this report possible. The Carbon Trust would also like to thank members of the following institutions for further input and support: World Bank, AfDB, UNDP, IRSEA (Regulatory Institute for Electricity and Water Services), ENDE (National Electricity Distribution Company), RNT (National Electricity Transport) and PRODEL (Public Electricity Production Company).

Benjamin Curnier
Director General, Carbon Trust
benjamin.curnier@carbontrust.com

Gracia Munganga
Manager, Carbon Trust
gracia.munganga@carbontrust.com

Kate Hooper
Associate, Carbon Trust
kate.hooper@carbontrust.com

Yuri Lima Handem
Rural Electrification Expert
yhandem2002@yahoo.com

PREFACE

This paper, part of the Green Mini-Grid Market Development Programme (GMG MDP) document series, assesses the green mini-grid market in Angola. 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, required to sell power at prices significantly below the cost of production and delivery. Moreover, it leaves the most remote towns and villages unelectrified. 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 %, with 69 % of the population in urban areas electrified compared to only 15 % 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.

The development of GMGs is not without its challenges, however. In addition to unfriendly 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 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). 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 includes 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 for 2.5 years.

In its Africa Energy Outlook 2014, the International Energy Agency (IEA) predicted that by 2040, 70 % of new rural electricity supply in Africa will most affordably come from stand-alone systems and mini-grids. The GMG MDP funded by SEFA, SEforALL, ESMAP and similar programmes, which are contributing to falling costs, technological advancements 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 at the request of the AfDB, SEFA team. It was written by Kate Hooper and Gracia Munganga and reviewed by Benjamin Curnier of the Carbon Trust. The Carbon Trust is a mission-driven organization helping businesses, governments and the public sector accelerate the move to a low carbon economy.

The content of this report was reviewed by Brendan Coleman of the AfDB's GMG MDP, and Anders Pedersen, Chief Regional Power System Officer (AfDB) and cleared by Dr Daniel-Alexander Schroth, Advisor to the Vice President for Power, Energy, Climate and Green Growth at the African Development Bank.

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List of Acronyms

AFD	Agence Française de Développement/ French Development Agency
AfDB	African Development Bank
CAPEX	Capital expenditure
ENDE	National Electricity Distribution Company (ENDE- Empresa Nacional de distribuição de Eletricidade)
ESMAP	Energy Sector Management Assistance Program
FiT	Feed in Tariff
GDP	Gross Domestic Product
GIS	Geographic Information System
HV	High Voltage
INDCs	Intended Nationally Determined Contributions
IRSEA	Electricity and Water Sector Regulator (Instituto Regulador dos Serviços de Eletricidade e de Águas)
IPP	Independent Power Producers
LV	Low Voltage
MINEA	Ministry of Energy and Water
MDP	Market Development Programme
MT	Metric tons
MV	Medium Voltage
MW	Mega Watt
NAMA	Nationally Appropriate Mitigation Action Organisation
OPEX	Operational expenditure
PPA	Power Purchase Agreement
PPP	Private Public Partnership
PRODEL	Public Company for Electricity Generation (Empresa Publica de Produção de eletricidade)
PV	Photovoltaic
REDD	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
RNT	National Distribution Network - Rede Nacional de transportes de Eletricidade
SADC	Southern Africa Development Community
SE4ALL	Sustainable Energy for All
SHS	Solar Home System
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program

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 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 Angola. Previous country reports can be downloaded from the GMG Help Desk (Https://greenminigrid.afdb.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 and 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.

Angola has an estimated GDP of $88.4 billion, and is the sixth-largest economy in sub-Saharan Africa based on the 2016 IMF ranking. Despite this, it faces significant development challenges. The economy is heavily dependent on the oil sector and vulnerable to oil price shocks, having not yet recovered from the 2014 crash in oil prices. The GDP continued to decline by 2.1% in 2018 and inflation averaged 17.5% in 2019.

Although today politically stable, Angola is still recovering from its civil war, which had left much vital infrastructure in need of repair and had pushed swathes of the population into poverty. Around 30% of the population lives below the poverty line and nearly 60% of Angolans lack access to electricity (only 16% have access in rural areas). There are huge income and livelihoods disparities between urban and rural areas in Angola. With a population of around 31 million people, more than 65% are concentrated in urban areas.

The Ministério da Energia e Águas (MINEA, Ministry of Energy and Water) has oversight of the power sector, proposing, formulating, managing and executing policy and strategies. Under the Ministry, are several Directorates, including the Directorate for Rural Electrification. The national regulatory agency is the Instituto Regulador dos Servicos de Electricidade e de Agua (IRSEA, Regulatory Institute for Electricity and Water).

Angola has a diverse climate with significant hydrological and solar resources, and the Government has committed to transforming the energy sector to take advantage of its resources. Today however, the energy mix is dominated by thermal and hydropower. The Government aims to increase the percentage of renewables, in particular, solar, to at least 7.5% of the total installed capacity by 2025 according to its energy policy 'Angola Energia 2025'.

The Government's main strategies for the energy sector are set out in its "Angola Energia 2025" policy, which sets the longer-term objectives for the energy sector. This document guides the development of the Ministry's 5-year action plans, the latest of which is the Ministry of Energy and Water's Sector Action Plan (2018-22) (Action Plan). These documents together set out the objectives relating to generation, expansion of transmission network, distribution network and private sector participation.

Angola Energia 2025 is targeting a national electrification rate of 60% by 2025. This means targeting a total of 9.9 GW of additional installed capacity, with (large-scale) hydro and gas to make up 66% and 19% of this mix respectively. In addition, the Action Plan sets out the Ministry's ambition to achieve 500MW installed capacity of renewables (that is, solar, wind, biomass and small hydro power plants by 2022), and to issue at least 40 power distribution licenses for isolated systems.

The plan further highlights that rural electrification targets will be achieved through mainly (>80%) off-grid systems (micro and mini-grids), with the remainder through grid extension. It is important to note that standalone systems, including SHS and systems electrifying public buildings and facilities are not counted toward the 60% target in the "Angola Energia 2025". These are expected to electrify a further 7% of the population.

Currently there are a handful of mini-grids in Angola, totalling 6.8% of total installed capacity ((REN21, 2018)).

At the time of publication of the 2025 Angola Energia Strategy documents, there were 8 solar/hybrid mini-grids, with others being diesel minigrids. The 8 solar-hybrid systems are utility owned, relatively large scale (around 3-5MW), and funded entirely by the government. They are located in Cabinda (2 projects), Tomba, Cunene, Chandongo, Benguela, Sansapombo and Uíge. The cost of these projects was approximately US$19m each, and they provide electricity for up to 12,000 people each. The two projects Cabinda are smaller than the others, at 2.5MW, each with 1MW from solar.

The Directorate within the Angola Ministry of Energy and Water (MINEA) currently responsible for rural electrification is under-resourced. Recognising the need for a more bespoke and clear approach to the regulatory framework for mini-grids, the GoA is trying to set up a specialised agency for rural electrification (INEL) and is seeking support from donors to establish this. The government is currently revising the renewable energy regulatory framework, which is expected to specify updated off-grid targets and provide a more appropriate framework for mini-grids. However, there is scepticism that this will happen in the near term based on the engagements held.

Three public companies were established in 2014 to be responsible for electricity generation, transmission and distribution; PRODEL, RNT and ENDE respectively. These companies were established following a reform to unbundle the power sector and allow for private sector participation in 2014. While the reforms were a positive step forward for the sector, the governance and regulatory frameworks still has a number of gaps, and areas that require further clarification, particularly in relation to the relationships and responsibility sharing between actors.

The Government has recognised the need for the involvement of the private sector to achieve its ambitious electrification targets. The Government has a clear objective to attract private sector investors into the energy sector. However, the Angolan private sector remains comparatively weak, hampered by decades of state intervention, corruption, weak governance and unfavourable policies. Indeed, the country's ease of doing business ranking was 173 out of 190 in 2018 (World Bank, 2019). With the oil crises of 2014 and a weakening public purse, the Government of Angola (GoA) now aims to reduce public expenditure in the sector, including reduction of fuel and electricity subsidies. This in turn has highlighted the need to improve sector institutional structure to attract private sector investments to meet its electricity generation, diversification and electricity access targets.

The regulatory environment is unclear, and lacks incentives for private sector participation in the electricity sector as a whole. It is our understanding that while there has been some private sector involvement in the development of larger-scale electricity generation projects, following construction and a couple of years of operation, the ownership and management of these projects is transferred to public sector bodies. The regulations allow for private sector participation in the sector, and the government is working to improve the regulatory environment (for example, with the publication of a new Draft Regulation for the Electricity Sector, and a draft model Power Purchase Agreement (PPA), recently released for public comment), however the current shortcomings have deterred private investment in the sector to date. Neither the Draft Regulation, nor the draft PPA model, addresses mini-grids specifically.

Presently, only a handful of private sector actors are involved in rural electrification, mainly with solar home systems (SHS). There is limited private sector participation in mini-grids in Angola. Most mini-grids in Angola are diesel systems publicly owned and operated (estimated to amount to a total capacity of 139MW (REN 21, 2018), and there is little information on these isolated diesel systems. With public entities being required to apply the national tariff (estimated at US$0.02/kWh for the social tariff applied in poor and rural areas), these systems are far from profitable.

Producers connected to the Public Electricity System establishes this connection through an Energy Purchase Agreement (PPA) signed with the Single Buyer (RNT-E.P). And the selling price is defined in the Energy Purchase Agreement. The tariffs approved by this Decree no longer contain the price subsidy, only operational subsidies (fuel) and investment by public companies that continue to be supported by the State, so they are not reflected in the tariff.

Outside of the public electricity system, electricity producers can enter into contractual agreements to sell electricity at cost-reflective tariffs. There is little evidence where this has occurred in Angola, and has not been applied in the case of mini-grids. It is unclear as to whether privately owned and operated mini-grids, selling to the public, would be considered part of the public electricity system, or would fall outside this system. This has implications too, for licencing processes and requirements for private mini-grids.

In order to address some of these issues, and encourage private sector participation in rural electrification, the Government is looking to establish a new agency for

rural electrification, the National Institute for Rural Electrification (INEL) and an accompanying Rural Electrification Fund (REF). A National Electrification Plan is also under development. It is unclear when these will be established/released.

A clearer regulatory environment and private sector incentives could unlock an estimated market for mini-grids of around $252.5m in Angola, based on average per capital annual spend on electricity in rural areas. This estimate was based on a market population size of 9.9 million potential customers in Angola; people who would be best served by mini-grids, who are currently without access to electricity. To arrive at this estimate, Angola's land area was segmented into three area categories — grid extension, mini-grid and standalone system (SHS) — based on distance between the existing transmission and distribution network and the population. Those best served by mini-grids are those outside of a 15km 'grid extensions buffer zone', and in areas where there is sufficient population density to justify this type of solution.

1. INTRODUCTION TO THE GREEN MINI-GRIDS 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 helps 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 required for successful mini-grid development;
- Strengthening capacity of developers to develop and operationalize 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 (https://greenminigrid.afdb.org/).

Phase 2 of the Market Development Programme is implemented, funded almost exclusively by SEFA, a multi-donor trust fund administered by the African Development Bank to support small- and medium-scale Renewable Energy (RE) and Energy Efficiency (EE) projects in Africa. SEFA supports private-sector led economic growth initiatives under three financing windows: project preparation, equity investments and enabling environment support.

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 seeks galvanise 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 coordination of the efforts of development partners to advance the adoption of GMGs. The MDP was designed from the beginning to be integrated and closely coordinated with the activities carried out in the framework of the Partnership.

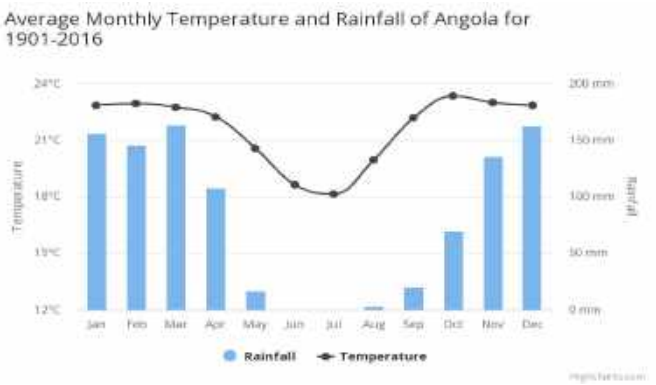
2. COUNTRY AND SECTOR OVERVIEW

2.1 Country Overview

Figure 1 Political Map of Angola (Source: Ontheworld Maps, 2019)

Located in the South-West of the African continent, Angola has a land area of 1,246,700 km2 and a population of nearly 31 million. Angola is bordered by Namibia to the south, Zambia to the east, the Democratic Republic of Congo (DRC) and Republic of Congo to the north, and the Atlantic Ocean to the west. Angola's population density is relatively low (24.71 people per km2), especially when compared with the sub-Saharan African (SSA) average of 50.76 people per km[1]. The population is largely concentrated in the western half of the country, particularly in urban areas and the capital, Luanda, as 65.5% of the population live in urban areas (World Bank, 2019). Angola is divided into 18 provinces, 164 municipalities, 44 districts and 518 communes.

Figure 2 Average Monthly Temperature and Rainfall of Angola 1901-2016 (Source: World Bank)



The country's climate is characterised by diverse climactic zones, influenced by maritime currents. The coastal region is semi-arid and narrow. Its interior is largely a plateau, with a warm and wet northern region, tropical central area and a semiarid southwest zone near the Kalahari Desert (USAID, 2018). Inland provinces experience pronounced dry and rainy seasons. In the centre of the country, the rainy season lasts from October to May, when precipitation can be up to 1500 mm and the dry season last from June to September as illustrated in Figure 2.

Climate change is negatively affecting average rainfall and temperature across the country. The average rainfall across the whole of Angola is around 600mm per year. However, due to climate change this has decreased at an average of 2mm per month per decade, the most significant decrease seen in the period of March to May (5mm decrease per month, per decade). At the same time, mean average temperature has increased 1.5 degrees since 1960, and the frequency of hot days, particularly in September-November, increased between 1960 and 2003 (World Bank, 2019).

The country experienced a 27-year long civil war from 1975 until 2002 which took a heavy toll on Angola's infrastructure, with roads, railways, and bridges built during Portuguese rule destroyed, along with much of the country's agricultural infrastructure. Much of the power sector infrastructure that was built before the country attained independence in 1975 was severely damaged during the war, and has not been upgraded since, nor has

1 Data extracted from the UN Department of Economic and Social Affairs https://population.un.org/wpp/

the infrastructure that survived the war been maintained adequately, in part due to war-related access problems. In the aftermath of the war, approximately 80% of the road network was left in extremely poor condition, the rail network barely functioned, electricity distribution was limited and unreliable, and water and sanitation services were poor in both urban and rural areas. (World Bank, 2018). It was estimated that almost 1.5 million people were killed and 4 million displaced during this civil war (CIA World Factbook, 2019).

Angola has maintained relative political stability since the end of the civil war in 2002, and recently experienced an important political transition with the election of João Manuel Gonçalves Lourenço as president in 2017, substituting Eduardo dos Santos who had been in power for 38 years. President Lourenço has made a commitment to improve the quality of life for all Angolans; to tackle widespread poverty and address the concentrated wealth.

The country's human development index score is low, at 147 out of 189 countries, with approximately 30% of Angolans living below the poverty line (living below US$1.90 per day) and large inequalities between rural and urban areas (UNDP, 2019). That said, the country has been addressing infrastructure deficits and the high poverty rates. As a result, life expectancy has increased from 41.7 in 1990 to 61.5 in 2016, though this is still below the average of 67.9 for lower middle-income countries (USAID, 2018). There are huge inequalities in income and livelihoods between urban and rural areas in Angola. Only 16% of the population in rural areas have access to electricity. The Gini index was 0.55 in 2017 (compared with a SSA average of around 0.43), with the top 20% of the population receiving 59% of all income compared with the bottom 20% receiving only 3% (Wiig, et al., 2018).

Angola is the sixth largest economy in SSA, at USD$92.2bn and is an oil-dependent economy, with the sector accounting for one third of GDP and more than 90% of exports (IMF, 2019). It is one of the least diversified economies in the world: oil and diamonds accounted for 96.5 % of exports in 2016 (IFC, 2019). This concentration makes Angola extremely susceptible to price fluctuations, with the country still experiencing the effects of lower oil prices and production levels following the 2014 crash in oil prices. This meant GDP growth collapsed in 2015, reaching -2.58% in 2016. The average growth in GDP in 2018 was -2.1%, and the IMF predicted only 0.3% growth for 2019, and inflation of 17.5%. Prior to the economic crisis from the sharp fall in oil prices, Angola had experienced considerable economic growth (average annual growth of 12.5% between 2006 and 2015), driven by the oil sector. The country's more recent economic woes have prompted significant cuts in public spending, delaying State payments and putting restrictions on foreign currency supplies. Angola's economic activity by sector comprises 50.4% from agriculture, 40.8% from services and 8.7% from industry.

The new President committed to addressing the country's economic challenges, setting a reform agenda targeting macroeconomic stability and growth through the following interventions:

- The presidency, in January 2018, launched, and began to implement the Programa de Estabilização Macroeconomica (PEM, Macroeconomic Stabilisation Plan). The PEM envisages a reduction in public debt through 'fiscal consolidation' (including a reduction in public expenditure, addressing the number of public employees and state-owned entities), the implementation of anti-money laundering legislation, and greater exchange rate flexibility with a move to a more market-based exchange rate (IMF, 2018). Since the announcement to end the peg of the Kwanza (the local currency) against the US Dollar, the Kwanza has since depreciated close to 100% (World Bank, 2019).

- The new administration is also targeting structural reforms to foster growth in the private sector. The release of a new Private Investment Law and Law on Competition aims to facilitate foreign direct investment easier. Further, the government is launching a programme aiming to diversify exports, substituting imports, promoting competition domestically, and address monopolistic practices. The president is further targeting improving governance and addressing corruption which has remained in recent years, and hampered private sector investment in the economy (IMF, 2018). Political influence has been prevalent throughout many areas of the business environment, with and business seen as inextricably linked.

Government is prioritising the need to address the economy's vulnerabilities by diversifying away from oil, since the oil crisis is severely cutting tax revenues and exports and halting economic growth. Services trade was identified as a key sector to promote sustained economic growth and human development, and the is keen to expand the technical skills of Angolans to support this.

Since the end of the war, infrastructure and human capital development have been limited, which has hindered the

diversification of the economy. The huge need to rebuild following the civil war has only been partially addressed. Only 20% of Angolan roads are paved and only one third of the country's population has access to electricity (IFC, 2019). The country also ranks behind the SSA average (0.36 to 0.40) in the World Bank Human Capital Index, which measures how much capital countries lose through lack of education and health (IFC, 2019). The government appears to be committed to addressing this "dramatic loss of potential", with the Minister of Economy and Planning revealing in early 2019 the initial steps the country will be taking towards developing healthy and productive human capital, in its draft Human Capital Strategy (World Bank, 2019). Between 2004 and 2016, school enrolment increased from 2.2 to 10 million, though these gains have been mostly in primary education only, as secondary and tertiary levels are well behind Sub Saharan African (SSA).

The ICT market is likewise underdeveloped, especially when compared to other countries in SSA. Mobile phone access in Angola is relatively low, and very poor in remote areas. Mobile phone penetration in Angola is below the SSA average, at 46 per 100 people in 2017, compared with 74. While coverage is relatively good for the west of the country, in some remote parts of the country, particularly in the south east regions of Cuando Cubango and Moxico, coverage is poor, or even non-existent. There is a lack of competition in the market, with Unitel being the dominant operator. Telecommunications access is also expensive compared to neighbouring countries (IFC, 2019).

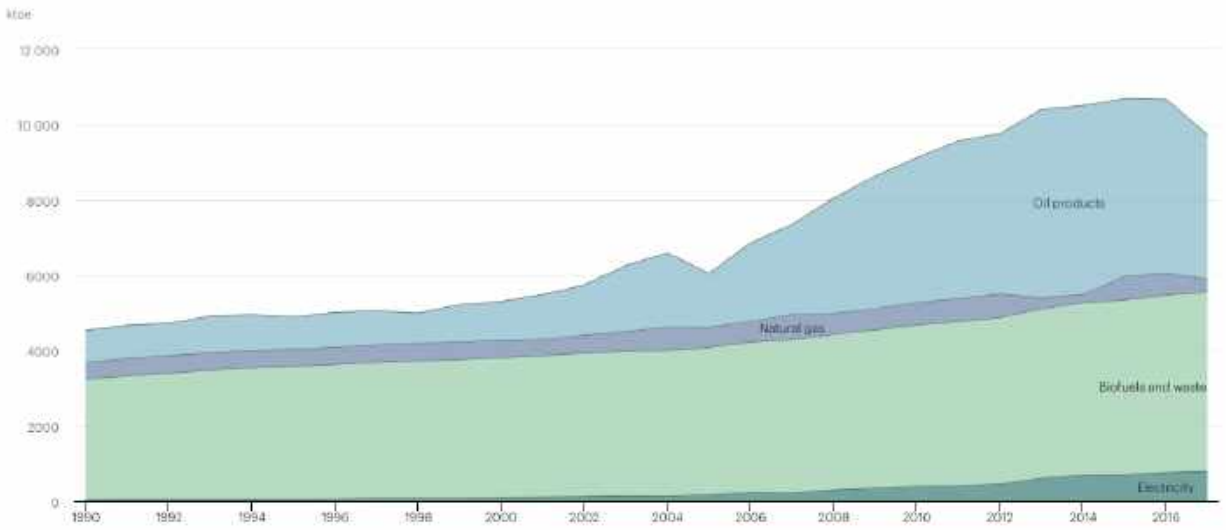
The country's ease of doing business ranking was 173 out of 190 in 2018 (World Bank, 2019). Decades of state intervention, corruption, weak governance and unfavourable policies has made private sector weak, hence reducing the country's ability to leverage the rich natural resources, including its arable land. Private capital contribution to growth is very limited, with growth being driven largely by public spending. Consumption has been driven by the high oil prices, with any growth in finance, distribution and construction being largely been connected to the oil sector. Economic diversification is furthered hampered by underperforming, dominant state-owned enterprises and the prevalence of politically connected interests. The government has made large investments in agriculture and manufacturing, but these sectors have failed to take off, having not seen much spill over from the rest of the economy. Access to electricity remains the biggest infrastructure challenge for the emergence of processing and irrigated agriculture (IFC, 2019).

2.2 Overview of the Energy Sector

2.2.1 Energy Mix, Emissions and Trends

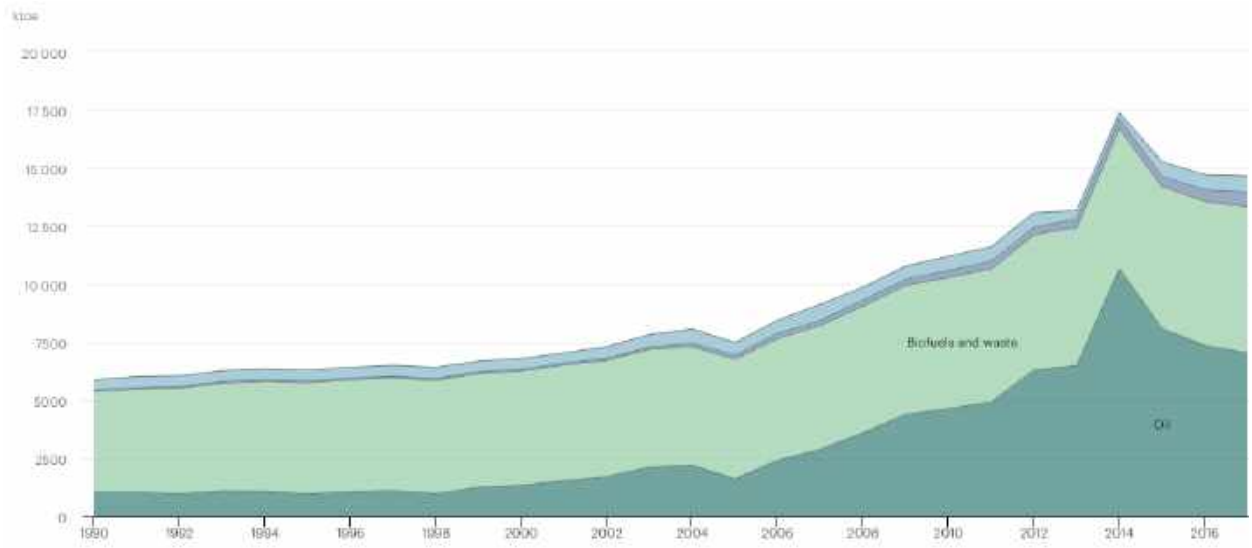
The average energy consumption per capita in Angola is low, averaging at 544 kg of oil equivalent per year in 2014, compared to a 686 kg average for SSA (IEA , 2017). Total final consumption of energy by source in 2017 was 9.716Mtoe, with the mix being dominated by oil products (39%), followed by biofuels and waste (49%). While biofuels consumption for energy has steadily increased since 1990, oil products consumption increased more than 4.4 times between 1990 and 2016, which may be attributed to increased economic activity after the end of the civil war(see Figure 3, below).

Figure 3 Total Final Consumption (TFC) by Source, Angola 1990-2017 (Source : IEA, 2017)



Total primary energy supply was 14.68Mtoe in 2017, again, biofuels and waste and oil making up 42.77% and 48.01% of the mix respectively. Natural gas and hydro both represented less than 5% of the total. The total primary energy supply peaked in 2014 with 17.34Mtoe, having steadily increased since 1990 from 5.88Mtoe (see Figure 4).

Figure 4 Total Primary Energy Supply (TPES) by Source 1990-2017 (IEA, 2019)

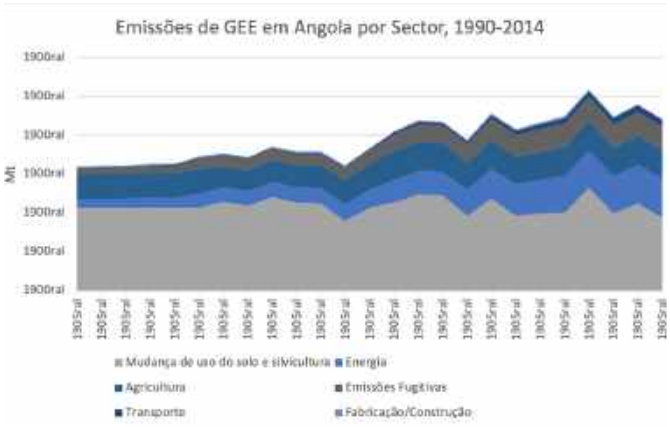


Angola's net energy imports (energy use less production) in 2017 were -76.0Mtoe, which means, Angola is a net exporter (IEA, 2019). The country's economy is highly dependent on revenue from oil exports and having faced unstable oil prices in the last decade in particular, this has been the cause of volatility in macroeconomic variables such as GDP growth, inflation, exchange rates and debt.

In 2014, the government began implementing a subsidy reform programme to eliminate subsidies on most fuel products by the end of 2015. This was largely prompted by the oil price crisis, which had begun to impact revenues and threatened fiscal balance. In 2012, fuel prices in Angola were among the lowest in SSA at around US$0.5 per litre for diesel and gasoline which were 55 and 67% below the average price for SSA, respectively. (World Bank, 2016). The subsidy reforms removed all fuel subsidies with the exception of a 40% subsidy for LPG and a 10% subsidy for kerosene. Reforms were not met with a great deal of social resistance, as they coincided with the dramatic drop in the oil price, and the implementation of social protection programmes supported by the World Bank, which alleviated some of the economic impacts on the poor (EIA, 2019). Even with the gradual recovery of international oil prices, no fuel price adjustments have been made since 2015, according to the IFC, which has led to the emergence of implicit fuel price subsidies (IFC, 2019). In 2019, the finance ministry announced it would offer new fuel subsidies for the agriculture and fishing sectors to boost food production, though this has been criticised by the IMF (Mendes, 2019).

Angola's total GHG emissions in 2014 was 252.09 MtCO2e, representing around 0.52% of global emissions (Figure 5). Land-use change and forestry is the largest source of emissions, accounting for 49.4% of the total share, followed by 28% from the energy sector, 20.8% from agriculture, 16.7% from fugitive emissions and 4.7% from transport (ClimateWatch, 2019).

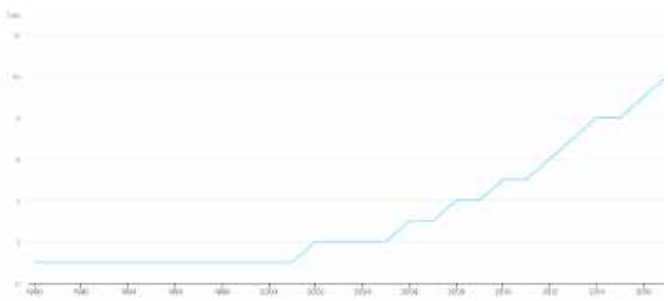
Figure 5 Angola GHG Emissions by Sector 1990-2014 (Source: ClimateWatch, 2019)



Electricity demand has grown significantly in recent years and continues to grow in Angola. Electricity final consumption grew by over 400% in the decade between

2004 and 2014 (IEA, 2019), driven by sustained economic growth following the end of the civil war in 2002 (World Bank, 2019), see Figure 6. The IEA estimates that in 2017, total electricity final consumption in Angola was 10TWh, with per capita consumption at 0.3MWh. The residential and industrial sectors accounted for 66% and 33% of this demand, respectively (IEA, 2019). This demand is expected to continue, with MINEA forecasting a total demand of 39.1TWh (and 1.23MWh per capita) in 2025 in its Angola Energia 2025 Strategy document, and a required installed capacity of 7.2GW to meet this demand. MINEA anticipates that the residential sector will account for 37% of this demand, followed by the services sector 28% and industry, 25%. The Ministry anticipates that this growth in demand will be driven by the 60% electrification target, coupled with population growth and furthered economic development (MINEA, 2017).

Figure 10 Electricity Final Consumption per capita in Angola 1990-2016 Source: IEA 2019

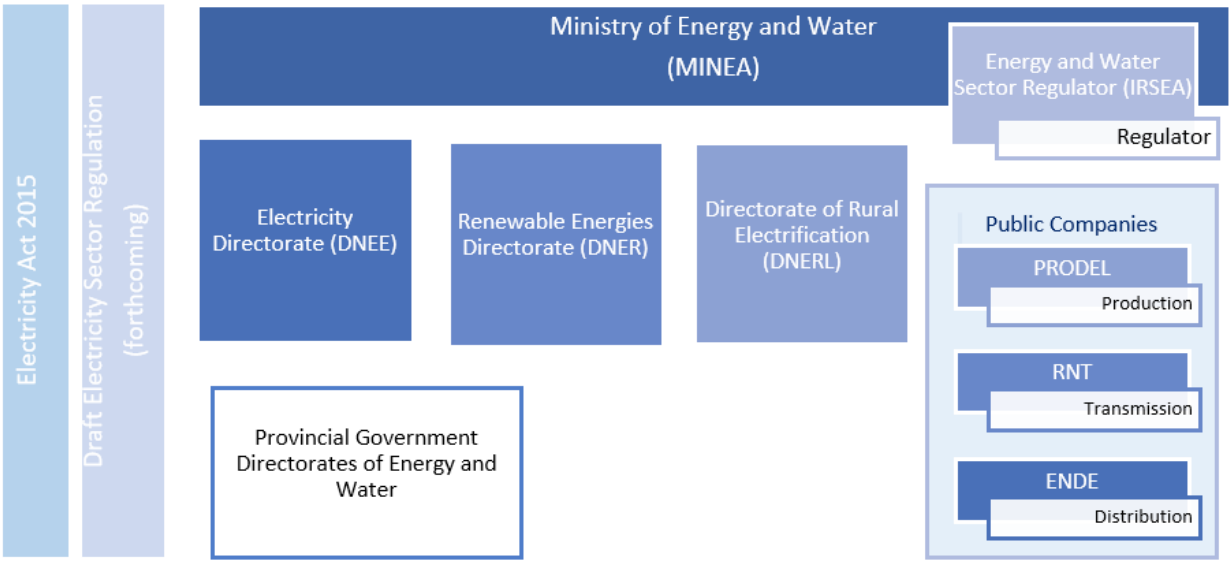


Angola's Draft Intended Nationally Determined Contribution (INDC) set out an unconditional commitment to cut GHG emissions by 35% below the business as usual (BAU) scenario (base year 2005) by 2030 through increasing the share of renewable energy in the country's energy mix, the stabilisation of emissions in the agricultural sector, industrial sector, and in land use and forestry. It also provides for an additional 15% reduction under a conditional mitigation scenario. The total 50% emissions reduction figure is forecast to require an investment of more than 14.7billion USD (Government of Angola, 2015).

2.2.2 Key Energy and Electricity Sector Stakeholders

Oversight of the power sector is entrusted to the Ministério da Energia e Águas (MINEA, Ministry of Energy and Water). Under the Ministry, are several Directorates, including the Directorate for Rural Electrification. The national regulatory agency is the Instituto Regulador dos Servicos de Electricidade e de Agua (IRSEA, Regulatory Institute for Electricity and Water Services. The Instituto Regulador do Sector Electrico (IRSE, Regulatory Institute of the Electric Sector) falls under IRSEA and is the institute that specifically regulates the electricity sector. IRSEA was officially established in 2015 by an amendment to the presidential decree No. 59/16, however due to capacity constraints has had limited capacity and autonomy.

Figure 6: Overview of key public sector actors in the Angolan Energy Sector. Souce: Carbon Trust Analysis



A reform to unbundle the Angolan power sector was launched in 2014. The Presidential Decree 305/14 provided for the cessation of the State-Owned Enterprises (SOEs) and the then vertically integrated utilities: the Empresa Nacional de Eletricidade (ENE, National Electricity Company) and the Empresa distribuidora de Eletricidade (EDEL, National Electricity Transmission Company). ENE was, until 2014, the national utility in charge of generation, transmission and distribution in Angola, while EDEL was responsible for the distribution of electricity in Luanda (the capital). Following the unbundling, three state-owned enterprises were created:

a. Empresa Publica de Produção de Eletricidade (PRODEL, Public Company for Electricity Generation);

b. Rede Nacional de transportes de Eletricidade (RNT, National Electricity Transmission Network); and;

c. Empresa Nacional de distribuição de Eletricidade (ENDE, National Electricity Distribution Company) (see Table 1).

PRODEL, as well as IPPs are responsible for the country's electricity generation. PRODEL's sole mandate is to produce electricity and manages almost 90% of the country's generation capacity. PRODEL responsible for generation assets larger than 5MW. The generation sector is open to IPPs. There are few private companies with PPAs and their total generation accounts for less than 10% of the total installed capacity. A notable IPP is African Energy.

RNT and ENDE are responsible for transmitting and distributing electricity, respectively. RNT transmits electricity through the National Electricity Transmission System, which comprises the high voltage grid, interconnection network, national dispatching facilities and related goods and rights, in parallel with the function of the market operator (sole off-taker). ENDE's role is the distribution, commercialization and sale of electricity at the national level, through the public distribution networks (also sometimes referred to as the public electricity system, (PES)), including high, medium and low voltage lines. Distribution is carried out under a public service concession or by a license when exercised in isolated systems (including mini-grids).

The primary institutional actor in rural electrification and energy access is MINEA through the Directorate of Rural Electrification. There is currently no rural electrification agency. The main role of the Directorate is to promote electrification outside of urban areas. However, the capacity of the Directorate is limited, due to lack of funding for the implementation and management of electrification projects. Recognising the Directorate's current limitations, the government is looking to establish a new agency for rural electrification, the National Institute for Rural Electrification (INEL) and an accompanying Rural Electrification Fund (REF). The MINEA is currently looking for support from its development partners to support the design and implementation of these entities and outline their functions. Following this, legislation to define the roles of the institutions would need to be enacted before they could be operational. At time of writing, progress on the establishment of the entities has been slow.

Table 1 (below) presents the primary public sector entities that make up the institutional framework in the energy sector.

Table 1 Key actors of the energy sector in Angola and their mission

Entity	Description and Responsibilities
Ministério da Energia e Águas (MINEA) Ministry of Energy and Water	• Overall sector oversight • Prepares and implements energy policies and strategies
Instituto Regulador do Sector Electrico e de Aguas (IRSEA) Regulatory Institute of the Electric and Water Sector[2]	• Oversees sector regulation • Regulates the activities and service quality of entities involved in the generation, transmission, distribution and commercialisation of electrical energy in the public system (Quality of services is provided for by Presidential Decree nº310 of 2010) • Regulates the electricity tariff and verifies compliance with established standards (in accordance with the Presidential Decree nº4 of 2011).
Empresa Publica de Produção de eletricidade (PRODEL) Public Company for Electricity Generation	• Responsible for electricity generation • Manages all public generating assets of 5MW or more (that is, over 90% of electricity production assets in Angola)
Rede Nacional de transportes de Eletricidade (RNT) National Electricity Transmission Network	• The commercial agent for the electrical sector, RNT is responsible for electricity transmission through the management of high voltage lines and the interconnectors. • Manages contractual processes for buying and selling electricity, monitors the sector's competitiveness • Electricity off-taker
Empresa Nacional de distribuição de Eletricidade (ENDE) National Electricity Distribution Company	• Responsible for electricity distribution • Responsible for grid extension • Operate and manage the distribution network and all lines of 60KV and below
Gabinete de Aproveitamento do Medio Kwanza (GAMEKE) Cabinet of Middle Kwanza River Development	• Utility company responsible for implementing and managing the hydro projects in the Kwanza river • Has been expanded to include oversight of the development and construction of most major hydropower projects in the country.
Independent Power Producers	• There are a limited number of IPPs in Angola currently. It is anticipated these entered an agreement with RNT based on the single buyer model used in Angola. There is currently a new entity being created with the financial support of the African Development Bank to establish the Energy Project Implementation Support Unit (EPISU) which establish a structure for contracting independent power producers (IPPs) in Angola. Limited additional information was available at the time of writing this report.

2 As part of the wider Instituto Regulador dos Serviços de Eletricidade e de Águas (IRSEA, Regulatory Institute for Electricity and Water Services

2.2.3 Energy Policies, Strategies, Targets, Roadmaps, Plans and Programmes

Strategies and Action Plans

- Angola Energia 2025 is the main long-term strategy for Angola's energy sector and provides objectives for the period 2018-2025. The high-level objectives of the strategy are to promote sustainable, equitable, economic and human development, to be achieved through the expansion of generation capacity, the increase of renewable energies in the generation mix and the extension and improvement of the grid. Recognising the vast financial resources required to attain such objectives (approximately US$23 billion), the mobilisation of private sector capital is highlighted as a further aim in the document. To support investments, the vision is to ensure electricity tariffs are gradually increased to be more aligned to cost, and those charged in the wider region (MINEA, 2014). The following aims and objectives for the sector are set out in the document:
- Demand: The 2025 strategy forecasts the electricity peak demand to reach 7.2GW by 2025, which is a four-fold increase from peak demand in 2014 driven by industrialisation, the growth of the services sector and increased electrification (60% of the population by 2025).
- Rural electrification: the National Institute for Rural Electrification (yet to be set up) will be responsible for rural electrification:
  - Grid extension will be the priority where there is the economic rationale to do so (generally municipal townships);
  - Isolated systems have been prioritised as the means for electrification for 31 locations in Angola. Seven will be by mini-hydro (serving 9 townships) and one medium-sized hydro site was identified on the river Cuango, which has the potential to supply power to four municipalities with a population of more than 300,000 people. The remaining sites will be served by diesel generators and solar systems;
  - Individual (standalone solar) systems, seen as an intermediate solution, will provide electrification to community buildings in several towns and settlements. The 2025 strategy also mentions provision by MINEA of additional solar lanterns and cook-stoves to remote villages.
- Supply/Generation: The primary options for increasing generation capacity in Angola include hydro, thermal and new renewable energies. The government is targeting a total of 9.9 GW of installed capacity, with (large-scale) hydro and gas to make up 66% and 19% of this mix respectively, and the remainder to come from a mix of renewables (see later).
- Abastecimento/Geração: As principais opções para aumentar a capacidade de geração em Angola incluem as energias hídrica, térmica e novas energias renováveis. O governo tem como objectivo um total de 9,9 GW de capacidade instalada, com a hidroeléctrica (em larga escala) e o gás a representarem 66% e 19% desta mistura, respectivamente, e o restante a provir de uma mistura de energias renováveis (ver mais adiante).

The below chart (Figure 7) shows the breakdown by technology of the 60% electrification target. 54% of those electrified by 2025 will be in urban centres, with a further 5% of the population being electrified through grid extension, and 1% via mini-grids (which would equate to 99MW of the installed capacity in 2025). Note that those to be electrified via individual systems, including systems for the electrification of community centres and other public buildings are not counted under the 60% target. These systems represent a further 7% of the population. The target would therefore be, if these systems were counted, 67% of the total population electrified by 2025.

Currently, only 42% of Angolans have access to electricity, 16% have access in rural areas, and 72% in urban areas (SEforAll, 2019)(World Bank, 2019). Having achieved 67% electrification by 2025, Angola Energia 2025 suggests a further 33% percent of the population would be electrified through grid extension in the years after 2025 to achieve universal access for all Angolans. However, no further details were provided for the additional 33%.

Figure 7 Electrification target 2025 broken down by technology. Source: MINEA 2014

The Atlas and National Strategy for New Renewable Energies, is linked to the Angola Energia 2025 strategy, though has been published as a separate document. Based on the 2025 strategy, it provides further details around new renewable energies plans and targets, including the objective of achieving 800MW of generation capacity with solar, biomass, wind and small hydro (to contribute to the 9.9GW target discussed above). The Atlas section presents renewable energy potential studies, and potential project sites across the provinces. Around 680 projects were identified, resulting in a total potential capacity of more than 40 GW of renewable projects (specifically those with the potential to be grid connected in the near term). The Strategic goals and targets (set out in further detail in Table 3 below) within the National Strategy for New Renewable Energies include:

- Improving electricity access in rural areas through establishing the dedicated National Institute for Rural Electrification (INEL);
- Supplying power to 500 villages through solar and small hydro systems;
- Developing 800MW of new renewables, both on and off grid;
- Establishing a Research Centre for Renewable Energy;
- In line with the above, establishing of at least one Training Centre dedicated to renewable energies;
- Approving legislation specific to new renewable energy, including rules for grid connection;
- Approving subsidized tariffs (FiT) for renewables up to 10 MW and to review taxation;
- Providing 1,000 million of Kz (equivalent to 2 million USD) per year to FUNEL and establishment of micro, mini and small-scale credit mechanisms; and
- Capacity building and communication.

The 2018-2022 Action Plan for the Energy and Water Sector sets out the sector's medium-term strategy. The action plan is based on the targets set out in the long-term strategy Angola Energia 2025 document. The timeframe aligns the Sector Action Plan with the Angolan National Development Plan (NDP 2018-2022) which aims to foster sustainable, inclusive growth and human development, through enhancing competitiveness beyond the oil sector, as well as improve governance and national institutions. It is split into 3 development programmes and sub-programmes, which cover (i) electricity access in rural and urban areas, (ii) optimisation of the energy sector management and (iii) private sector participation. This updated Energy and Water Sector Action Plan targets to achieve 7.5GW installed capacity in 2022, and an average electrification rate of 50%, estimated to require a total investment of US$13.6 billion.

At the time of writing, the Angola Energia 2040 Strategy was in development, but not yet publicly available. It is expected to include updated sector targets based on what has been achieved over the past few years and will further emphasise the importance of attracting private sector investments. As the 5-year Action Plans are based on the long-term Angola Energia strategy documents, the Action Plan for the 2023 – 2027 period will be based on the Angola Energia 2040 Strategy.

The government is developing a National Electrification Plan with support from donors such as the AfDB and the World Bank. The World Bank and the AfDB are supporting MINEA in establishing the National Institute for Rural Electrification, as set out in the Ministry's strategy documents. The AfDB will also be providing support, along with UNDP, to initiate a rural electrification strategy. The rural electrification strategy is envisaged to include: (i) an assessment of institutional options (such as concessions, or cooperatives, (ii) financing options and (iii) a clear demarcation of regions best served by grid extension, mini-grid and other off-grid technologies, and finally (iv) fiscal incentives, including tax and duty exemptions (AfDB , 2019).

Government of Angola (GoA) Sector Plans

The Angolan has committed to a Programa de Transformação para o Sector Energético (PTSE, Transformation Programme for the Energy Sector) in order

to implement the ambitious Angola Energia 2025 Strategy. The programme is intended to ensure the economic and financial sustainability of the sector, and is aimed at meeting the targets set out in the Strategy document.

Table 3 below presents an overview of the main sector energy sector plans in Angola chronologically, with more details about targets and spilt between grid connected and off-grid. The Government is currently working with various donors to support the required key interventions.

Table 2 Key Energy Sector Strategy Documents for Angola chronologically

Strategy document	Period	Description	Key Targets
Angola Energia 2025 (MINEA, 2014)	To 2025	This is the Angola Power Sector Long Term Vision, which sets out the goal for human development and sustainable economy growth.	Electrification to increase to 60% by 2025 9.9 GW installed capacity by 2025 At least 7.5% of the electricity generated in the country will come from new renewable energies, foreseeing the installation of 800 MW (these are detailed in the Strategy for the New Renewables, below).
Atlas and National Strategy for the New Renewables (MINEA, 2014)	To 2025	This strategy puts forward the 's goal of promoting the diversification of the national energy mix. It also presents the high-level strategy for Rural Electrification, rural development and poverty reduction. It is organised in two parts: Part I: National Strategy: sets out the principles and strategic direction guiding the promotion and development of new renewable energy sources in Angola, concentrating on solar, wind and biomass, and small hydro Part II: Renewable Energy Atlas and Projects: This presents the results of potential studies and projects.	As with the Angola Energia 2025, energy generated by new renewables exceeds 7.5% of the energy produced, (about 3 TWh, being expected for that installation of 800 MW), by 2025 The strategic goals to meet this target includes: 1. Improve access to energy services in rural areas based on renewables, including: – Establishing the National Institute for Rural Electrification (INEL) and in parallel the creation of the National Electrification Fund, (FUNEL) which will be organized and managed by INEL. – Source: MINEA – Increasing solar/renewables powered villages by 500 (more than 10MW of solar and 50 systems based on micro or pico-hydro), – Increasing agricultural communities with access to renewable energies for productive uses by 200). 2. Develop use of new renewables connected to the grid, including: – Implementation of 100 MW of solar energy plants, of which 10 MW are off-grid – Implementation of 100 MW of mini-hydro – Implementation of 450 MW of forest and agro-industrial biomass projects – Implementation of 50 MW with urban waste – Implementation of 100 MW distributed by 2 to 3 wind farms across the territory – Establishment of a Research Centre for Renewable Energy 3. Promote and accelerate public and private investment in new renewables, including: – To approve specific legislation for renewable energies, including rules for grid connection – To approve subsidized tariffs (FiT) for renewables up to 10 MW and to review taxation – To provide 1,000 million of Kz per year to FUNEL and establishment of micro, mini and small-scale credit mechanisms – Capacity building and communication – Establishment of at least one Training Centre dedicated to renewable energies Launch a communication campaign on renewable energies

Action Plan for the Energy and Water Sector (MINEA, 2018)	2018 – 2022	This Action Plan is the Medium-Term Vision for the sector and is based on the Angola Energia 2025 Strategy. The Plan establishes the priorities and projects for the development of the sector over the 5 years, (2018-22) through 3 main initiatives: 1. Expansion of Access to Electricity; 2. Optimization and Sustainable Management of the Electric Sector and 3. Private Participation in the Electricity Sector	• 50% of nationwide electrification rate by 2022, (corresponding to reaching a total of 2.6 million customers by 2022, and ensuring this access be equitable – including a minimum electrification rate of 20% in all provinces) • 7.5 GW total installed capacity (5.4GW available in 2022 by PRODEL) • To surpass 1.5 GW of installed power from the private sector in 2022 • To achieve 500 MW (of the 800 MW mentioned in the Angola Energia 2025) installed capacity (of the 7.5GW) through solar, wind, biomass and small hydro power plants by 2022. • To issue at least 40 power distribution licenses in isolated systems • 100,000 solar home systems imported and distributed.
Angola Energia 2040 (MINEA, forthcoming)	To 2040	As Angola Energia 2025 was published in 2014, with longer-term vision based largely on expectations of where the sector would be by 2017, MINEA is updating the long-term strategy. This updated strategy document, which extends the long-term vision time horizon to 2040, is due to be published shortly.	Forthcoming
National Electrification Action Plan (NEAP) (MINEA, forthcoming)	-	Along with the establishment of the National Institute for Rural Electrification, a rural electrification action plan or strategy is to be developed.	Forthcoming/No details available

Government of Angola Laws and Regulations

The main law that governs the electricity sector in Angola is the General Electricity Act (modified in 2015) Law No. 14-A/96 of 31 May. This establishes the legal framework around the generation, transmission, distribution and use of electricity as illustrated in Figure 8. This law codified the restructuring of the sector and unbundling reforms and also established the legal framework for independent power producers (IPPs). The Act was developed to increase private sector participation, as IPPs are almost non-existent in Angola at present. The 2015 law theoretically opened up the entire supply chain to the private sector, including concessions for generation, transmission and distribution. Licences for distribution and commercialisation of isolated systems, including mini-grids, were also provided for. However, to date very few private projects have gone ahead.

The Angola Private Investment Law (APIL), which entered into force on June 26, 2018, establishes guiding principles and requirements of private sector investments in Angola. The production and distribution of Electric Energy is considered by APIL as a priority sector, and there are tax benefits associated with investments in priority sectors (anything between 25 and up to 85%, for a period of 10 years[3]). The provisions set out in the Regulation cover the entire cycle of the Investment Projects from (i) the submission of the investment proposal, (ii) its approval, (iii) execution and (iv) cancellation of private investment registration. However, the authors were unable to identify any energy related projects profiting from this law.

The Draft Regulation on the Generation, Transmission, Distribution and commercialisation of Electricity, released late in 2019 for public comment, brings electricity sector regulations together, alongside licensing procedures for isolated systems, including mini-grids. The activities in the Draft Regulation are subject to further regulations, including the Independent Power Regulation, the Tariff Regulation, Regulation of Licencing of Generation, Transmission and Distribution.

For the purposes of the Electricity Law and Regulations, the Angolan National Electricity System is divided into two separate segments:

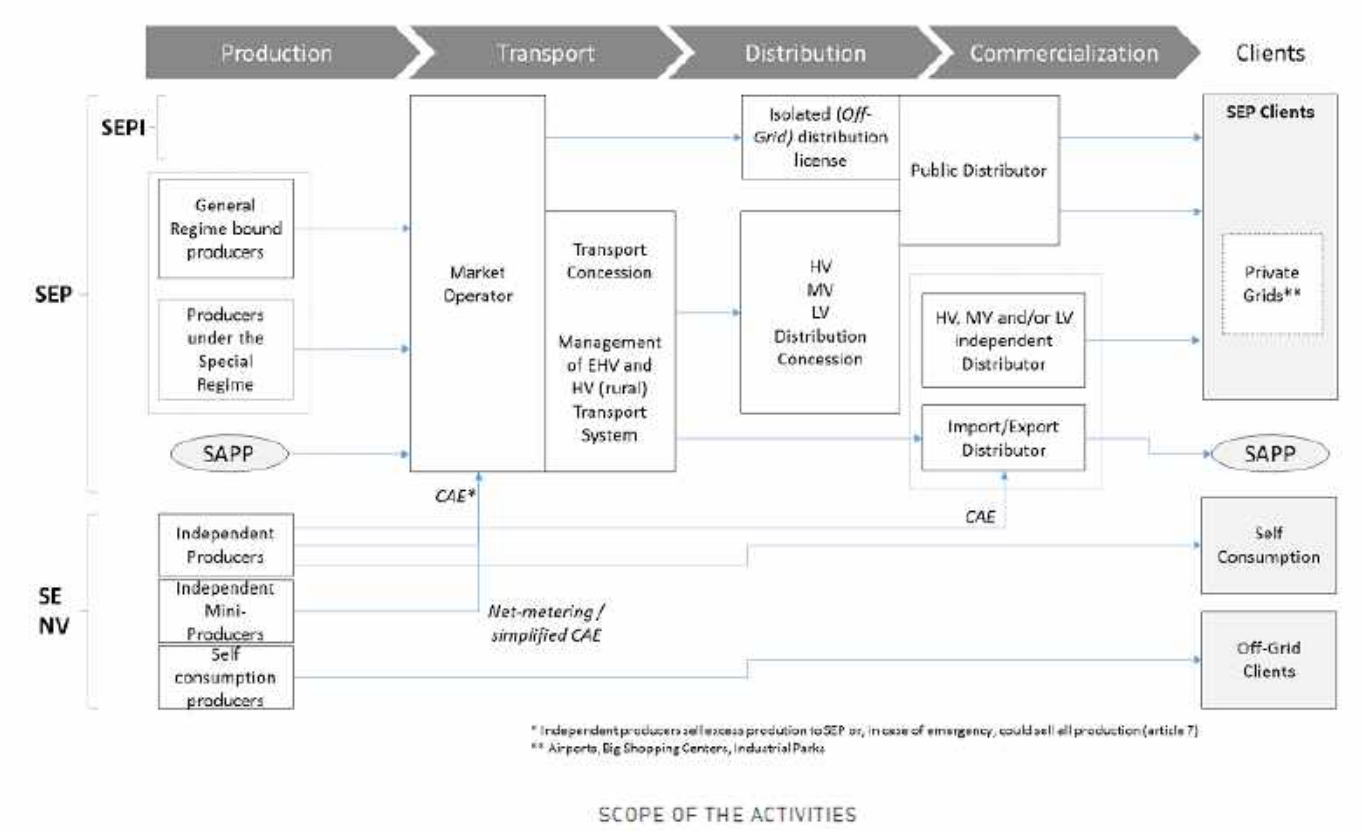
1. The Serviço Eléctrico Público (SEP, Public Electricity Service), where the national tariff applies to all activities where the provision of electricity is primarily to the public. Isolated systems (up to 5MW) and generation from renewable resources (excluding hydro projects bigger than 10MW) are covered under a 'special regime'. Here, special provisions and rules apply, for example, in obtaining production concessions, which are linked to the Government's renewable energy targets.

2. The Sistema Eléctrico Não Vinculado (SENV, Unlinked Electrical System): Where the activity is considered to be outside of the scope of the SEP, it is considered SENV. This is still part of the National Electricity System as a whole but is another 'subsystem'. For activities under the SENV, the national tariff may not apply and a bilateral contractual agreement between producers and consumers can be established. SENV covers independent producers where electricity is only partially intended for public supply, and self-production (i.e. electricity generated is not intended for public supply). The SENV includes:

   - independent production;
   - self- production; and;
   - the private supply of isolated electrical systems.

3 https://furtherafrica.com/2018/11/27/understanding-angola-new-regulation-on-private-investment-law/

Figure 9 Scope of Activities under the General Electricity Act (Source : (Gesto Energy, 2016))



The General Electricity Law Amended by Law No. 27/15, of 14 December indicates a private operator hwith a distribution license, for an isolated system, can sell his energy to final consumers within the isolated system. However, specific regulations are missing to clearly define private mini-grids, nor sets out the framework allowing private entities to sell directly to end customers. The SEP covers 'isolated systems' (up to 5MW), however it appears as though this may only apply to publicly owned mini-grids. Private isolated systems, used for self-production, fall under the SENV, however, it is unclear if the SENV would also cover isolated systems where private entities would sell to end customers.

The way private mini-grids are treated under the law has implications for licensing and the allowable tariffs. This ambiguity has impacted the ambition of the private sector to enter into the mini-grid market. The Draft Regulation is, at the time of writing, available for public comment. The finalised regulation may include specific provisions for privately owned mini-grids. It is anticipated that the establishment of the National Institute for Rural Electrification will be accompanied by a clear and refined regulatory framework for rural electrification, specifically addressing mini-grids.

2.2.4 Other donor support projects and programmes

Most donor programmes focus on creating an environment that facilitates renewable energy deployment from IPPs. The World Bank and the AfDB are the primary actors, providing support to MINEA to realise its ambitious Transformation for the Electricity Sector Programme. Key projects include the current Electricity Sector Improvement Project of the World Bank, where support is targeting the three public entities, PRODEL, ENDE and RNT. The EU has provided support for the development of a model PPA which has been released for comment in Draft form at time of writing. The AfDB's support has included broad technical assistance support across the sector, particularly in further developing and strengthening the legal and regulatory frameworks for the sector. The below table summarises some of the donor initiatives that have contributed to the government's Transformation Programme.

Table 3 Selected Donor Supported Projects and Programmes related to the Energy Sector in Angola

Donor / Implementing Agency	Description
World Bank	Electricity Sector Improvement Project: The World Bank is providing $250m of support to improve the operational and commercial performance of the electricity sector utilities and increase electricity access in selected cities in Angola. The project consists of three components: (i) the first focuses on improving the performance of the transmission network to enhance reliability (working with RNT), (ii) the second is working with ENDE to improve its performance, including through a revenue improvement programme, and financing grid expansion in selected areas. And (iii), the project will provide technical assistance at the utility level and support for project implementation, working with RNT on its planning capacity, PRODEL on improving its generation capacity, more specifically hydropower, and with MINEA to establish a Project Implementation Unit(World Bank, 2018) The World Bank is also conducting a study of least cost electrification options in rural areas, looking at three main options: i.e. grid extension, mini-grid and SHS. At the time of writing, results from this study are not yet available. Scaling Solar programme: This programme is aimed at promoting private investment in on-grid PV solar projects in Africa in the period 2018-2022. MINEA presented plans for Angola to join this programme at the end of 2018. Several sites for solar parks have been identified, but the programme is its initiation phase with limited details finalised to date. World Bank ENDE Project: This ENDE project is aimed at 4 cities in Angola's 4 most densely populated provinces, namely Luanda, Benguela, Huambo and Lubango, focusing on increasing the rate of access to electricity, through the densification of the low voltage network. On the other hand, in order to improve the existing tariff structure for electricity services, including subsidization for low-income consumers, there is a study underway, financed by the World Bank, regarding the correct assessment of the costs of services in the Public Electric Sector, in its most different value chains, in order to strengthen the capacity of the Tariff Setting Structure, as well as increase the financial viability of the Electric Sector, through mechanisms that should be implemented to establish the annual revenue requirements
Global Environmental Facility (GEF)	Promoting Sustainable Energy Access for Rural Communities in South Eastern Angola: Approved in 2018, this US$ 24.7m programme aims to catalyse investments in decentralised renewable energy systems. There are three components to this programme: (i) the first being technical assistance support for policy de-risking for decentralised renewables. This component centres on the building of a favourable environment for private sector participation in small-scale renewables. This will be done through assessing successful renewables diffusion in the region to identify key success factors and the potential to introduce the technologies into Angola, looking to the establishment of microfinance options and mobile payment models in the South Eastern Region. (ii) The second component is focused on the development of the off-grid renewables market (including SHS, cook stoves and solar lanterns). It will try to address barriers related to last mile distribution, technology awareness issues and limited human capital in the sector. Finally, (iii) the third is an outreach programme, aimed at sharing lessons learned, including through cooperation with technical institutes, and universities (GEF, 2019). The programme is being implemented by the United Nations Development Programme (UNDP). At the time of writing, this programme's focus is on promoting SHS, and not mini-grids.

AfDB and SEFA	The AfDB provided an US$1bn Electricity Sector Transformation Program Loan in 2014, supporting major reforms and restructuring in the sector. The programme aimed to strengthen public sector financial management, through fostering private sector investment, enhancing transparency in public financing, and improving the regulatory framework. This was concluded in 2015. Energy Sector Efficiency and Expansion Programme Phase I (ESEEP-1): The AfDB has been providing support to MINEA for the development and construction of the 343km 400kv transmission line between Huambo and Lubango, linking Angolan and Namibian grids. The ESEEP-1 Project's Environmental and Social Impact Assessment was produced in 2019, and construction is due to commence shortly. The development processes had previously been held up due to lack of funding. Construction is estimated to take 30 months. (AfDB, 2019) Angola Programme for Renewables (AREP): AfDB through SEFA is supporting the AREP, the primary objective of which is the review of the legal/regulatory framework for renewable energies, with a particular focus on the establishment of a competitive procurement programme for Independent Power Producers (IPPs). As part of the review, which commenced in 2019, the programme identifies the institutional and regulatory gaps, propose incentives for private sector investors, and set out a framework for the identification and assessment of RE projects suitable for IPPs. In an effort to better coordinate processes and procedures for IPPs, SEFA is looking to establish a 'one-stop-shop' unit known as the Energy Project Implementation Support Unit (EPISU). The IPP procurement framework is due to be completed in 2021 (AfDB, 2018) (AfDB, 2019). Furthering the support to improve the enabling environment, the AfDB is looking to explore the provision of Partial Risk Guarantees for RE IPPs. Establishment of the National Institute for Rural Electrification: The AfDB will support MINEA in the establishing of the National Institute for Rural Electrification, as set out in the Ministry's strategy documents. The AfDB will also be providing support, along with UNDP, to initiate a rural electrification strategy. This is envisaged to include: (i) an assessment of institutional options (such as concessions, or cooperatives), (ii) financing options and (iii) a clear demarcation of regions best served by grid extension, mini-grid and other off-grid technologies, and finally (iv) fiscal incentives, including tax and duty exemptions (AfDB , 2019). Mini-Grids Framework Development: Specific to mini-grids, the AfDB and SEFA, with support from the International Finance Corporation (IFC), will support MINEA to improve the framework for the implementation of mini-grids. This will include updating the policy and regulatory framework for distribution generation below 5MW and assess the potential for developing a mini-grid scale-up programme.
EU	Angola: Power Purchase Agreement (PPA) model for Renewable Energy Projects: The EU through the Technical Assistance Facility (TAF) for Sustainable Energy is providing financing support to MINEA and other relevant stakeholders to prepare bankable legal documentations, to enhance the enabling environment for private sector investments in RE. As part of this support it is preparing standard legal documents, including PPA templates, concession agreement and an implementation agreement, as well as standard bidding documents for different technologies. At the time of writing, a draft PPA was released publicly, and the private sector was invited to comment. Support is also being provided by the AfDB.
USAID (Power Africa)	Southern African Energy Programme (SAEP): Power Africa, through the SAEP is providing support to MINEA to improve the regulatory and enabling environment, aimed at making the sector more attractive for private participation. Technical assistance (TA) support was provided to identify the key constraints on investment, specifically working with RNT to establish a Project Management Office for the transmission projects and ENDE to establish an Electrification Management Unit for connection work. Power Africa will also work to build the capacity of RNT and ENDE to develop projects, through a US$500m loan guarantee from the AfDB.

2.3 Overview of the Power Sector

2.3.1 Context

Angola has historically had low electricity tariffs which severely impair the financial standing of Angola's power sector and ability to scale up electricity access. The average tariff for businesses of Kz 6.05/kWh (US$0.02/kWh). Furthermore, electricity consumption is mostly unmetered and ENDE's billing system remains below standards which further constrains ENDE's capacity to expand its network and connect new customers. In early 2016, the government increased retail tariffs for electricity by 60% for private consumers to $0.071/kWh), and by 190% to $0.059/kWh for businesses. Despite that, these tariffs remain well below average production costs of $0.22/kWh in 2015 (see Table 8). The Government intends to reform electricity tariffs following the ongoing fuel subsidy reform and has mandated IRSEA to identify a new tariff regime. However, an early assessment of the (World Bank,2018)[4] reveals that that no robust analysis of cost of service and revenue requirements along the value chain has been conducted (World Bank, 2018)[5]

The Executive Decree No. 122/19 of 24 May 2019 brought in a significant change to electricity prices, establishing a new tariff system. The statute provided for rules to protect vulnerable customers such that subsidies would remain in place to benefit only the poorer populations. The tariff reform aligns with the 's ambition of spending less public money in the energy sector, and will rely on the private sector to fill the space (GLI, 2019). The tariffs approved by this Decree no longer contain the price subsidy, only operational subsidies (fuel) and investment by public companies that continue to be supported by the State, so they are not reflected in the tariff.

Electricity tariffs are proposed by IRSEA, the electricity regulator and applied by RNT and distribution companies to the users connected to their grids. The actual value of the tariffs is calculated from the formulas established in the Tariff Regulation. Tariffs in Angola have historically been heavily subsidised which has in turn severely impaired ENDE's ability to recover its costs. The has mandated IRSEA to develop a new tariff regime with cost reflective tariffs (World Bank, 2018).

Table 4 Revised June 2019 Electricity Tariffs in each category

Category	Previous Tariff (kwanzas / kWh)	New June 2019 Tariffs (kwanzas / kWh)
Special domestic category (three-phase domestic)	7.04	14.74
General domestic category	6.53	10.89
Consumption of <200kW	3	6.41
Social category (customers with reduced consumption)	2.46	2.46
Industry	7.05	12.83
Trade and services	14	(Now covered in three-phase domestic category)

It is unclear from the Regulations, whether the national tariff (including the social tariff) would apply to private mini-grids, or whether a cost-reflective tariff could be applied. Isolated systems of public entities (<5MW) are required to apply the national tariff. However, for some existing diesel-based systems, cost reflective (or nearly cost reflective) tariffs have been applied. It is likely that many of these mini-grids are for the production of electricity primarily for self-consumption (under the current draft regulation, this means they fall under the SENV (see 2.2.3 Energy Policies, Strategies, Targets, Roadmaps, Plans and Programmes).

2.3.2. Generation

At the end of 2018, a total of 6.4 GW of installed power was expected, in reality the installed power in 2018 was 4,898 MW (MINEA, 2018; USAID, 2019). The 6.4GW capacity is predominantly hydroelectric and thermal (approximately 3.7GW and 2.7GW respectively). In 2017, Angola ranked 5th in terms of installed hydroelectric capacity, behind Ethiopia, South Africa, Egypt and the DRC, according to the International Hydropower Association's Status Report of 2018 (IHA, 2018). Angola is among the fastest growing countries in terms of new installed capacity for hydropower behind China, Brazil, Portugal and India. The prioritisation of hydropower development in Angola is reflected in the 2025 strategy. The share of hydropower to the Angolan power mix is set to increase with the completion of the 2.1 GW Caculo Cabaça hydro power plant by 2025. A list of noteworthy power stations is provided in Table 5.

4 https://www.powerutilityleadership.com/wp-content/uploads/2018/02/Angola_FuturePlans.pdf

5 https://www.powerutilityleadership.com/wp-content/uploads/2018/02/Angola_FuturePlans.pdf

The current government has made diversification of the power mix a high priority. As previously detailed above, the Angola Energia 2025 goal is to achieve a total installed capacity of 9.9GW by 2025, of which 800MW would come from new renewables technologies. The New Renewables Strategy breaks this 800MW down into 100MW of solar, 100MW from small hydro, 100 MW from wind and 500MW from biomass (MINEA, 2018). The Energy and Water Action Plan (2018-2022) sets the interim goal of achieving an additional 500MW of renewables by 2022, the focus being on solar.

Table 5 Main power stations in Angola

Technology	Power station name	Capacity
Hydro	Laúca	2.070 MW
Hydro	Capanda	520 MW
Hydro	Cambambe	960 MW
Diesel	Luanda	148 MW
Diesel	Soyo	750 MW

Current estimates of current installed capacity and targets for different technologies are set out in Table 4 below.

Table 6 Installed Capacity Current and Targeted by Technology

Technology	September 2017 Installed Capacity	Estimated for end of 2018 (per Action Plan)	Action Plan Target 2018-2022	Angola Energia 2025 / New Renewables Strategy 2025
Hydropower	2.4GW	3.7GW		5,7-7,2GW
Gas	0,5GW	0,8GW		1,6-2,3GW
Other thermal	1.8GW	1.9		0,7-1GW
Solar	Negligible	Negligible	0,5GW	0.1GW
Wind				0.1GW
Small-Hydro				0.1GW
Biomass				0,5GW

This growth in capacity is anticipated to deliver 60% electricity access nationally by 2025. According to the Sector Action Plan, total estimated investment required for the execution of all the projects, that is, both ongoing and new projects is around 13,591 million USD over the 2018-2022 period (MINEA, 2018).

Currently there are a handful of mini-grids in Angola, totalling 6.8% of total installed capacity (see Table 10). At the time of publication of the 2025 Angola Energia Strategy documents, there were 8 solar/hybrid mini-grids, with others being diesel minigrids. The 8 green/hybrid systems are utility owned, relatively large scale (around 5MW), and funded entirely by the government. They are located in Cabinda (2 projects), Tombwa, Cunene in Xangongo, Benguela, Sanza Pombo in Uíge and Huambo. The cost of these projects was approximately US$19m each, and they provide electricity for up to 12,000 people each. The two projects Cabinda are smaller than the others, at 2.5MW, each with 1MW from solar.

The Energy Sector Action Plan 2018-22 sets out Private Participation as one of the target Programmes. Under this target theme, MINEA set out explicit goals to be met by 2022 through private participation such as:

1. 1.5GW of installed power to be funded through private investments by 2022
1. 500MW of installed power in solar, wind, biomass and small hydro by 2022 (the is prioritising large-scale solar)
1. To issue 40+ power distribution licences for isolated (mini-grid systems) and 100,000 SHS

According to the Action Plan, the private sector is expected to fund projects of US$3.85M. This will require the Angolan Government to provide guarantees of $2.7m ($1.62 from foreign currency). Priority will be given to blended financing, using DFI concessional financing, and those tying in international funding with local supply to stimulate the local market.

Table 7 Estimated total financing required for ongoing and new projects in the energy sector required to meet targets (source: MINEA 2018)

Programme	Total Cost (USD, millions)	Cost 2018-2022 (USD millions)
Expanding Access	4079	3771
Generation Optimisation	16501	7979
Transmission Optimisation	2234	1604
Distribution Optimisation	198	197
Private Sector Participation (Producers)	17	17

Private Sector Participation (New Renewables)	25	23
Total	**23 054**	**13591**
Current/ongoing projects	17832	9276
New Projects	5222	4315

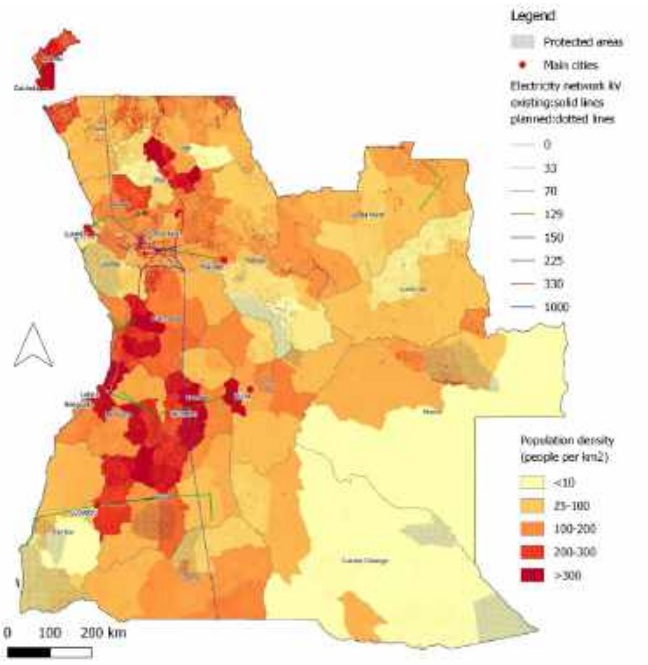
There has been an unwillingness of the private sector to get involved in the power sector due to perceived vested interests, high costs and payment risks. Private sector actors consulted as part of this study have reported that their willingness to participate has significantly decreased since the oil crisis due to payment delays or non-payment by State Owned Enterprises. The government recognises that private investment and financing will only happen with the provision of guarantees by the state that payments by RNT (the off-taker) will be made, and that future tariffs will need to be high enough to make the business models work, and projects financially sustainable (MINEA, 2017). There are few private companies with PPAs and their total generation accounts for less than 10% of the total installed capacity. As an example of the challenges, IPP company African Energy reported that the PPA for the 120MW Bicom ethanol plant was cancelled due to high costs and allegations of corruption (African Energy, 2019). Currently there are no standard PPAs with IPPs, as these have historically been done on a case by case basis. There is, however, an ongoing project to set up the regulatory framework for PPA contracts, with support from the AfDB and funding from the EU, under the Angola Programme for Renewables (AREP).

According to the 2018 Southern African Development Community (SADC) Renewable Energy and Energy Efficiency Status Report, financing of power projects in Angola remains a significant challenge. The pipeline for Angola of renewable energy projects still seeking financing is large. In mid-2018, there was a total of 8,487MW of renewable energy projects financed, but not yet commissioned, including 4,941MW of Large-Scale Hydro projects, 10MW of small-scale hydro, 3,436 MW of solar PV, and 100MW of wind. In the pipeline of renewable energy projects approved but yet to be financed, are 65MW of small-scale hydro, 1,470MW of large-scale hydro and 78MW of wind (REN21, 2018).

2.3.3 Transmission

Angola's transmission infrastructure is comprised of four separate grid systems (northern and central, interconnected and and southern and Eastern isolated), Figure 10. The Northern grid runs 400kV, 220kV and 110kV lines, the Central 400kV, 200kV and 150kV lines, the Southern 150kv lines and the Eastern 110kV lines. There are also isolated grids in the east of the country. The distribution network extends only to the periphery of the country's 18 provincial capitals. The government plans to connect the grids and increase the length of transmission lines from 3,354 km to 16,350 km by 2025.

Figure 11 Existing and Planned Transmission Lines, and Population Density Map (Source: Carbon Trust Analysis)



Furthermore, the government of Angola plans to connect to the Southern African Power Pool (SAPP) through Namibia. At the time of writing, the status of the Angola-Namibia (ANNA) Transmission Interconnector project was still at the feasibility stage, with preparation funding sources coming from the Development Bank of Southern Africa, the European Union, Norwegian Agency for Development Cooperation (Norad) and Swedish International Development Agency (SIDA). US$2.1m has been secured for initial project preparation activities from the SADC Project Preparation Development Facility. The transmission interconnector would be 400kV, linking the electricity networks in the north-western part of Namibia with the southern part of Angola, initially supplying power to towns in southern Angola – predominantly Xangongo,

Cahama and Ondjiva (PIDA, 2019). Angola is set to be connected to the regional SAPP grid by 2023.

There are further plans for an additional connection with the Democratic Republic of Congo (DRC) under consideration, via the Inga Dam-however these plans are not finalised. The Angola energy sector strategy documents aims to have three connections to DRC agreed and implemented by 2025: a 400kV line between Soyo and Inga, 220kV line between Cabinda and Inga and 220kV between Luachimo and Kananga.

To date, grid extensions have been prioritised in highly densely populated areas; in the North and Central regions of the West Coast. According to the energy sector strategy documents, grid extension should be prioritised for larger populated villages, whereas villages with lower density inhabitant (<500 inhabitants) and located at more than 10km from the grid, would be electrified by mini-grids or solar home systems (SHS). We have taken a more conservative view in our analysis in Section 3, defining areas that are best served by mini-grids as areas further than 15km from the grid (and where with household density greater than 50 households per km2).

Responsibility for the grid in Angola is divided between 2 public institutions: RNT and ENDE. The sole off-taker for electricity in Angola, RNT is responsible for all the networks above 60KVA and the safe transmission of power to ENDE. ENDE is responsible for distribution grids - 60KVA and below. RNT is unable to fully meet its safety obligations due to outdated and inadequate infrastructure, and dispatch hardware and software. The World Bank is currently working with RNT on a number of upgrades to address these issues.

To help reduce the ENDE's commercial losses, one of the objectives in the Sector Action Plan 2018-22, the is proposing the use of pre-paid meters. In 2018 there were over 262,000 installed (out of 1.276 million of ENDE's clients). The World Bank is also providing support to ENDE, through the project to install Smart multifunctional meters for all medium and high voltage customers, to help increase the company's revenues by reducing unmetered consumption. The support is being provided in parallel to a programme sponsored by AfDB, project to install low voltage prepayment meters for all customers without measuring devices which is targeting reduction of technical and commercial losses (World Bank, 2018).

2.4 Overview of the Off-Grid Secotr

2.4.1 Energy Access Policy and Planning

Almost 60% of Angolans are without access to electricity, equivalent to 17 million people. Energy access is especially low in rural environments where only 16% have access to electricity (World Bank, 2019). In urban areas, access is around 70% (SEforAll, 2019). The government has set the target of increasing the average electrification rate across the entire country to 60% by 2025, as outlined in Angola Energia 2025. However, according to this document, only 6% of those additional to be electrified would be in rural areas (1% mini-grids, and 5% through grid extension). The 60% electrification target does not include an additional 7% of the population that would be electrified via individual systems such as SHS. The target, if these systems were counted, would be 67% of the total population electrified by 2025. Table 6 (in Section 2.3.1) presents the breakdown by technology of the 60% electrification target.

The primary institutional actor in energy access is the Ministry of Energy and Water (MINEA) through its Directorate of Rural Electrification. In an effort to address capacity limitations of the Directorate the government proposed in its 2025 strategy to establish the National Institute for Rural Electrification (INEL) coupled with a Rural Electrification Fund (REF). Limited information around the workings of the REF is available. With its creation, the INEL would become the focal point for rural electrification, and with a dedicated funding mechanism would be better equipped to address many of the challenges faced, including a clear framework for private sector participation in the off-grid market. However, the proposed structure is still at concept stage, and as such the exact mandate that will be given to INEL is unclear at this stage.

Other key actors in the mini-grid sector include the urban utilities (RNT, PRODEL, and ENDE) and the regulator IRSEA. PRODEL manages and maintains all the mini-grids in Angola, including the eight green mini-grids in Angola. RNT is the sole permitted off-taker for electricity in Angola (including cases where there is no transmission network), and therefore is also the off-taker for mini-grids projects in Angola. Given that there's no high-voltage network in these mini-grids, RNT acts completely remotely – buying from PRODEL, and selling to ENDE, who in turn manages the low voltage network of these isolated systems, and sells to end consumers (according

to the regulator (IRSEA)'s stipulated tariff). Given the tariffs are extremely low, there is little motivation for the public utilities to expand mini-grid operations. The tariff applied to publicly owned mini-grids is the same as the national tariffs, and it is IRSEA (in charge of tariff setting and control) which sets and ensures the national tariff is applied country-wide.

Currently mini-grids in Angola account for 6.8% of total installed capacity ((REN21, 2018)) which are mostly diesel systems, with 8 solar/hybrid mini-grids, and some mini-hydro (Table 11). The 8 green/hybrid systems are utility owned, relatively large scale (5 MW), and funded entirely by the government. They are in Cabinda (2 projects), Tomba, Cunene, Chandongo, Benguela, Sansapombo and Uíge. The cost of these projects was approximately US$19m, and they provide electricity for up to 12,000 people each. The two projects in Cabinda are smaller than the others, at 2.5MW, each with 1MW from solar respectively. For some of these diesel-based systems, it is understood from engagements with stakeholders, that different tariffs are applied and not the national tariff in order to better cover costs of operation.

Table 8 Installed capacity for mini-grid systems operational and under development (MW) (REN21, 2018)

Installed capacity for mini-grid systems operational and under development in Angola (MW)				% of total installed capacity (MW)
Diesel	**Mini-Hydro (1-9MW)**	**Solar PV**	**Total**	
139	21.3	0.051-0.085	160.35-160.38	6.8

A handful of diesel mini-grids in operation in Angola do not apply the national tariff. Some are owned by municipalities in remote areas, while others may be owned by private operators where the electricity produced is likely for self-consumption. It is unclear from the current regulations if a private mini-grid would be required to charge the national tariff or would be allowed to charge a cost reflective tariff. How the regulations, including licensing requirements and tariffs, would apply to private sector mini-grids is currently unclear (see Laws and Regulations, in section 2.2.3 Energy Policies, Strategies, Targets, Roadmaps, Plans and Programmes).

Currently, there is no clear electrification plan specific to the rural areas: Angola Energia 2025 suggests the need to deploy mini-grids in at least 31 locations (electrifying 1% of the population), and grid extensions in 174 locations in rural areas, in order to reach the 60% electrification target by 2025 (Figure 11). Outside of the 60% target, the plan is to deploy at least 500 standalone systems including SHS. Grid extension outside large urban areas is hoped to provide access to electricity for 1.7 million people, or 5% of the total population. The proposed grid extension plan is predominantly based on the installation of 60kV substations, branching from existing or planned 22kV substations, which are generally located in municipal townships. Rural electrification strategy and planning is addressed to a limited extent within the following strategic documents set out in Table 4. These strategic documents do not provide a firm roadmap and guidance for the rural electrification; however, they show the locations of the proposed mini-grid sites, and grid extensions.

Figure 12: Overview of rural electrification sites for mini-grids as presented in Angola Energia 2025

The proposed National Institute for Rural Electrification (INEL) would be responsible for the development of a specific roadmap to detail how the high-level objectives would be met.

There are a small number of donor-funded projects underway to support MINEA to reach its 60% electrification target, including enhancing the legal and regulatory frameworks for rural electrification. The initiatives are in support of the government's Energy Sector Transformation Programme mainly supported by the AfDB and the World Bank. The initiatives include:

- Support from the AfDB and UNDP for the development of an electrification framework. This includes support

to MINEA for the establishment of the National Rural Electrification Institute (INEL). INEL will be responsible for the promotion of rural electrification, the mobilization of financial resources and oversee the delivery of energy access projects. It also includes support to begin the development of a Rural Electrification Strategy. This strategy would have the aim of accelerating the access to electricity in rural areas, and would include an assessment of institution and financing options, demarcation of areas for mini-grids and fiscal incentives to be made available

- Creation of a mini-grid framework, with support coming from AfDB/SEFA, UNDP and the IFC. This initiative would see the finalization and improvement of a new policy and regulatory framework for distributed generation below 5 MW. The ambition of this project is to see that operators can:
  - Distribute to communities directly;
  - Charge cost reflective tariffs; and
  - Better understand future grid-integration and compensation options.

This project would also deliver a study assessing the potential to develop 'mini-grid scale up programme', looking at the existing policy and regulatory hurdles, and financing gaps (AfDB , 2019).

Discussions are underway between MINEA and private sector organisations to progress the development of a number of projects with off-grid solutions. Many of the identified sites would be up to 3MW capacity, where energy demand is low. It is our understanding that there is not a clear means of developing and proposing projects to MINEA. Private sector organisations have been involved in the development, construction and operations of electricity sector projects for a short time before they are transferred to public entities.

MINEAhas also progressed electrification via standalone systems for public facilities and street lighting, most notably through its Aldeia Solar (Solar Village) programme. Once again this was entirely government funded. The project's 3rd phase sees the installation of 4785 public lighting and 686 autonomous systems being planned. During the first 2 phases about 400 standalone systems were installed. See box below.

Box 1 Aldeia Solar (Solar Village)

Aldeia Solar

Driven by the Directorate for Renewable Energy within the MINEA, Aldeia Solar project focuses on electrifying public institutions (e.g. streetlights, hospitals, schools) in the rural areas with standalone solar systems (3-5KW). The project began in 2010 and has been implemented in two phases to install 400 systems, mostly in very isolated areas in the East, South and Central regions. Locations were selected on the basis that that grid electrification would not economically feasible. A 3rd phase is currently underway, with an additional 4785 public lighting and 686 kits planned.

The Capex was funded by, while users are expected to cover the costs of operating and maintaining these systems. The facilities are expected to reserve or allocate specific funds for operations and maintenance.

It is estimated that the Angolan Government has spent $102m USD during the latest phase, which is difficult to sustain in the long run. As such, there is particularly keen to encourage private sector investment and explore alternative business models to make the programme more sustainable.

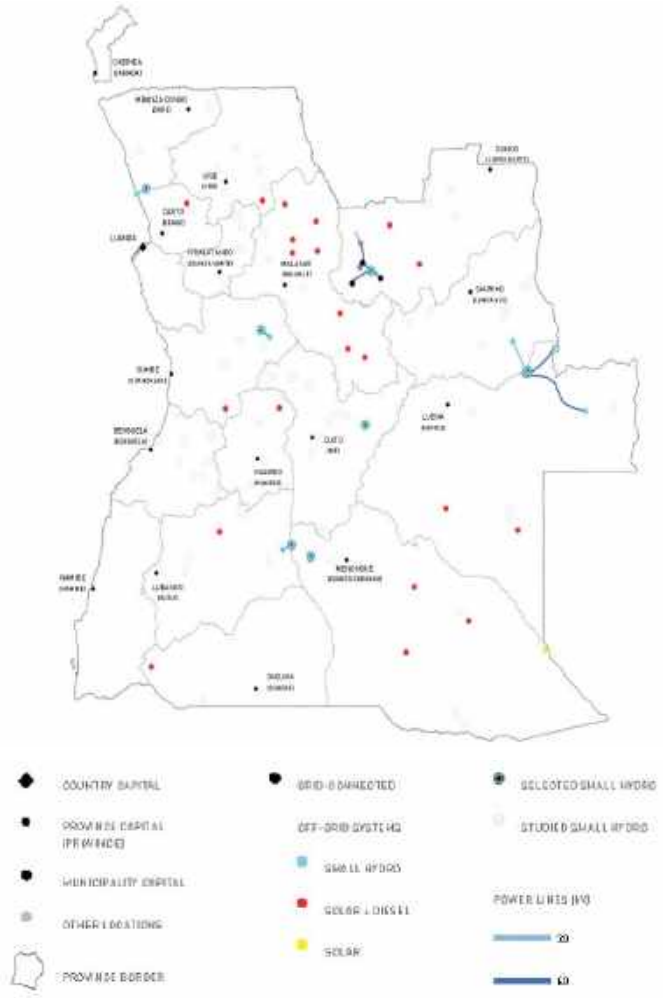
While there are no private owned and operated mini-grids in Angola, there are private sector actors involved in standalone solar home systems, and private actors have been involved in the development of publicly owned mini-grids. GreenTech, a local renewable energy company has installed 400 Solar home systems using a PAYG model in Kwanza Sul, collaborating with BBox (not related to the Aldeia Solar programme). They are collaborating to look to a wider roll out across Angola following this pilot study. Anglobal and PowerBox are the other two companies establishing themselves in the SHS market in Angola. Their focus is distribution of SHS in rural areas, not yet connected to the grid (predominantly in the south and east of the country). From our in-country engagements, it has been understood that while there are no private entities operating mini-grids in country, private sector companies have been commissioned to develop mini-grids, which were subsequently handed over to public entities.

The National Strategy for the New Renewables and the Atlas and National Strategy for Renewables (both developed from Angola Energia 2025) are the drivers of the off-grid sector in Angola. Both documents set out goals of broadening the Aldeai Solar (Solar Village) programme, to see that at least 500 sites in villages

and over 2000 inhabitants, implementing more than 10 MW of solar PV and installing 50 systems based on pico and micro-hydro. Further, it is envisaged that more than 200 communities will have access to systems for productive uses (e.g. irrigation, drying and milling) based on renewable energies. However, it is not specified whether this would be mini-grids or standalone systems); It is unclear, as to whether these would all be standalone systems, or mini-grids, but only that these would be small systems – powered by solar or hydro.

The Strategy Document considers areas most suitable for mini-grids, including the proposed technology. These are shown in the map below (Figure 4). Electrification of these localities, according to the 2025 strategy, would equate to electrifying 1% of the total population, and would ideally be done by the private sector, through competitive mini-hydro, and where this is not feasible, through diesel generators and solar systems.

Figure 13 Localities to be electrified through 'isolated systems' (mini-grids) (source: MINEA, 2014)



There is a lack of regulatory frameworks around mini-grid developments, which has to date, hindered the development of a private sector led market. Currently, there is no framework in Angola to guide the private sector in their involvement in mini-grids, as either investors, developers or operators. This is not to say the private sector cannot be involved, and MINEA is strongly encouraging their involvement in its strategies. However, the application of the electricity sector regulations to mini-grids is unclear, and our engagements suggest that the regulations would be applied on a case-by-case basis to private mini-grids. There are no examples of where this has been the case as all the mini-grids in Angola are owned and operated by the public sector utilities and charge standard national tariffs.

The Government of Angola (GoA) recognises that the involvement of the private sector is critical to meeting its electrification targets. However, private sector involvement in the off-grid market is constrained by a challenging regulatory, and unfavourable business environment. Consultations made as part of this report indicate that the lack of policies and clear regulations for mini-grids, and the off-grid sector in general, hamper private investment.

2.4.2 Licencing

Licensing Regulations are set out in the 2015 Electricity Law and Decree No. 31/04 of 2 July (the Regulation for the Licensing and Security of Electric Facilities), and the Draft Electricity Sector Regulation (released late 2019, for public comment). The Draft Regulation brings together the various regulations that apply to activities in the electricity sector, alongside licencing regulations and procedures. For projects above 100kW, licencing is covered by the Regulation for the Licensing of Electricity Production, Transmission and Distribution Facilities.

None of the regulations specifically refer to mini-grids with a framework for mini-grids under development with support with the AfDB and the World Bank. Therefore is no regulation that clearly defines private mini-grids, nor sets out the framework allowing private entities to sell directly to end customers. The Sistema Eléctrico Público (SEP, Public Electricity System) covers 'isolated systems' (up to 5MW), however it appears as though this may only apply to publicly owned mini-grids. Private isolated systems, used for self-production, fall under the SENV, however, it is unclear if the SENV would also cover isolated systems where private entities would sell to end customers. The

licensing procedures and requirements that would apply to private mini-grids, would depend on whether they would be considered part of the SEP or the SENV. Both are discussed below:

- SEP: The Draft Regulation provides for licences for the construction, distribution and commercialisation of isolated systems under a 'special regime'. Special arrangements linked to generation activities and licensing apply. Special regime generation includes renewable energy linked generation activities, based solely on renewable sources, and excluding hydro projects above 10MW. It also covers isolated systems up to 5MW, which are for the production of public electricity (that is, not for private or self-consumption). Related to isolated systems under the Special Regime, national tariffs apply and a license, which covers both production and distribution, must be obtained from MINEA, in consultation with IRSEA. In order to obtain this license, a request must be made along with a technical-economic study.

- SENV: Covering independent producers and self-production[7]. SENV, as defined in the Draft Electricity Sector Regulation (forthcoming), is the "subsystem of the National Electricity System whose operations are governed by a market based on contracts freely established between producers and consumers". Here, the national tariff does not need to apply, as the supply of electricity is not considered to be to the 'public electricity system'. Independent power producers not supplying to the public system may agree with their respective counterparties the terms and conditions of the sale of electricity. Though not entirely clear, SENV appears to cover independent producers, production for self-consumption including where electricity produced is intended, partially, for public supply. Where the facilities are less than 100 kW, an exemption from obtaining generation licences may be sought. Any generation of electricity under the SENV, is governed by the applicable provisions of the Regulation for the Licensing of Installations for the Production, Transport and Distribution of Electric Energy ("Licensing Regulation").

7 Private mini-grids, (or isolated systems) where electricity is sold by private entities directly to end customers is not addressed under systems to which SENV provisions apply. Isolated systems are addressed under SEP; however, this has been understood to apply to publicly owned and operated systems only.

2.4.3 Mini-Grid Tariffs

As there is no specific law or regulation for private mini grids, there is also no tariff that is specified for private mini grids. Most of the existing mini-grids are publicly owned and operated by ENDE or by the municipalities directly for the smaller grids. Generally, in these cases, the national social tariff is applied, since these fall under 'isolated systems' under the SEP (the public electricity system), in the Electricity Law and Regulations. The social tariff, which would apply to remote and poorer areas is very low at around $0.02/kWh and is far below cost to produce electricity. IRSEA, in charge of tariff setting and control has been mandated to develop a new tariff regime and to put in place a regulatory framework that would be more attractive to Independent Power Producers (IPPs). There may be some aspect of this that would apply to the mini-grid sector, but this is unclear at the time of writing (World Bank, 2018)

It should be noted however, that the Electricity Sector Regulation, newly released in draft for public comment, includes a provision that the tariff must be uniform across the country. The exception to this is where systems are not part of the Public Electricity System (the SEP), and where the operations are based on freely established contracts between producers and consumers. Should this be applied to mini-grid systems, even at the current upwardly revised rates, such rates are unlikely to be cost reflective and therefore a subsidy mechanism would need to be employed, which as yet is non-existent.

Since 2015, per the General Electricity Law, charging cost-reflective tariffs is permitted by IPPs. As such, mini-grid operators could legally be allowed to charge tariffs that differ from the national tariffs where such activities were considered SENV, part of the unlinked electricity system. Here, operations are based on freely established contracts between producers and consumers. However, it is unclear whether private entities selling directly to end customers in isolated systems, would be considered SENV. Based on engagements held during the country visit, no developers have sought to apply cost-reflective tariffs to date, and there is much uncertainly around their ability to do so. Even if cost-reflective tariffs were able to be applied, the question must be raised as to whether customers would be willing and/or able to pay tariffs much above the social tariff in poor and remote areas.

2.4.4 Subsidies and Incentives

There are currently no subsidies specific for the private sector neither for off-grid nor the renewable energy sector. Consultations with private sector developers in Angola as part of this report suggest that one of the most effective incentives would be CAPEX subsidies. This mainly because such an incentive would provide a buffer for the foreign exchange (FX) risk experienced by developers of mini-grids: CAPEX investments are made in foreign currencies, where project revenues are collected in the Angolan kwanza (Kz).

There are some tax incentives that apply to the renewable energy sector. In the Customs Tariff, there are two product codes related to the renewable energy sector in which there is exemption from import duties and consumption tax. These are (1) spark-ignition internal combustion piston engine (wind energy); and (2) electric storage batteries, including those used in solar PV. Other electrical equipment such as generators and electric transformers which are exempt from the above task.

The new Private Investment Law, Law No. 14/15 of 2015 revoked by Law no. 10/18, of 26 June, establishes the benefits and criteria for access to grants as well as the rights, duties and the guarantees of private investors. The electricity sector is considered a priority sector here, and tax benefits in the form of reductions in industrial tax, property transfer tax, and investment income tax for up to 10 years, apply for domestic investments of USD 500,000 or more, and foreign investments of USD 1,000,000. Investments in more remote areas attract higher tax breaks. However, the above is conditional upon registration of a local company which must have at least 51% Angolan ownership. It is also currently unclear whether these have been applied in the off-grid sector to date.

2.4.5 Power Purchase Agreements (PPA)

IRSEA, in June 2019, released a standard PPA model for renewable energy projects for public consultation. The document, which was prepared with technical assistance from the EU, was well received on the whole, however, it has been pointed out there are a number of key provisions that are missing, including details on the state guarantee mechanism (African Energy, 2019).

According to the Draft Regulation for the Electricity Sector, the initial maximum term of contracts for the purchase of energy for isolated systems (part of SEP) is 5 years, though may be a longer period where "duly justified and approved". A Power Purchase Agreement is signed between the producer, the market operator and the network operator to which the production plant is interconnected.

The General Electricity Law as it stands, allows independent power producers, including in isolated/mini-grid systems, to establish bilateral agreements for the terms and conditions of the sale of electricity. This may occur where the production is considered to fall outside of the SEP (for example, where electricity production is not, or only partially intended for public supply). The terms of the sale of electricity are determined by the parties to the agreements, but these agreements must comply with the Regulation for the Licensing and Security of Electric Facilities and the Networks Access Regulation, as well as the rules and procedures put into force by the IRSEA.

2.4.6 Arrival of the Grid

There are currently no specific rules or incentives dealing with the arrival of the grid. Technical and commercial terms and conditions to use SEP networks and interconnections vary in accordance with the type of user and must be agreed upon by the network operator and IRSEA. This is in accordance with the Network Access Regulation, approved by Presidential Decree 19/11 of 17 January.

If private mini-grids are considered outside of the SEP (i.e. SENV), then should they wish to sell electricity to the grid tied areas (i.e. under SEP), they will need to enter into generation concession agreements or request the attribution of a power generation license, under the terms of the Electricity General Law.

2.4.7 Technical Rules

There are currently no mini-grids specific technical rules in Angola. However, rules that must be complied with include those in the Electricity Act which establishes the general framework of the legal regime for generation, transmission, distribution and use of electrical energy. Principles that govern these activities within the act include compliance with safety rules regarding both people and assets, and respect for property rights and natural resources.

2.4.8 Mobile Services

Mobile phone access in Angola is relatively low, and very poor in remote areas. Mobile phone penetration in Angola is below the SSA average, at 46 per 100 people in 2017, compared with 74. While coverage is relatively good for the west of the country, in some remote parts of the country, particularly in the south east regions of Cuando Cubango and Moxico, coverage is poor, or even non-existent. There is also a lack of competition in the market, which results in higher costs. Unitel is the dominant operator, followed by Angola Telecom's Movicel. A new licencing regime introduced in 2017 allows for new market entrants.

Telecommunications access is expensive compared to neighbouring countries, and high-speed internet access remains a challenge. Broadband subscribers went from 2.7 per 100 people in 2010 to 22.3 in 2016, though this is still below the regional average of 28. The government has taken steps to improve this, as it is seen as essential for the country to expand its services sector and participate in the growing digital economy (World Bank, 2018) (IFC, 2019).

2.4.9 Barriers and Potential Interventions for Mini-grid Deployment

Today, one of the biggest barriers to the deployment of mini-grids in Angola is the lack of a clear framework to attract private sector investment and participation in the sector. Angola's lack of off-grid specific regulations and enabling environment has limited private sector participation in the off-grid sector. Angola has a small number of mini-grids, however these remain utility owned and operated, and subject to highly subsidised national tariffs. Without significant improvement to the regulatory framework that (i) allows cost reflective tariffs, (ii) creates a mini-grid specific framework for licencing, and arrival of the grid, it will remain challenging to reach the Angola Energia 2025 energy access goals.

Further, efforts to address this challenge are only in their infancy. The Draft electricity sector regulation, and the release of the draft PPA model provides some additional clarity for the production of renewable energy in Angola. However, mini-grids are still not addressed specifically in current regulations, and as such, it remains unclear how the regulations apply to mini-grids. Limitations in the regulatory framework are expected to be addressed with the establishment of the rural electrification agency (INEL) and a new policy/regulatory framework for distributed generation (>5MW) to allow operators to sell/distribute directly to communities, charge cost-reflective tariffs, understand future grid integration and compensation options. The timing of these remain uncertain.

In addition to the regulatory framework, more clarity is needed at a policy level in terms of support structures and/or incentives available for the sector. A number of private sector actors in-country who had expressed interest in becoming mini-grids developers, reported the lack of incentives as a key deterrent to market entry. Although in principle, cost-reflective tariffs could be charged under one of the electrification regimes, it has not been achieved in practice (existing public sector projects all run at a loss). A clear legal and regulatory framework for renewable energy IPPs protecting investors, providing guarantees and mechanisms to ensure legal stability and protection of investments in the event of changes to the rules is required.

The current electricity tariffs are unlikely to attract any private sector investments. It is not yet feasible to charge cost-reflective tariffs and ensure adequate returns on investments to attract the private sector into the mini-grid market. The current social tariff is low, and those who would be electrified by mini-grids are in poor and remote areas of Angola. There is a significant gap between what people would be willing and are able to pay and the required cost-reflective tariff. The Government will need to close this gap, which may be through results-based subsidies, CAPEX subsidies or other forms of subsidy support.

The existing financial situation of Angola is not conducive to investment in the energy environment. The cash deficit since the oil crises makes it even more difficult to invest in a sector that in most cases can only be a viable business if part of the investment is a grant and/or a subsidy. Further, with high levels of national debt, poor credit ratings and lack of liquidity, there is limited ability to obtain longer tenors or payback periods: a number of projects have not been able to be financed as a result. Furthermore, Angolan banks tend to have little involvement in the energy sector. Potential interventions to address this barrier includes PPAs to establish mechanisms for currency convertibility. PPAs should include a currency indexation mechanism to allow investors to realize their returns on investment in hard currency.

Demand for mini-grid electrification is likely to be low, and variable. In rural and remote areas, where much of the population is poor, energy demand is likely to be low, and often inconsistent through the year. Rural income

patterns, seasonal factors, and crop cycles will all affect demand, and this is not always predictable. Information on such demand is unavailable, limiting the ability to match this with supply to ensure stable revenues from mini-grids. Mini-grids supporting productive use, and/or the use of anchor customers should be considered to increase and smooth out the demand for electricity from mini-grids.

Technical capacity building on both the public and private sector side has been identified as a limiting factor. The government has little experience in the development and management of sustainable mini-grids (these are currently heavily subsidised). Similarly, private sector actors that have expressed interest in entering the mini-grid market, tend not have experience in this sector beyond simply building energy installations.

Foreign exchange (FX) risk and import costs is a deterrent to private investment in the sector. Based on engagements held with stakeholders during the country visit, 22% of the final project cost is related to import-related costs (tax, transportation, other). CAPEX costs are usually in a foreign currency, where revenues are in kwanzas.

Table 9 Regulatory and policy environment in Angola: key takeaways of enabling and limiting factors

	Enabling factor	Limiting factors
Planning and institutional setting	National policies such as Angola Energia 2025 has been translated to 5-year action plans with clear on vs. off-grid targets A new policy/regulatory framework for distributed generation (>5MW) is expected to improve the framework for the implementation of mini-grids	Application of regulations to the off-grid sector unclear and lacks incentives for private sector participation
Data availability	The National Strategy for Renewables identified 31 potential sites for mini-grids with associated generation technology Distribution network is being remapped	No publicly available software or databases
Licencing	An exemption may be obtained for generation licences for facilities <100kW	How the regulations, including licensing requirements, would apply to private sector mini-grids is currently unclear, and therefore the process to follow to license a privately owned mini-grid is unclear Regulation does not clearly define private mini-grids, nor sets out the framework allowing private entities to sell directly to end customers
Tariffs	Allowable tariff is dependent on the applicable electricity system: National tariffs apply to SEP and cost reflective tariffs agreed through contractual agreement allowed through SENV	Unclear which electricity system will be applicable to isolated private systems Low local ability to pay - social tariff very low at c. $0.02/kWh
Subsidies and incentives	Tax incentives available to the renewable energy sector	No subsidies for the private sector, neither for off-grid nor the renewable energy sector
Power purchase agreements	Standard PPA model for renewable energy projects released for public consultation	Maximum term for contracts as part of SEP is 5 years

Arrival of the grid		No existing National Electrification Plans and current strategic documents do not provide a firm roadmap and guidance for rural electrification Limited information is available on the process of integrating a mini-grid into the main grid
Technical rules	Mini-grid should adhere to the health and safety requirements of the national grid	No technical rules specific to mini-grids
Mobiles services		Mobile phone access is low and very poor in remote areas

3. GREEN MINI-GRID POTENTIAL

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.

3.1 Data Availability

In Angola, population density data can be sourced from WorldPop or through the website of the National Statistics Institute (INE). WorldPop data estimates numbers of people per grid square, with national totals adjusted to match UN population division estimates.

This high-level analysis 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 (as at 2017) obtained from the World Bank. Planned power network data was also obtained from this dataset, however, when compared to maps of the planned network in the Energy Sector Action Plan (2018-2022) documents, was found to be limited, covering major transmission line extensions only.

For this analysis the national grid has been inferred using a combination of high voltage (HV) line data and satellite mapping of night lights, which is a more comprehensive measure than only using HV lines. HV grid line data is commonly available for countries in SSA. HV lines are not a reliable indicator of electrification coverage however, as long high voltage (HV) lines are often used to reach towns at distances exceeding 15km. This analysis combines HV grid lines and nightlights data, pre-processed by combining multiple nights of observations to remove noise, before buffering both by 15km to produce the grid extension area. Internal analysis found that the nightlights-inferred grid buffer zone covers a greater proportion of the population than for the HV lines alone (83% compared with 77%), and that all HV buffered areas are encompassed within the area covered by nightlights buffer zones. This reinforces the conclusion that this is the more comprehensive measure.

The distribution network is currently being re-mapped in Angola. There are no publicly available software or databases, which impedes the ability to analyse and exchange information on current and planned systems, including hybrid mini-grid systems. Donor support is expected to be provided on this.

3.2 Mini-Grid Potential: Methodology

O primeiro passo para compreender o potencial da mini-The first step in understanding mini-grid potential in Angola is to identify the number of potential mini-grid customers, based on population (or household) density and proximity to the grid. To do this, the country's land area is segmented into three area categories — grid extension, mini-grid and standalone system (SHS) — based on distance between the existing transmission and distribution network and the population density.

- Grid extension areas: defined as areas within 15km of the grid;
- Mini-grid areas: defined as areas further than 15km from the grid[8], with household density greater than 50 households per km2; and
- Standalone system (SHS) areas: defined as areas further than 15km from the grid, with household density less than 50 households per km2.

To understand where these different areas lie, the national grid is inferred using a combination of high voltage (HV) line GIS data and satellite mapping of night-lights, buffered by 15km to produce the grid-extension area[9]. Potential off-grid populations are outside of this grid extension area, with mini-grid populations identified based on population density greater than 50 households per km2.

Once mini-grid population sizes are established, mini-grid market sizes can be estimated by multiplying the number of potential mini-grid customers by likely electricity expenditure (either per capita or by household). This report uses four different electricity expenditure scenarios:

1. Existing rural household expenditure on electricity based on the World Bank Global Consumption Database (World Bank, n.d.). This approach assumes that 60% of rural household energy expenditure is on electricity, and that household revenue comprises 60% of the total revenue of a mini-grid (when including revenue from businesses, public sector buildings and industrial users).
2. Existing rural household expenditure on electricity based on other literature and sources. This may be based on international or local studies, or local stakeholder interviews (in theory, this should yield similar results to scenario (1) above, although this may not be the case in practice).
3. Potential rural household expenditure on electricity, estimated based on a bottom-up calculation of what would be required to deliver SE4ALL Tier 2/3 energy access nationwide, and an average allowable tariff currently used in-country. This approach assumes that the average rural household's electricity use would be approximately 2.2 kWh/day; according to the SE4ALL Multi-Tier Framework, this represents a supply level between Tier 2/3 (1kWh per day) and Tier 4 (3.4kWh per day), which allows for electrical lighting, air circulation, television and phone charging (Tier 2 level), plus additional appliances that can allow for productive uses.
4. Potential rural household expenditure on electricity, estimated based on a bottom-up calculation of what would be required to deliver SE4ALL Tier 2/3 energy access nationwide, and a flat tariff of $0.4 / kWh. This tariff has been chosen as the minimum tariff needed for private developers to recover their costs. Such a rate is assumed to be one which in many contexts in Sub-Saharan Africa, and in other developing countries, is cost reflective. It has been used to allow comparisons across countries in terms of market size, but also to highlight the shortfall between feasible tariffs, and often-cost-reflective tariffs.

Results from these four scenarios are discussed in the results section that follows.

3.3 Assessing Mini-Grid Potential: Results

Angola's transmission infrastructure is comprised of four separate grid systems (northern and central interconnected, and southern and easter isolated), and the distribution network extends just to the periphery of the country's 18 provincial capitals. The Northern grid runs 400kv, 200kV and 110kV lines, the central, 400 kv, 220kV and 150kV lines, the southern runs 150kv lines and the eastern 110kV lines. There are plans to interconnect the southern and eastern lines in the transport grid extension plan. By 2025 The plans to link up the grids and expand the grid from 3,354 km to 16,350 km by 2025.

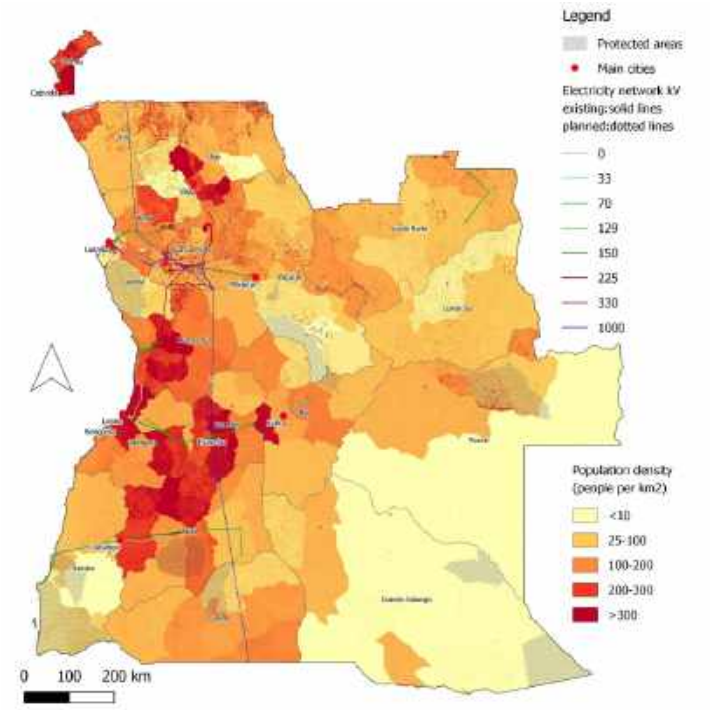
With a landmass of 1.246.700 km2 and a population of 30,809,762 in 2018, population density is 24.71 people per square kilometre of land. As seen on the map below, the

8 While we have assumed GMG, populations are those beyond 15km of the grid, some developers may also wish to consider regions already serviced by the grid. In some areas currently reached by the grid, mini-grid market potential exists due to both high main grid connection costs, as well as its lack of reliability due to the aging grid network. The possibility of mini-grids in proximity to the main grid is not considered in our analysis due to its high dependence on the business model used and local demographics.

9 Using this combination of night-lights and HV line datasets provides a more comprehensive picture of current electrification than using HV lines alone. Although HV grid line data is commonly available for countries in Sub-Saharan Africa, these lines provide a limited view of electrified areas, since medium voltage (MV) lines are often used to reach towns at distances exceeding 15km. This analysis therefore infers the position of the MV lines from satellite data of night-time light emissions, pre-processed to provide yearly average datasets from which noise and cloud cover have been removed.

population is largely concentrated in urban areas (65.5%) to the West of the country (World Bank, 2019). The population of Angola is expected to be 35,027,000 in 2022, at the end of MINEA's current medium-term strategy document, the Action Plan (2018-22). In this document it sets out the goal of 50% electrification by 2022. In 2025, relevant to the long-term strategy goal of 60% electrification by 2025, the population is forecasted to be around 38,478,000 according to the World Bank. This represents a growth rate from 2018 to 2022 of 13.7% and to 2025 of 24.9%.

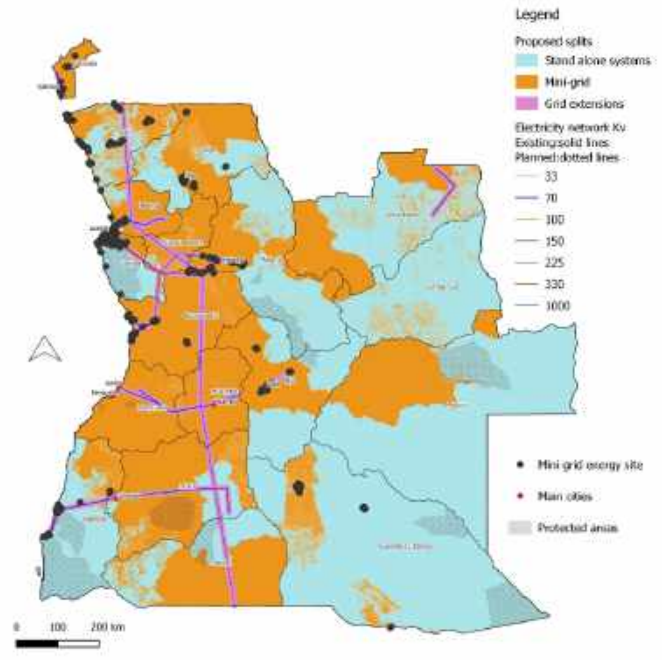
Figure 14 Population density in Angola by region, with current and planned transmission network, (Source: Carbon Trust analysis)



By inferring the presence of the transmission and distribution lines using night lights, and overlaying population density onto the resultant map (Figure 8), we can identify those areas best served by mini-grids (Figure 9).

Figure 9 shows large areas in the east and particularly in the south east of the country as being unsuitable for the development of mini-grids. This is owing to the low population densities in these areas, for which SHS is a more appropriate technology solution for rural electrification.

Figure 15 Areas best served by mini-grids, SHS and grid extension (source: Carbon Trust analysis)



Our analysis estimates that 9.9 million people (32% of the total population, and 47% of the non-electrified population) could be best served by mini-grid solutions in Angola. A further 1.2 million people (6% of the non-electrified population) will be best served by solar home systems (SHS) and 10 million people (48% of the non-electrified population) will be best served by grid extension, based on proximity to the existing grid. This calculation is based on the current grid coverage only.

Taking into account the planned grid extension data that was made available by the World Bank, our analysis estimated a significantly larger mini-grid market population size of 19.7 million people. Using project population figures to 2025 of nearly 38.5 million people, it represents more than 50% of the population (and 91% of the total un-electrified population). Rather than reduce the market size, as is often the case when the grid is extended as planned, in the case of Angola, the market size has almost doubled. We are assuming this growth in the potential market size is due to the significant growth in population between 2018 and 2022/2025 which, as mentioned above, is an expected growth rate from 2018 of 13.7% to 2022, and 24.9% to 2025.

However, given the maps published by MINEA in the Action Plan for the sector (shown below), there appears to be some discrepancy between the publicly available data on the planned grid, and that used by MINEA. We believe the planned network data publicly available at present is incomplete and as such, gives unreliable estimates of

potential customers for mini-grids. We have proceeded with the analysis using current network information only. Our analysis can be updated once information from MINEA is made publicly available, for the future grid expansion scenario.

Figure 16 RNT Infrastructure and isolated generation (Current and ongoing projects in 2017) Source: MINEA, 2017

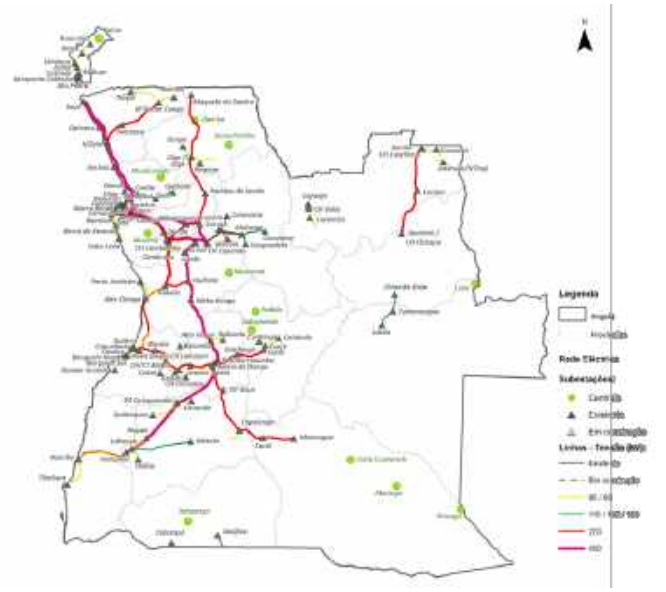


Figure 17 Northern Grid: Current (2017) and grid extension projects under construction and due to be completed by 2022.

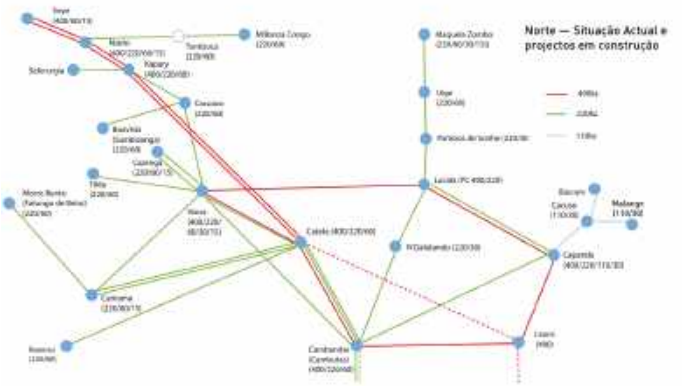
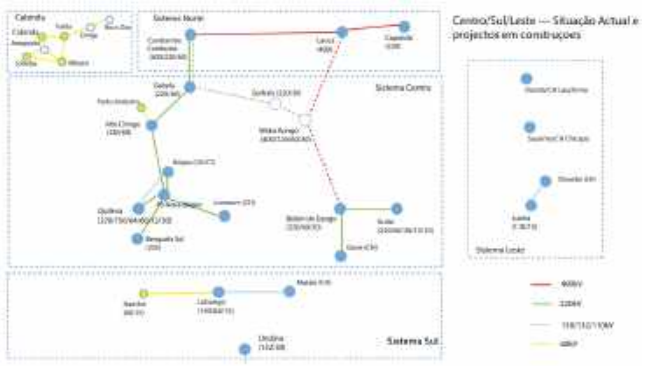


Figure 18 Southern, Central and Eastern Grids: Current (2017) and grid extension projects under construction and due to be completed by 2022.



Given the discrepancy between the publicly available data, and the MINEA strategy maps, and the significant jump in market size, our analysis will focus on the mini-grid market potential based on the current grid.

Our analysis shows that the mini-grid market potential is highest in Cuanza Sul, Huila and Uige, where at least 1 million people are best served by mini-grids in each province. Here, the potential markets are more than 50% of the population in Huila and Uige, and 46% in Cuanza Sul. More than 50% of the population of the province of Bengo, would also be best served by mini-grids, though only representing 264,148 people, which is among the smaller markets compared to other provinces. The provinces are all located in the eastern half of Angola, where there is sufficient population density in the un-electrified areas to support mini-grids, and all but Bengo are inland.

Population sizes and the mini-grid market size best served by either grid extension, mini-grid or SHS are shown by province in Table 10:

Table 10 Suitable electrification solutions per region in Angola (Carbon Trust analysis)

State	Current grid network					Planned grid network to 2025			
	Electrification rate	Population (thousands)			Mini-Grid Market ($, thousands)	Population (thousands)			Mini-Grid Market ($, thousands)
		< 15km of grid	Mini-Grid	SHS		< 15km of grid	Mini-Grid	SHS	
Bengo		78	264	0		23	319	-	
Benguela		1,301	841	0		-	2,142	2	
Bié		326	676	0		-	1,002	191	
Cabinda		69	383	0		-	452	0	
Cuando Cubango		-	148	257		-	148	257	
Cuanza Norte		96	225	81		41	281	-	
Cuanza Sul		345	1053	0		51	1,346	-	
Cunene		-	545	120		24	521	96	
Huambo		658	993	0		135	1,515	-	
Huíla		529	1565	0		20	2,074	75	
Luanda		6,240	225	0		1	6,464	37	
Lunda Norte		30	479	182		-	509	211	
Lunda Sul		-	199	225		-	199	225	
Malanje		232	455	0		16	671	138	
Moxico		-	427	154		-	427	154	
Namibe		196	71	0		-	267	127	
Uíge		-	1061	75		0	1,061	75	
Zaire		-	330	76		18	312	58	
Total		10,100	9,939	1,170		329	19,709	1,648	

In terms of potential revenue, the size of the market based on 9.9 million potential customers varies according to the four electricity expenditure scenarios described in section 3.2:

1. Existing rural household expenditure on electricity from the World Bank Global Consumption Database was not available for Angola: No data was available for Angola.
2. Existing rural household expenditure on electricity based on other reports/literature: A report by the IMF (IMF , 2015) suggested that poorer households in Angola are spending 4.8% of total consumption on fuel. In the bottom quintile, per capita spend is only around USD$2 annually. Even averaging all but the top quintile[10], this per capita spend increases only to around USD5 per year.

The World Bank published a policy research working paper on household use of electricity in SSA in 2016 (Kojima, et al., 2016). In this report, for Angola, rural monthly expenditure per capita was estimated in 2014 in US$73 and share of total household expenditures on electricity in rural areas is 2.9%. Therefore, the annual spend on electricity per capita could be estimated as being USD25.40. This was the spend amount that was used in this report.

Table 11 Angola Consumption by Quintile and Per capita spend of total consumption on fuels (Source: IMF 2015)

	Bottom Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile	All Households	Average of bottom 4 quintiles
Household consumption kz/month	7,849	12,730	18,479	25,928	49,175	24,949	23,185
Household consumption USD/year	207.21	336.07	487.85	684.50	1,298.22	658.65	428.9
Per capita consumption kz/month	1,762	3,114	4,669	7,099	17,010	7,517	6,861.8
Per capita consumption USD/year	46.52	82.21	123.26	187.41	449.06	198.45	109.85
%age of overall consumption on fuels	4.80%	5%	4.90%	4.80%	3.60%	4.30%	4.88%
Per capita spend on fuels USD/year	2.23	4.11	6.04	9.00	16.17	8.53	5.36

3. Potential rural household expenditure on electricity, estimated based on a bottom-up calculation of what would be required to deliver SE4ALL Tier 2/3 energy access nationwide, and an average allowable tariff currently used in-country: Annual cost of electricity from a mini-grid was estimated based on forward-looking household electricity consumption of 2.2kWh per day, represents annual per capita electricity demand of 160Wh (5 people per household). Communications with private sector actors for this report suggest that existing mini-grid tariffs, which are publicly run at a loss, charge around 8-9 kwanzas/kWh, which is less than USD 0.2/kWh. However, it was suggested that private sector entities may be charging around USD 0.75 for other network connection projects. The World Bank Angolan Electricity Sector Improvement Project report (World Bank, 2018), also suggests average tariffs are only around USD 0.2/kWh, and as such, this was the tariff used for this analysis.
4. Potential rural household expenditure on electricity, estimated based on a bottom-up calculation of what would be required to deliver SE4ALL Tier 2/3 energy access nationwide, and a flat tariff of $0.4/kWh: This tariff is assumed to be cost reflective. Based on annual electricity demand of 160kWh per capita, a tariff of $0.4/kWh gives an average annual electricity expenditure of $64.24 per capita: an overall annual mini-grid market size of $632 million given a mini-grid population of 9.9 million. However, estimating a tariff of $0.4/kWh does not reflect the current market conditions of Angola with extremely low tariffs and a population with a limited ability to pay for its electricity.

A summary of these four market size estimates is shown in Table 5 . Scenario (1) yields no results, as the data was not available. Scenario (2) is based on the per capita spend on electricity in rural areas derived from household surveys published in a World Bank policy report in 2016. Scenario (3) is based on national tariffs in Angola and on demand levels observed elsewhere in SSA. Finally, scenario (4) is based on a theoretical higher tariff than currently available and demand levels observed in SSA. Scenario (2) was selected as it was based on more recent data obtained through use of household surveys, specifically in rural areas and addresses spend on electricity.

10 Here we are assuming that populations best served by mini-grids may not necessarily be in the bottom quintile, though certainly would not be at the top. The average across the country still gives a per capita annual spend of USD198, which is almost double that of the average rate chosen here.

Table 12 Market size estimates for the four scenarios

Scenario	Estimated per capita annual costs for GMG	Market Size given current GMG population
1 World Bank Database	NA	NA
2 Other reports	$25.40	$252.5m
3 'Bottom-up' + existing tariff	$3.21	$31.9m
4 'Bottom-up' + theoretical tariff	$64.24	$638.5m

Selecting this methodology gives an estimated annual mini-grid market size of $252.5m in Angola, based on average per capital annual spend on electricity in rural areas.

3.3 Renewable Energy Potential for Mini-Grids

Angola has important renewable energy resources. Thus far only hydropower has been exploited. However, through their strategy documents (MINEA, 2017). Renewable energy source will play an important role in the energy mix of the National grid but also in accelerating access to electricity to the rural population.

3.3.1 Hydro

The average rainfall in Angola is 1,060 mm, with the most rainfall occurring between the months of November to March. The Northeast is the wettest region (1400mm), with coastal areas and the south of the country being driest (<500mm annual average rainfall). With the rainy season coinciding with the warmest temperatures, effective rainfall is less due to evaporation and evapotranspiration. In the Northeast and Central Plateau in particular, however, the runoff is relatively high. (MINEA, 2014).

There are 47 main drainage basins in Angola, offering significant hydropower potential. The hydroelectric potential is estimated at 18GW according to the latest Hydro Atlas (within the New Renewables Atlas, (MINEA, 2014)). According to PRODEL, only about 900MW has been exploited which represents about 44% of the total generated power. However, there are two significant projects under construction, namely the Laúca Hydroeletric Power Station (2,070 MW) and Cambambe (960 MW) which will increase this capacity four or five folds

Figure 19 Hydropower potential and location of small-hydro potential sites inventoried by DNEL (MINEA, 2014)

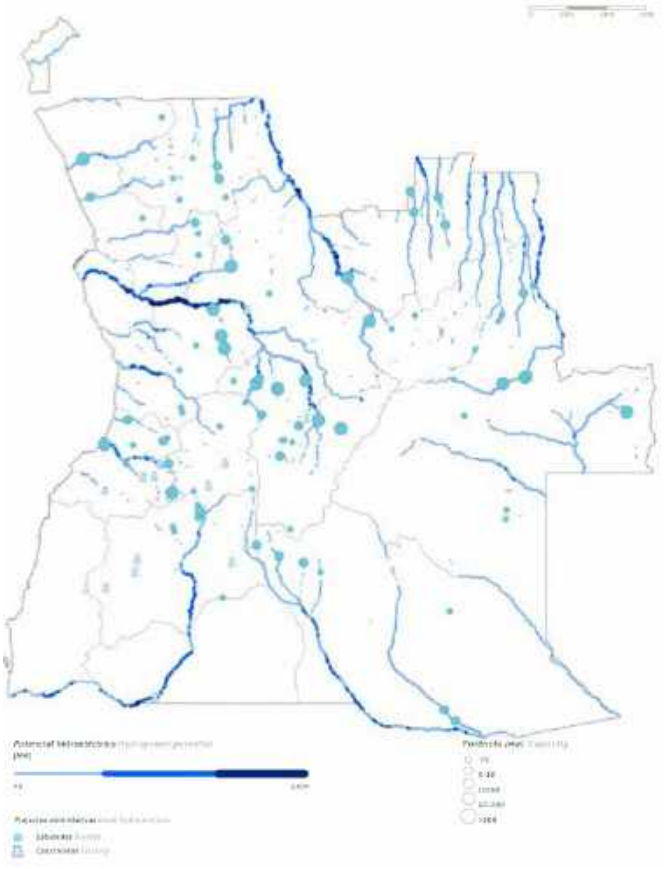
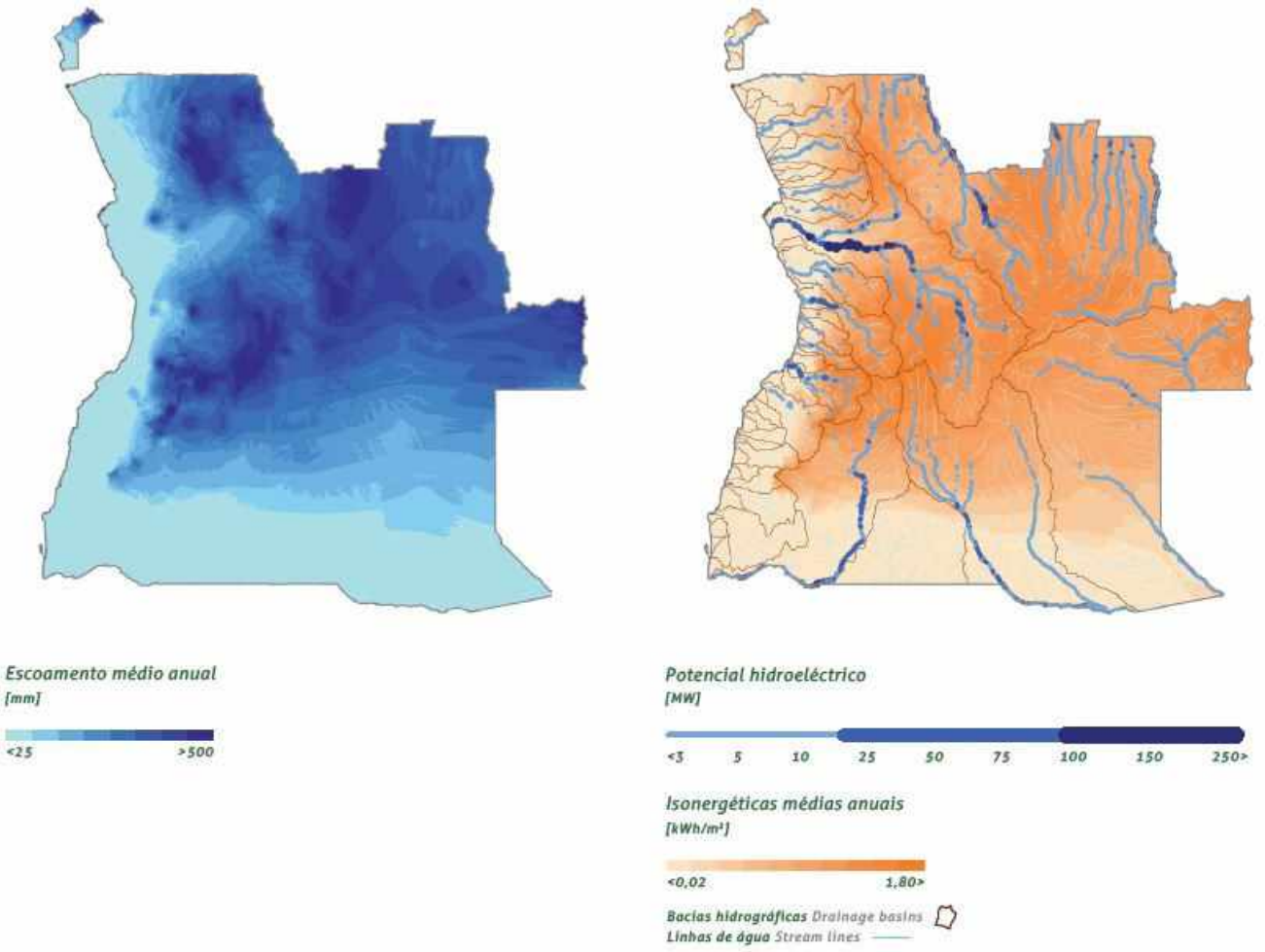


Figure 20 Surface Run-off map and Hydropower Potential Atlas



The government has prioritised the development of large-scale hydroelectricity in Angola, expanding the Cambambe Plant, commissioning of the Lauca and Caculo Cabaca Hydroelectric Plants. The Luachimo hydroelectric power plant began construction in 2017 for renewal and extension.

In addition, as of 2017, the following studies have been undertaken:

- Study, launch and construction of Cacombo Regularization Hydroelectric Power Plan (Catumbela River);
- Study, launch and construction of Vuka Hydroelectric Power Plant (Cuango River);
- Detail studies and preparation of contract documents for Jamba Ya Oma Regularization Hydroelectric Power Plant (Cunene River);
- Detail studies and preparation of contract documents for Cafula or Genga Regularization Hydroelectric Power Plant (Queve River);
- Detail studies and preparation of contract documents for Mucundi Regularization Hydroelectric Power Plant (Cubango River);

At the time of the launch of the Action Plan in 2017, the 12MW Cutato small-hydro plant (to be linked to the planned Capelongo/Cuvango substation), had concluded its preliminary studies. Projects already identified in the Angola Energia 2025 strategy document will be further analysed, and aims to launch tenders for 100MW of mini, and small-scale hydro projects soon.

3.3.2 Biomass

Angola has a significant biomass potential, given vast forested areas in the east of the country, estimated at 3.7 GW. According to the Atlas, 42 potential biomass sites were identified (including planned or ongoing projects) (MINEA, 2014). Of these, 1.5GW of projects were studies in further detail, and divided into different technologies:

- Forest biomass: 32 projects with a potential of 1,130 MW;
- Sugar cane: 8 projects with a potential of 250 MW;
- Urban solid waste: 2 projects with a potential of 20 MW.

The Central and Eastern regions are areas that have the highest potential, with both forestry and agro-industry(Figure 16 and Figure 17). Biomass from livestock waste and other crops have significantly lower potential than forests and sugarcane. Biomass potential in some areas has been estimated at 170MW (MINEA, 2014). Around city centres, for example in Saurimo and Luena, there has been significant deforestation by local populations, and biomass is still a major source of energy for many rural populations. The government has stressed the need to implement reforestation projects to support energy supply in these cities, with two biomass plants planned: Luena Biomass Power Plant (20 MW) and the Saurimo Biomass Power Plant (20MW).

Figure 16 Biomass Potential from Forests (MINEA, 2014)

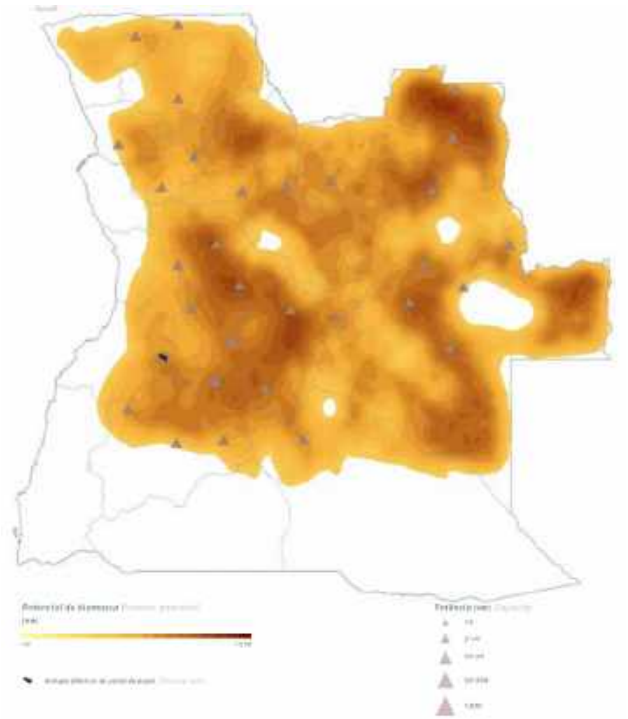


Figure 17 Biomass Potential from Sugar Cane (MINEA, 2014)

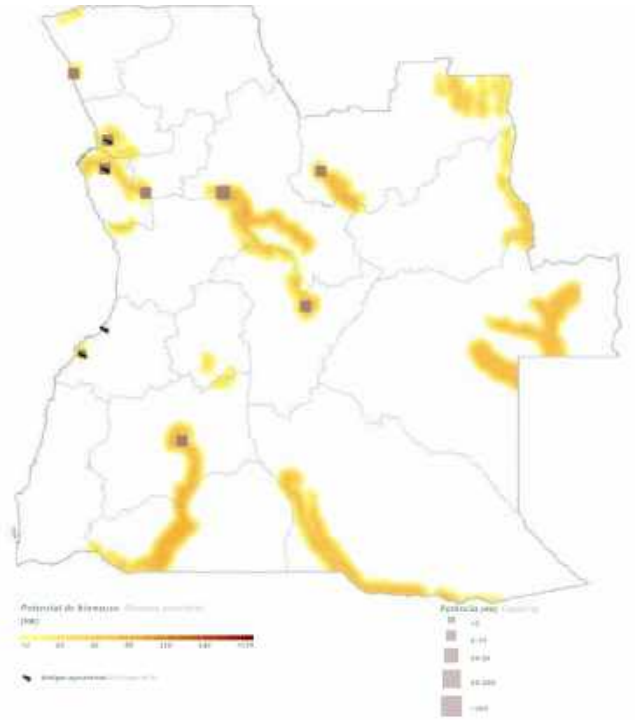
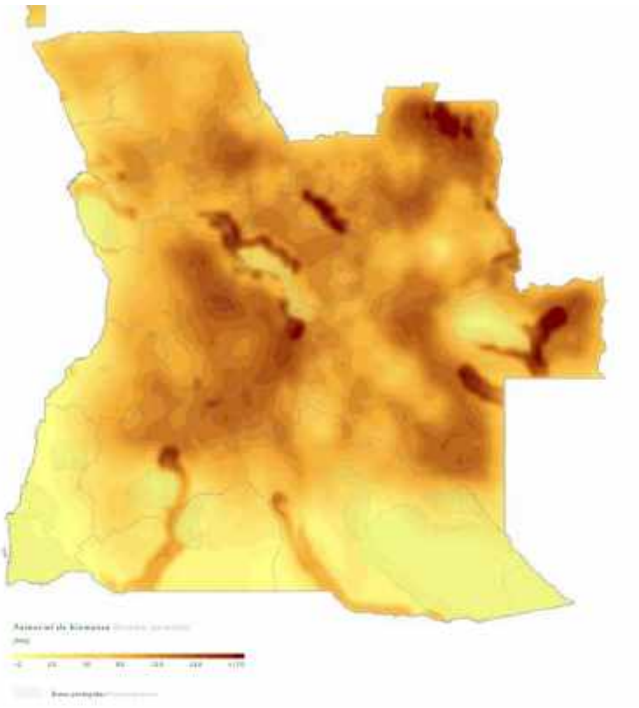


Figure 18 Biomass Potential - All technologies (MINEA, 2014)

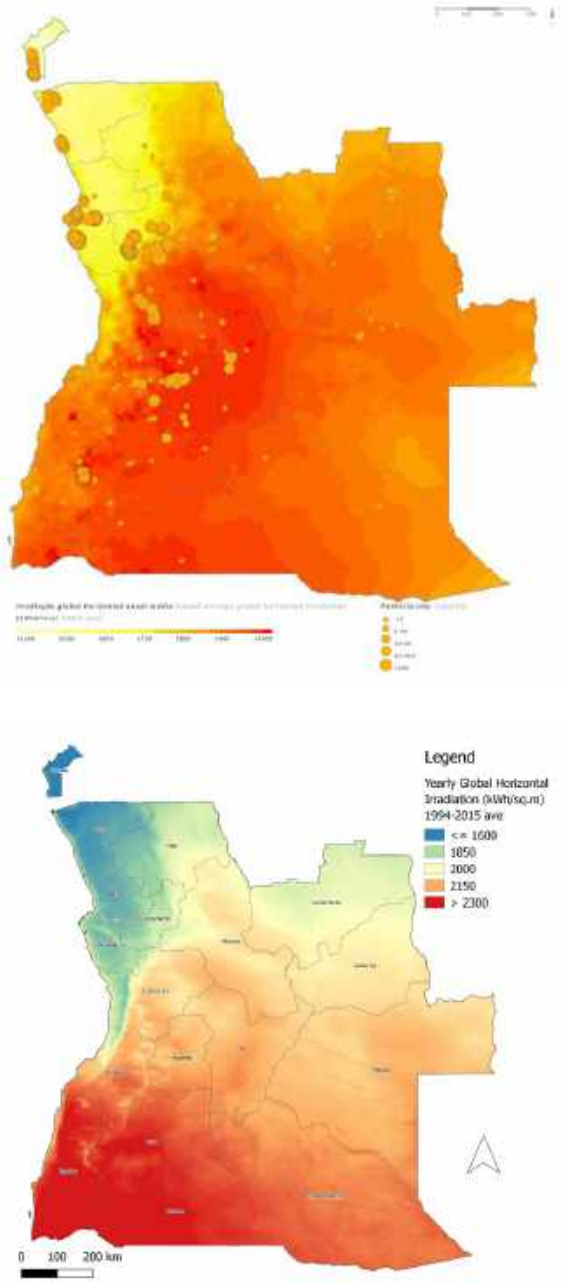


3.3.4 Solar

Angola has a high potential of solar resource estimated at 55 GW and a global annual horizontal solar irradiation between 1,355 and 2,068 kWh/m2/year. The Angola 2025 Atlas for New Renewable Energies (MINEA, 2017), identified a series of localities that are ideal for solar

projects. 704 sites were identified, with 368 prioritised for development, representing 17.3GW. Of these, 120 projects were identified as being eligible for grid connected in the near term. (Figure 19). The majority of the projects with the highest viability are located in the provinces of Luanda, Cuanza Norte and Cuanza Sul (MINEA, 2014).

Figure 19 Annual average global horizontal irradiation and solar projects with grid connection capacity (MINEA, 2014)

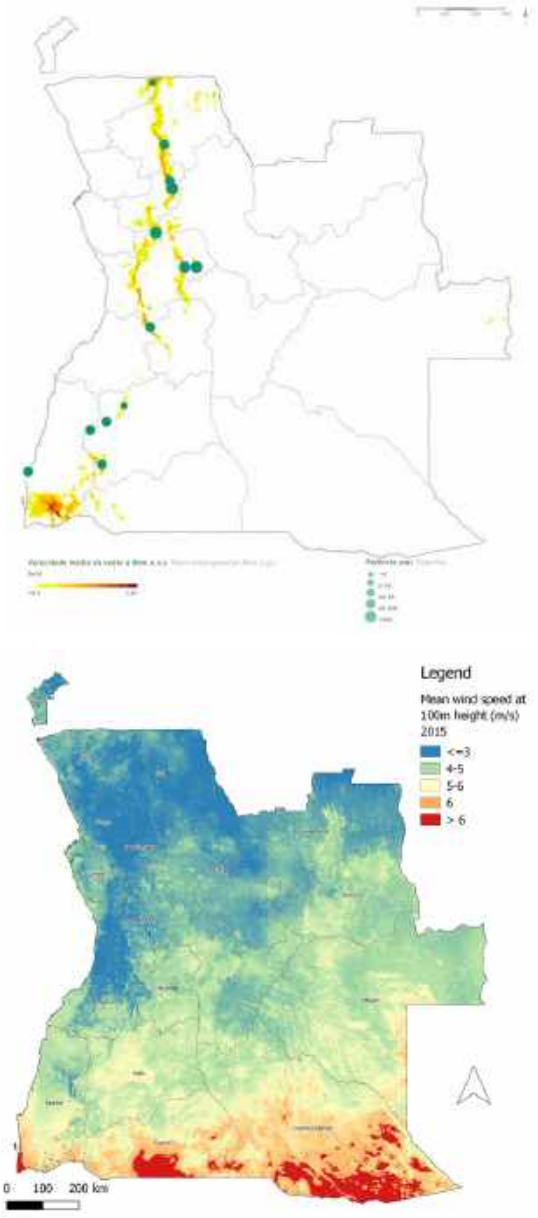


3.3.5 Wind

The Atlas for Renewable Energies estimates Angola's wind potential as being 3.9GW, (MINEA, 2014). In the Atlas, 604MW of this, was identified as 13 priority projects to be completed in the short term. The 13 projects are shown on the figure below, all of which had windspeed averages of at least 6m/s. It is understood that EREDA, a private company, supporting the government with wind projects has completed the construction of a 100MW wind farm, and was also responsible for the design of another 30MW hybrid system (wind and solar) on the Island of Baia Dos Tigres in Namibe, Angola.

According to the Sector Action Plan (MINEA, 2018), a more recent study showed 7 possible wind farm projects with potential production of more than 2,000 equivalent hours (MWh/MW). Projects were prioritized based on wind speed averages, but also their proximity to the grid network (<100km), and access roads. The is due to carry out to determine which wind farms will be developed ahead of 2022.

Figure 20 Mean wind speeds and high potential identified sites (MINEA, 2014)



4.1 Energy Sector Policies and Regulatory Frameworks Directory

Law	Governing
General Electricity Law 2015 (Law nº 27/15 of December 14th)	Establishes the legal frameworks relating to the generation, transmission, distribution and use of electricity
Executive Decree No. 705/15 of 30 December 2015 Repealed by Executive Decree No. 122/19, of May	Electric Energy Selling Rates
Presidential Decree No. 4/11 of 6 January 2011	The Regulation of the Tariff. The Decree determines the criteria and methods for the formulation of tariffs and prices of electric energy to be practiced by the entities covered by it.
Presidential Decree No. 19/11 of 17 January 2011	Regulation on access to grids and to the interconnections
Presidential Decree No. 310/10 of 31 December 2010	Regulation on the Quality Scheme for the service provided by the entities of the public electric system
Presidential Decree No. 82/10 of 22 November 2010	Models of concession contracts and models for the purchase and sale of electricity for small hydroelectric power stations
Decree No. 41/04 of 2 July 2004	Regulation of the licensing of electric power production, transmission and distribution facilities
Decree No. 40/04 of 2 July 2004	Regulation of the licensing of facilities for the use of electric power
Decree No. 47/01 of 20 July 2001	Regulation of Electricity Production (established the legal regime production of electric power in the public electric system).
Decree No. 45/01 of 13 July 2001	Regulation of Electricity Distribution
Decree No. 27/01 of 18 May 2001	Regulation of the Electric Power Supply – (establishes the regime of the supply of electrical energy in very high voltage, high voltage, medium voltage and low voltage to electrical facilities).
Presidential Decree No. 2/11 of 5 January 2011	Approved the Regulation of Commercial Relations between the al entities, state and private, involved in the activities of production, transmission, distribution and use of electricity).
Presidential Decree No. 305/14 of 20 November 2014	Created the Public Company of Energy Production ("PRODEL E.P."), the company National Electricity Transmission System ("RNT, E.P.") and the National Electricity Distribution Company ("ENDE, E.P.")
The Private Investment Law, June 26 of 2018	This law establishes the benefits and criteria for access that grants as well as the rights, duties and the guarantees of private investors. The electricity sector is considered a priority sector here (and some tax benefits are provided for this).
Presidential Decree No. 250/18 of October 30, 2018	Approved the Regulation of Private Investment Law (Law no. 10/18 of June 26).
Law n.º 9/16, of June 16th	Public contract Laws
Law n.º 11/19, of May 14th	Public private partnership Law

4.2 Data Sources Directory

This methodology was developed during the first phase of this project, the Green Mini-Grids Market Development Program - Market Intelligence business line, which is also available via the African Development Bank. The two methodology papers are published on the AfDB's Green Mini-Grid Help Desk.

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 2025. The GIS sources used in this analysis are detailed below.

Electricity transmission network (medium and high voltage)
Source: EnergyData – Angola Electricity Transmission Network
Link: https://energydata.info/dataset/angola-electricity-transmission-network-2017

Population density
Source: World Pop data portal
Link: http://www.worldpop.org.uk/

Renewable energy power plants
Source: EnergyData - Angola - Hydro powerplants
Link: https://energydata.info/dataset/hydro-powerplants-in-central-africa

Nightlights
Source: EnergyData – World – Night Light Annual Composite
Link: https://energydata.info/dataset/world-night-light-annual-composite-2015

Administrative Boundaries
Source: Humanitarian Data Exchange
Link: https://data.humdata.org/dataset/angola-administrative-levels-0-3

Wind: Mean Wind Speed at 100m Height
Source: DTU, IRENA
Link: https://irena.masdar.ac.ae/gallery/#gallery

Solar: Annual Total Global Horizontal Irradiation (GHI)
Source: Global Solar Atlas
Link: https://globalsolaratlas.info/download/angola

4.3 Stakeholder Directory

4.3.1 Government Departments and Agencies

Agency: Ministry of Energy and Water (MINEA)

Description

- Overall sector oversight;
- Prepares and implements energy policies and strategies.

Agency: Electricity and Water Sector Regulator (IRSEA - Instituto Regulador dos Serviços de Eletricidade e de Águas)

Description:

- Responsible for sector regulation;
- Regulates the activities and service quality of entities involved in the generation, transmission, distribution and commercialisation of electrical energy in the public system (Quality of services is provided for by Pressidential Decree nº310 of 2010);
- Regulates the electricity tariff and verifies compliance with established standards (in accordance with the Presidential Decree nº4 of 2011).

Agency: Public Company for Electricity Generation (PRODEL - Empresa Publica de Produção de eletricidade)

Description:

- Responsible for electricity generation
- Manages all public generating assets of 5MW or more (that is, over 90% of electricity production assets in Angola).

Agency: National Distribution Network (RNT - Rede Nacional de transportes de Eletricidade)

Description:

- The commercial agent for the electrical sector, RNT is responsible for electricity transmission through the management of high voltage grid and the interconnectors;
- Manages contractual processes for buying and selling electricity, monitors the sector's competitiveness;

- Sole Electricity off-taker;
- Responsible for the elaboration and coordination of the expansion and rehabilitation plans for the public electricity network, including generation plans;
- Coordinates studies on the integration of generation projects in the public electricity grid.

Agency: National Electricity Distribution Company (ENDE-Empresa Nacional de distribuição de Eletricidade)

Description:

- Responsible for electricity distribution;
- Responsible for grid extension and distribution;
- Operate and manage all the grids transports of 60KV and below;
- Operate the distribution network infrastructures;

Agency: Gabinete de Aproveitamento do Medio Kwanza (GAMEKE)

Description:

- Utility company responsible for implementing and managing the hydro projects in the Kwanza river;
- Is has been expanded to include oversight of the development and construction of most major power projects in the country.

4.3.2 Mini-Grid Practitioners and Product Developers

Company/Organisation: PowerBlox

Brief description: Private sector organisation providing off grid solutions. Not currently involved in mini-grids, but expressed interest in the sector were the regulatory environment to be improved.

Website: https://www.power-blox.com/

Company/Organisation: Aggreko

Brief description: Private sector providing Solar off grid solutions. They have identified 29 location for hybrid off grid solutions and are in discussion with the regarding the development of mini-grids.

Website: www.aggreko.com

Company/Organisation: GreenTech

Brief description: Private sector providing solar off grid solutions (SHS). Not currently involved in mini-grids, but expressed interest in the sector were the regulatory environment to be improved.

Website: https://www.energygreentech.solutions/

4.3.3 Bilateral and Multilateral Donor Organisations

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

Contacto:

Email: giz-angola@giz.de

Link: https://www.giz.de/en/worldwide/339.html

Banco Mundial

Link: http://www.worldbank.org/en/country/angola

Brief description: A number of energy sector and electrification projects have been led by the World Bank team in Angola. Current work includes a least electricity cost study in Angola.

United Nations Development Program (UNDP)

Link: https://www.ao.undp.org/

Brief description: UNDP are providing support to MINEA on the rural electrification strategy along with the AfDB, and have been implementing a GEF-funded Sustainable Energy Access for Rural Communities projectin South Eastern Angola

5.2 Installed Capacity envisaged by MINEA in 2018

Table 13 Available and installed capacity at the at the end of 2018. Source: Angola Energia 2025

LOCALIZAÇÃO E NOME DA CENTRAL *LOCAL AND NAME OF THE POWER PLANT*	MW INSTALADOS 2018 *MW INSTALLED 2018*	MW DISPONÍVEIS 2018 *MW AVAILABLE 2018*	ANO DE ENTRADA EM SERVIÇO *YEAR OF COMMISSIONING*
NORTE			
Bengo	-	-	-
CH Mabubas	26	26	2012
Bengo Total	26	26	-
Cabinda	-	-	-
Central Hibrida Belize	3	3	2018
Central Hibrida Dinge	3	3	2018
Cabinda Total	5	5	-
Kwanza Norte	-	-	-
CH Cambambe 1 (alteamento)	260	260	2017
CH Cambambe 2	700	700	2017
CH Laúca	2004	2004	2017
Kwanza Norte Total	2964	2964	-
Luanda	-	-	-
CDE Morro Bento (APR)	50	50	2013
CT Benfica Luanda	40	24	2013
CT Boavista 1 (até 2018)	90	-	2011
CT Boavista 2 (até 2019)	41	13	2011
CT Camama	50	25	2017
CT Cassaque	20	10	2013
CT Cazenga	140	97	Vários
CT CFL	125	35	2012
CT CIF	111	111	2016
CT Morro Bento 2	50	27	2017
CT Morro da Luz (ERA)	40	40	2016
CT Quarteis	32	19	2013
CT REFINARIA	26	26	2016
CT ROCHA PINTO (APR)	20	20	2016
CT Viana 1	22	20	2010
CT Viana 2 (km9)	40	28	2013
Luanda Total	898	544	-
Malanje	-	-	-
CH Capanda	520	360	2004
CT BIOCOM	50	50	2016
CT Capopa 2	20	13	2015
Malanje Total	590	423	-
Uíge	-	-	-

LOCALIZAÇÃO E NOME DA CENTRAL *LOCAL AND NAME OF THE POWER PLANT*	MW INSTALADOS 2018 *MW INSTALLED 2018*	MW DISPONÍVEIS 2018 *MW AVAILABLE 2018*	ANO DE ENTRADA EM SERVIÇO *YEAR OF COMMISSIONING*
Central Hibrida S Pombo	4	4	2018
CH Luquixe	1	-	1972
Uige Total	5	4	
Zaire			
CT Kianganga	20	11	2014
CT Soyo 1	750	750	2017
CT Tomboco*	1	1	2016
Zaire Total	771	762	
Norte Total	**5257**	**4728**	**1972**
CABINDA			
CT Belize	2	1	2014
CT Buco Zau	2	1	2014
CT Chibodo	31	15	2014
CT Malembo	95	57	2012
CT Santa Catarina	10	7	2014
CT Pangala (Relocalização)	6	6	2018
Cabinda Total	146	87	-
Cabinda Total	146	87	-
Centro	-	-	-
Benguela	-	-	-
CDEQuileva(AGGREKO)	30	30	2013
CH Lomaum	50	50	2014
CT Cavaco	20	8	2013
CT Lobito	20	-	1986
CT Quileva	182	115	Vários
CH Biópio (Reabilitação em estudo)	15	7	1956
Central Hibrida Bocoio*	5	5	2018
Benguela Total	322	215	-
Bié	-	-	-
CT Calapuanda/Cuito	10	4	2011
CT Cuito 1 (Dongfang)	20	20	2018
CT Camacupa*	3	1	2001
CT Chinguar*	2	2	2008
Bié Total	35	27	-
Huambo	-	-	-
CH Gove	60	7	2012
CT Belém Huambo	50	50	2017
CT Benfica Huambo	15	11	2013

LOCALIZAÇÃO E NOME DA CENTRAL *LOCAL AND NAME OF THE POWER PLANT*	MW INSTALADOS 2018 *MW INSTALLED 2018*	MW DISPONÍVEIS 2018 *MW AVAILABLE 2018*	ANO DE ENTRADA EM SERVIÇO *YEAR OF COMMISSIONING*
CT Lossambo	8	7	2016
CT Bailundo*	3	2	2013
Central Hibrida Lundimbale*	5	5	2018
Central Hibrida Longonjo*	5	5	2018
Huambo Total	146	87	-
CENTRO TOTAL	**503**	**329**	-
SUL			
Cunene	-	-	-
Central Hibrida Xangongo	5	5	2018
CT Ondjiva	10	5	2013
Cunene Total	15	10	-
Huila	-	-	-
CH Matala	41	27	1959
CT Arimba (Lubando Ind)	40	32	2013
CT Lubango (Anexa SE)	40	25	2013
Huila Total	121	85	-
Kuando Kubango	-	-	-
CT C.Canavale	8	8	2015
CT Menongue 1	12	8	2013
CT Menongue 2	56	56	2017
Kuando Kubango Total	75	71	-
Namibe	-	-	-
Central Hibrida Tombua	5	5	2018
CT Aeroporto (Namibe)	12	12	2013
CT Tombwa	10	3	2014
CT Xitoto 2	10	8	2013
CT Xitoto 3	56	56	2017
Namibe Total	92	83	-
Lubango	-	-	-
CT Central Móvel GE (1ª fase)	31	31	2018
Lubango Total	31	31	-
SUL TOTAL	**335**	**281**	-
LESTE			
CT Nova Dundo	30	17	2013
Lunda Norte Total	30	17	-
Lunda Sul	-	-	-
CH Chicapa 1	16	16	2001
CH Chiumbe Dala	12	7	2017

LOCALIZAÇÃO E NOME DA CENTRAL *LOCAL AND NAME OF THE POWER PLANT*	MW INSTALADOS 2018 *MW INSTALLED 2018*	MW DISPONÍVEIS 2018 *MW AVAILABLE 2018*	ANO DE ENTRADA EM SERVIÇO *YEAR OF COMMISSIONING*
CT Saurimo 1	14	4	2011
CT Saurimo 2 (AEnergia)	20	20	2017
CT Saurimo 3 (Dongfang)	20	20	2018
Lunda Sul Total	82	67	-
Moxico	-	-	-
CT Luau	5	4	2014
CT Luena 1 (Caterpillar)	6	2	2012
CT Luena 2 (Hyundai)	8	3	2013
CT Luena 3 (Dongfang)	20	20	2018
Moxico Total	39	28	-
LESTE TOTAL	**151**	**112**	**-**
TOTAL GERAL	4397	3837	-

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Document Series

Contacts:
Sustainable Energy Fund for Africa (SEFA)

Hosted by the AfDB

African Development Bank
Statutory Headquarters
Immeuble du Centre de Commerce
International d'Abidjan-CCIA
Avenue Jean-Paul II
01BP1387
Abidjan 01, Côte d'Ivoire

Sustainable Energy Fund for Africa (SEFA)
Coordinateur
Joao Duarte Cunha
sefa@afdb.org

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