Mini-Grid Market Opportunity Assessment: Madagascar

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

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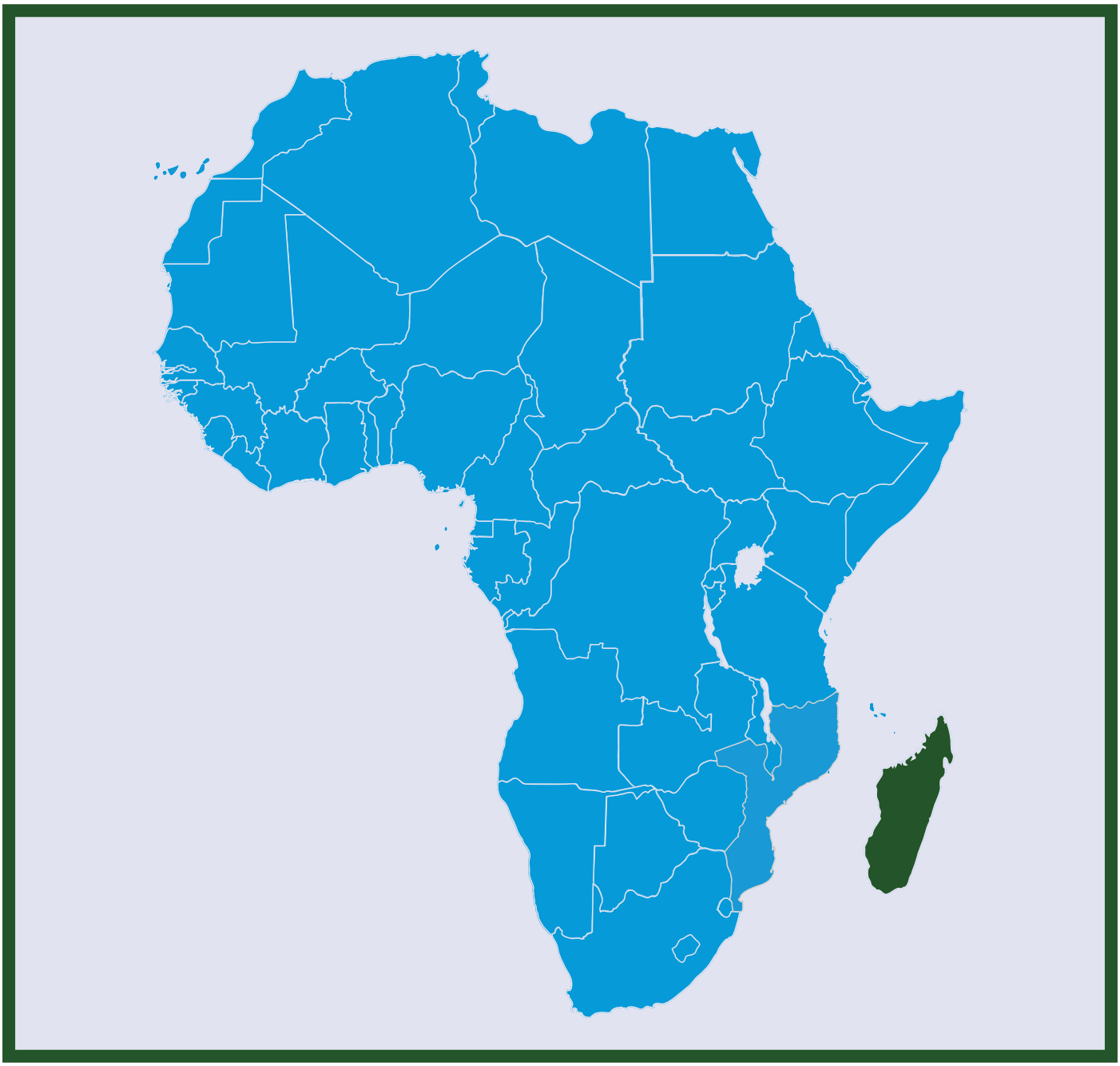

The African Development Bank has an overarching objective to spur sustainable economic development and social progress in its Regional Member Countries (RMCs), thus contributing to poverty reduction. The Bank Group aims to achieve this objective by mobilising and allocating resources for investment in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

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

The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) aspires to contribute to the sustainable economic, social and environmental development of West Africa by improving access to modern, reliable and affordable energy services, energy security and the reduction of negative environmental externalities of the energy system (e.g. GHG emissions, local pollution).

The Carbon Trust would like to thank the following organisations who made this report possible: Madagascar Rural Electrification Agency (ADER), the Economic Development Board of Madagascar (EDBM), the Ministry of Water, Energy and Hydrocarbons (MEEH), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the World Bank, United Nations International Development Organisation (UNIDO), Agence Française de Développement (AFD), Power Africa Southern Africa Energy Programme (SAEP), the World Wildlife Fund (WWF), AXIAN Group, BETC Natala, EOSOL, Henri Fraise & Fils.

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PREFACE

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

Mini-grids are not a new phenomenon in Africa. Almost all national utilities own and operate diesel-powered generating facilities not connected to the main grid, which supply electricity to secondary towns and larger villages. This solution to rural electrification often results in significant financial losses for the utility, needed to sell power at prices significantly below the cost of production and delivery. It also leaves the most remote towns and villages 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 percent, with 69 percent of the population in urban areas electrified compared to only 15 percent in rural areas.

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

However, the development of GMGs is not without its challenges. 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).[1] The GMG MDP is a pan-African platform that addresses the technical, policy, financial and market barriers confronting the emerging GMG sector. It is part of a larger Department for International Development (DFID) funded GMG Africa Programme, which also 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.

In its Africa Energy Outlook 2014, the International Energy Agency (IEA) predicted that by 2040, 70 percent of new rural electricity supply in Africa will most affordably come from stand-alone systems and mini-grids. The GMG MDP, SEforALL, SEFA, ESMAP and similar programmes, which are contributing to falling costs, technological 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 and the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) at the request of the AfDB. It was written by and Micol Salmeri of the Carbon Trust and Yuri Lima Handem from ECREEE. Carbon Trust is a mission-driven organisation helping businesses, governments and the public sector accelerate the move to a low carbon economy. ECREEE is a specialised agency of the Economic Community for West African States.

The content of this report was reviewed by William Hudson of Carbon Trust and Jeff Felten of the AfDB's GMG team. It was edited by Kimberlee Brown.

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

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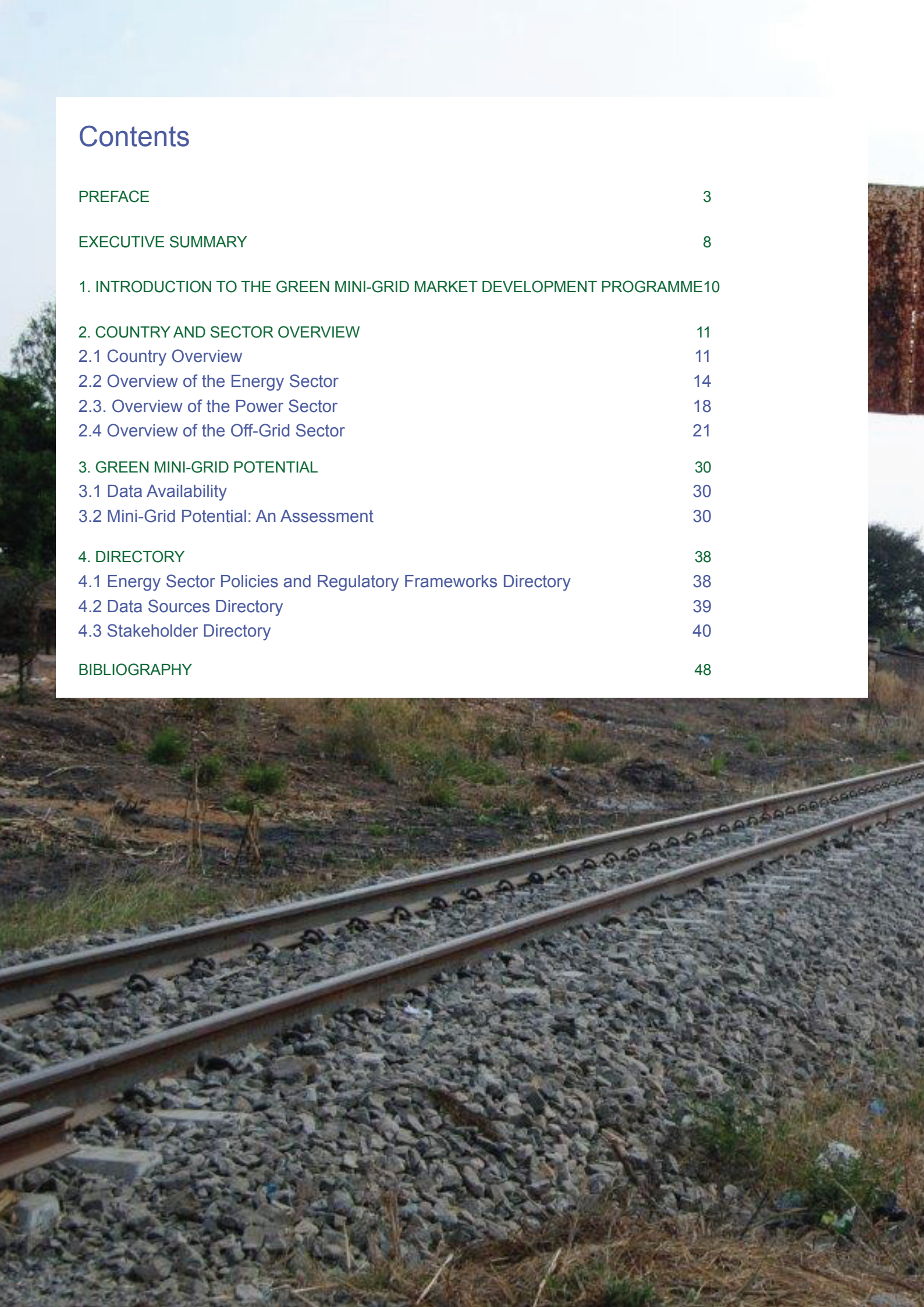

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ADER	Rural Electrification Agency/Agence de Développement de l'Electrification Rurale
AfDB	African Development Bank
AOPEM	Association des Opérateurs Professionnels en Electrification de Madagascar
ARELEC	Regulatory Electrification Authority/Autorité de Régulation de l'Electricité
BNM	Madagascar Bureau of Norms/Bureau des Normes de Madagascar
CEMG	Clean Energy Mini-Grid
DFID	Department for International Development
ECOWAS	Economic Community of West African States
ECOWREX	ECOWAS observatory for Renewable Energy and Energy Efficiency
ECREE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EDBM	Economic Development Board Madagascar
EIA	Environmental impact assessment
EUEI	European Union Energy Initiative
ESMAP	World Bank's Energy Sector Management Assistance Program
FNE	National Electricity Fund/Fond National de l'Electricité
FNED	National Sustainable Energy Fund/Fonds National de l'Énergie Durable
GDP	Gross Domestic Product
GMG	Green Mini-Grid
GIS	Geographic information system
HIO	High Impact Opportunities
IEA	International Energy Agency
IFC	International Finance Corporation
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
INSTAT	National Office of Statistics/Institut National de la Statistique
IPP	Independent Power Producer
MDP	Market Development Programme
MEEH	Ministry of Water, Energy and Hydrocarbons/Ministère de l'Eau, de l'Energie et des Hydrocarbures
MPAE	Ministry in Charge of Agriculture and Livestock/Ministère auprès de la Présidence en charge de l'Agriculture et l'Elevage
NAMA	Nationally Appropriate Mitigation Action
NEP	New Energy Policy/Nouvelle Politique de l'Energie
NEPAD	New Partnership for Africa's Development
ORE	Electricity Regulatory Authority/Office de Régulation de l'Electricité

PDMC	Least Cost Power Development Plan/Plan de Développement au Moindre Coût
PDRI	Indicative Regional Development Plans/Plans Directeurs Régionaux Indicatifs
PERC	ECOWAS Renewable Energy Policy
PNE	New Energy Policy/Nouvelle Politique de l'Energie
PPA	Power Purchase Agreement
PPP	Private Public Partnership
PV	Photovoltaic
REC	Regional Economic Communities
REDD	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
SADC	Southern African Development Community
SEforALL	Sustainable Energy for All
SEFA	Sustainable Energy Fund for Africa
SEM	Malagasy Society of Energy/Société des Energies de Madagascar
SMEE	Malagasy Society of Water and Electricity/ Société Malgache de l'Eau et de l'Electricité
SSA	Sub-Saharan Africa
UN	United Nations
UNDP	United Nations Development Programme

EXECUTIVE SUMMARY

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

This report's methodology combines a high-level opportunity assessment with practical knowledge and information targeted at mini-grid practitioners. Information provided covers key stakeholders, raw data on physical and non-physical factors and a policy and regulatory analysis. Assessing the potential for mini-grids is challenging as such analysis requires plenty of data and assumptions. 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.

Madagascar has an estimated population of 24.8 million people in 2016 (growing 2.7% annually), with around 35% living in urban or peri-urban areas. Like many Indian Ocean island nations, Madagascar has a tropical climate. At the same time, it is one of the countries most exposed to extreme weather events, and experiences, on average, three major natural disasters per year, with associated impacts on life, economy, and the infrastructure. The country's infrastructure is relatively limited. The Malagasy road network is characterised by little tarred infrastructure (13% of the 32,000km of roads (AFD, 2018)). In terms of telecommunications, the combined fixed-line and mobile-cellular tele-density is about 45 per 100 persons, which remains relatively low.

Madagascar is a semi-presidential representative democracy: The President is head of state and the Prime Minister is head of government. There are three levels of authority in Madagascar. The executive branch is consists of a president, and a prime minister (appointed by the president) and council of ministers who carry out day-to-day management of government. The legislative branch is made up of the two parliamentary chambers; the National Assembly (Antenimieram-Pirenena/Assemblée Nationale) has 160 members, elected for a four-year term in single-member and two-member constituencies, whilest the Senate (Sénat) has 33 members; 22 are indirectly elected, one from each of the 22 regions of Madagascar, and 11 are appointed by the President. Finally, the country has an independent judiciary. The president is elected by a popular vote, and can be re-electedis renewable twice (a maximum of three five-year terms).

Madagascar's nominal Gross Domestic Product (GDP) was US $10.4bn in 2017 with nominal GDP per capita of $1,563. The economy grew 4.1% in 2016 and 4.5% from 2017, an increase from 3.1% the prior two years and from 2.7% between 2009 and 2013. The economy relies primarily on the agricultural sector (34.6% of GDP in 2016). The agriculture sector is the greatest employer (more than 70% of the Malagasy workforce). The sector faces many challenges, notably from natural disasters. Rice accounts for 28% or 3.8 million tonnes of all agricultural output and is an important cash crop and food source for the country. Madagascar is Africa's, and the world's largest producer of vanilla, accounting for 37% of global production.

The average energy consumption per capita in Madagascar is 0.315 toe/year; one of the lowest in the world. Madagascar is a least developed country with non-significant greenhouse gas emissions. As of 2016, the installed generation capacity in Madagascar was 680 MW (some sources suggest this could have risen to 840MW by Jan 19), consisting of 23% renewable sources (mostly hydropower) and 77% fossil fuel-based sources. Madagascar has an average electrification rate of 15%, unevenly distributed between urban areas (53%) and rural areas (6.5%). Madagascar suffers from heavy non-technical network losses, with 37% of energy produced not being billed. Madagascar does not have a single central grid, but three larger independent grids. The most suitable grid expansion options are principally in the central and northern part of the country.

Several government agencies play a role in the energy sector in Madagascar. The Ministry of Water, Energy and Hydrocarbons (Ministère de l'Eau, de l'Energie et des Hydrocarbures - MEEH) develops and implements policies for the provision of adequate and reliable power supply in Madagascar. The Rural Electrification Agency (Agence de Développement de l'Electrification Rurale - ADER) was established in 2002 to advance rural electrification. Its main activities include identifying potential sites for rural electrification, managing the competitive tender process and supervising concessions. The Electricity Regulatory Authority (Office de Régulation de l'Electricité - ORE, soon l'Autorité de régulation de l'électricité - ARELEC) is the regulatory body of the electricity sector. JIRAMA (Jiro sy rano Malagasy) is the state-owned water and electricity operator.

Until recently there was no renewable energy policy in Madagascar. With the help of the European Union Energy Initiative (EUEI), Madagascar developed the New Energy Policy (Nouvelle Politique de l'Energie - NPE) for 2015 to 2030. The NPE sets energy targets including increasing the energy access rate to 70% by 2030. Of the 70%, only 20% are expected to be connected to an off-grid renewable energy supply, although in reality this will need to be higher if the 70% target is to be hit. Madagascar's efforts to develop a regulatory framework for mini-grids are ongoing. Concessions on sites are being awarded following a competitive public tendering process, yet also through unsolicited applications and 'reservations' of villages.

ADER has been providing subsidies for rural electrification projects with funding from donor agencies. Additionally, it can subsidise projects through the management of the National Electricity Fund (Fond National de l'Electricité - FNE). However, the current functioning of the FNE has been questioned due to a lack of funds and a delicate financing set-up. The NPE is replacing the FNE with a new National Fund for Sustainable Energy (Fond National de l'Énergie Durable - FNED), which will be an independent, multi-instrument fund able to channel government, donor and private funds. It is hoped the FNED will follow a more independent and transparent procedure and hence be more closely aligned to the needs of buyers in the market.

There is a need to strengthen and enforce the legal and regulatory framework to become more attractive to the private sector. The existing framework needs to create a more enabling and favourable environment to investments, and sharing of information on the local market needs. Despite reinforcement of ADER's processes, there remains too much uncertainty in the process to develop projects, and in what levels of funding are available. Access to land also remains an important challenge. The biggest barrier remains the extremely limited ability of the local population to pay, and therefore the provision of electricity through viable projects.

The main renewable energy potential in the country comes from hydropower, that has been a cornerstone of grid-powered generation in Madagascar for decades. Madagascar also has enormous solar energy potential. As part of the NPE, the government plans for almost 15% of households to be supplied by solar power. Diversification is key as about 92% of energy in Madagascar is supplied by fuelwood.

Based on our analysis of current grid coverage, high voltage (HV) line data and satellite mapping of night lights, we estimate that 40% of the non-electrified population would be best served by mini-grid solutions, with the highest potential in the Fianarantsoa state. This corresponds to 8.3 million people (33% of total population). A further 11.3 million people living within 15km of the grid should be electrified through grid extension, and 4.5 million best served by solar home systems.

This analysis estimates a total annual revenue market size of $106 million for mini-grids alone. The highest-potential state is Fianarantosa, with an estimated market size of $34 million and 2.7 million people most economically served through mini-grids.

When considering planned network extensions up to 2025, this drops to an estimated total market of $95 million, an 11% reduction compared to the market for mini-grids under the current grid. The largest market reduction when including these extensions is in the Fianarantosa state, at 14.7% (-$5 million). The largest market however remains in the state at $29 million. The actual market size may be greater than the estimates given here considering decentralised solutions could also be feasible in areas in grid proximity.

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

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

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

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

The Market Development Programme is implemented by the African Development Bank through a grant of the Sustainable Energy Fund for Africa (SEFA). The MDP is central to the Bank's effort to support the continent's progress towards the Sustainable Development Goal #7 on energy access, renewable energies and energy efficiency and on the Bank's own New Deal for Energy in Africa, which targets universal access by 2025.

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 to 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

Madagascar had an estimated population of 24.8 million people in 2016, with around 35% living in urban or peri-urban areas. The country is divided into six provinces, 22 administrative regions and 116 districts, and is said to have 2,200 communities. The capital city is Antananarivo, which is also the largest city with a population of 1.3 million. Life expectancy is 64 years for men and 67 years for women, averaging out to 65.9 in 2016, according to World Bank figures.

Figure 1. The six autonomous provinces of Madagascar

The nation consists of the island of Madagascar spanning 587km² (the fourth largest island in the world by area) and several smaller islands. The country is located off the coast of Southeast Africa, east of Mozambique, in the Indian Ocean. Central Madagascar is characterised by a high plateau with hills that range from 800m to 1,800m in altitude.

Like many Indian Ocean island nations, Madagascar has a tropical climate characterised by a ho -rainy season from November to April and a coole -dry season from May to October. The combined effects of southeast trade winds, with abundant moisture, and northwest monsoon winds dictate the climate. As a result, it rains across the whole island, except for the southwest, which is protected from the air masses and remains semi-arid all year round. The east coast is generally wet all year and has the highest annual precipitation on the island, yet there is no shortage of sunshine, as rain comes in the form of scattered thunderstorms. The trade winds have little effect on the northwest, where the monsoon winds prevail bringing precipitation to this part of the island, which creates a hot and muggy climate. The central region/plateau also experiences a similar climate. The west has very little rainfall. The southwest is almost a desert and the hottest part of the country, with the sun shining for an average of 10 hours.

Madagascar is one of the countries that is most exposed to extreme weather events and experiences, on average, three major natural disasters per year. Tropical cyclones, a common feature during the hot season, can cause significant flooding and damage especially on the east coast. Given this climatological cycle and varying landscapes of the country, there is a considerable range in total annual rainfall across Madagascar as shown in Figure 2.

Figure 2. Average monthly temperature and rainfall for Madagascar, 2010 to 2015, World Bank Climate Change Knowledge Portal

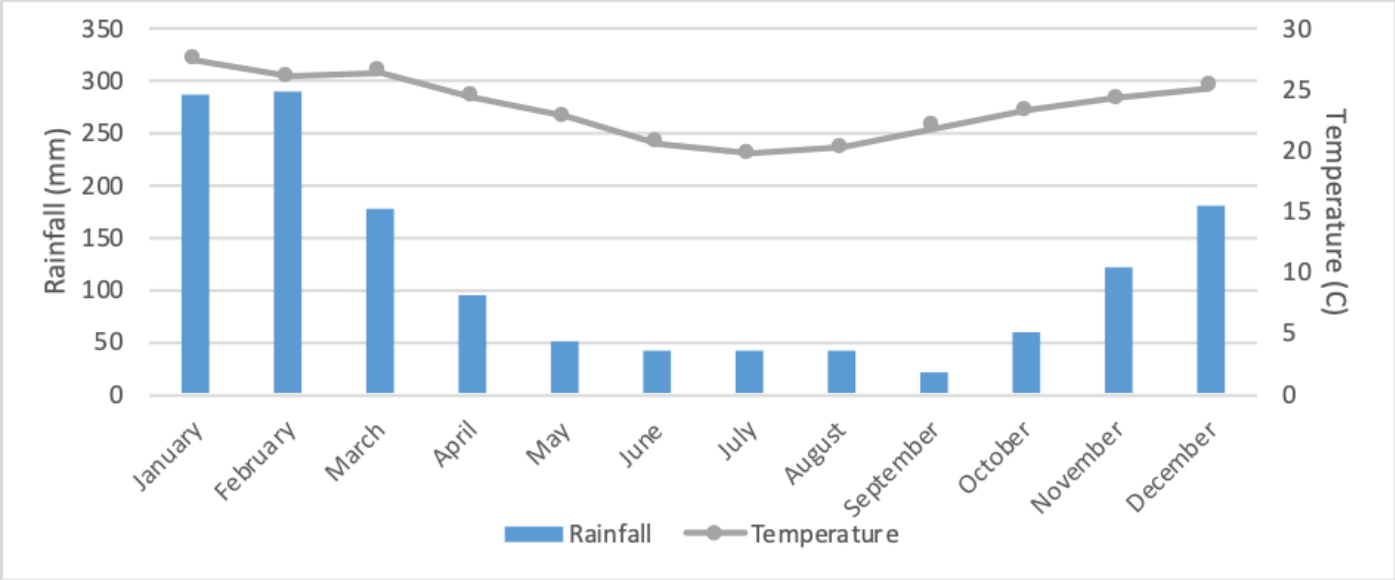
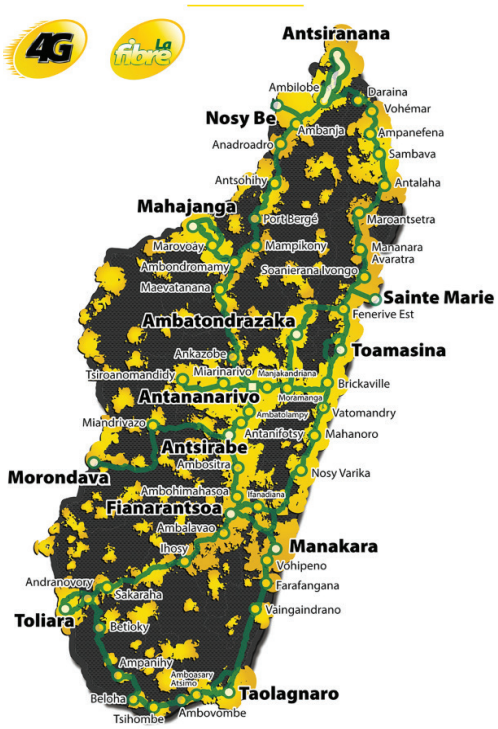


Figure 3. TELMA network coverage



The Malagasy road network is currently estimated at 31,64 km of roads and is divided into three categories of networks: the national roads (approximately 11,74 km), the provincial highways, and the network of municipal roads. Official statistics showed that only 10% of roads were in good condition and practicable throughout the year, 28% in average condition and 64% in poor condition. Only about 13% of the road network is paved (AFD, 2018).

The telecommunications sector in Madagascar is reasonably developed, with a combined fixed-line and mobile-cellular tel-density of about 45 per 100 persons. There are 12 operators providing services such as fixed telephony, GSM and internet standard mobile telephony, data transmission and other communication services such as electronic payment processing. The largest operators are TELMA (Figure 3), Orange Madagascar, and Airtel Madagascar. Competition among the three main service providers is spurring recent growth in the mobile market.

Madagascar was ruled by the French Colonial Empire from 1896 until its independence in 1960. The country has since undergone four major constitutional periods and a coup d'état in 2009. In 2010, a new constitution was signed, establishing a Fourth Republic, which restored the democratic multi-party system formed in the previous constitution. The current president, Andry Rajoelina was elected in January 2019, replacing Hery Rajaonarimampianina who had been in power since 2013 following a serious political crisis which started with the 2009 coup d'état. Political volatility remains a considerable threat in the country, with tension and instability occurring during the run-up to the latest elections, held in late 2018.

Madagascar is a semi-presidential representative democracy: The President is head of state and the Prime Minister is head of government. The Government consists of an executive branch (the presidency, a president appointed prime minister and his council of ministers), the legislative branch (a two2 chamber parliament consisting of the National Assembly (Antenimieram-Pirenena/Assemblée Nationale) and the Senate (Sénat)) and an independent judiciary. The president is elected by a popular vote and can serve a maximum of three five-year terms.

Madagascar's nominal Gross Domestic Product (GDP) was US $10.4 billion in 2017 with nominal GDP per capita of $1,563, according to figures from the African Development Fund (ADF, 2016). The economy grew 4.1% in 2016 and 4.5% from 2017, an increase from 3.1% the prior two years and from 2.7% between 2009 and 2013 (IMF, 2017). It should be noted that the Malagasy economy was one of few East African Countries to experience a positive GDP growth rate in 2015 to 2016. Although positive, this growth rate does not yet meet target rates of 5% per year set in the National Development Plan (2015 to 2019). In the context of the sub-region, Madagascar's growth rate in 2016 lagged East Africa: 4.1% compared to 5.5%, and its Tax-to-GDP ratio of about 11% is still one of the lowest in the world. Inflation rose sharply in 2017, reaching 9% in December 2017, the highest price increase in seven years (World Bank, The World Bank in Madagascar, n.d.). This trend is due to the commodity price hike linked to the decline in rice production. In 2018, the International Monetary Fund (IMF) projects a GDP growth of 6.3% and an inflation rate of 7.8%, showing signs for further economic improvements.

The Government has made recent efforts to improve the economic enabling environment of the country, such as the completion of the public-private partnership (PPP) law and the decree establishing the national authority in charge of corrective commercial measures (ANCC) (IMF, Republic of Madagascar Economic Development Document, 2017). Madagascar is now among the top 20 improvers in 2016 to 2017, according to the World Bank's 2018 Doing Business report.

The economy relies primarily on the agricultural sector (34.6% of GDP in 2016), followed by wholesale and retail trade, hotels and restaurants (16.3%) and the sub-sector comprising of transportation, storage and communications (13.1%) (AFD, 2018). The key drivers of the country's economic growth are agriculture, tourism, mining and the manufacturing sector. Madagascar is susceptible to commodity price volatility and demands from trading partners, in particular France. Other important partners are China, the United States and the European Union, although trade is on the decline. Madagascar's main export is nickel, which has seen lower market prices, affecting production and export values. This trend highlights the importance for Madagascar to diversify its economy, increase competitivity, investment and internal growth in key sectors.

More than 70% of the Malagasy workforce are employed in agriculture (WB Group, n.d.). The sector faces many natural disaster challenges. In late 2016 and early 2017 drought limited planting and crop development. Madagascar was then struck by Cyclone Enawo in March 2017, the strongest tropical cyclone since 2004, triggering devastating floods in the northeast. In total, 17 of the 22 regions were affected, further diminishing crop production. There was also a rodent infestation causing crop damage in the Menabe and Melaky regions. In the southwest, maize, black eye peas and groundnut harvests were affected by an outbreak of Fall Armyworms in November 2017 (MPAE, 2017).

Despite being a significant employer, agricultural productivity and output remains low. It is estimated that in 2017 national rice production fell 20% compared to 2016, while maize and cassava fell 11% and 4% respectively. Issues hindering crop production included limited access to seed variety, low levels of irrigation development, inadequate land area and farming techniques, high cost of farm inputs, lack of or high cost of fertilisers, inadequate storage facilities, conditions of roads and distances to markets. These hurdles have increased the reliance on food imports, which has seen 320,000 tonnes of rice imported between April and October 2017, more than during the whole of 2016 (FAO, 2018).

Madagascar is the world's largest producer of vanilla accounting for 37% of global production (FAO, 2018). The vanilla crop was not overly affected by the severe weather in 2017. It is an essential cash crop for its many farms and with global vanilla prices increasing due to crop uncertainty, it will remain a key component of the economy. In 2016, Madagascar produced 2,926 tonnes and exported US$408 million worth of vanilla, which equates to 18% of all of exports in 2016 (WITS, 2016).

Rice accounts for 28% or 3.8 million tonnes of all agricultural output and is an important cash crop and food source for the country. The average yield is 4.42MT per hectare. Based on the 2004 agricultural census, rice was harvested in 85% of farms and has increasingly become a larger source of household income, as high as 42% in 2012 (WB, 2016). With the decrease of rice output in 2017, prices increased across the country in the first half of the year. This is reflected in the 9% inflation rate, the highest price increase in seven years.

Cassava is the third largest crop, by production, behind rice and sugarcane. The country produces 2.6 million tonnes annually. The national average yield of cassava is estimated at about 8.03MT per hectare cultivated on 327,000 hectares. The crop is predominantly grown by poorer income groups for family consumption and local sale. The southern regions, those particularly susceptible to drought, account for 50% of production, leading to increased food insecurity.

The Madagascar fisheries sub sector has many resources that are yet to be tapped into. The export of shellfish provides a source of revenue, and fishing products historically contribute about 2 to 3% of the country's annual GDP (FAO, Madagascar Fisheries Data Management). However, the sector is predominantly a contributor to the population's nutritional requirements, as two-thirds of all catches are used for subsistence needs. Seaweed, sea cucumbers, octopus and crab farming could offer great expansion opportunities. Despite this high potential, domestic fish production still falls far below the total domestic demand, due to climate change, illicit trade, low profitability and cheaper imports.

The Government is making significant efforts to improve the agriculture sector. Specific actions include working with foreign and local companies to finance the construction and rehabilitation of hydro-agricultural and livestock infrastructure. In 2017, a range of policies and initiatives were undertaken by the Ministry in Charge of Agriculture and Livestock (MPAE) to strengthen agricultural value chains. MPAE collaborated with technical partners to secure investments for the sector, especially in rural areas. MPAE also launched the first International Agricultural Fair in 2017, together with l'Agence Première Ligne, to promote agribusiness and create an exchange platform for stakeholders (MPAE, 2017).

2.2 OVERVIEW OF THE ENERGY SECTOR

The average energy consumption per capita in Madagascar is 0.315 toe/year; one of the lowest in the world. In comparison, per capita average energy consumption in Mozambique is 0.407 toe/year, 2.655 toe/year in South Africa and 3.840 toe/year in France. Domestic consumption dominates the energy sector. Fuelwood provides households' cooking energy needs, estimated at 140,000 TJ/year, while kerosene and electricity meet lighting needs, about 8,000 TJ/year. The low energy consumption levels are reflective of the Malagasy economy.

Table 1. Breakdown of energy used by households, World Bank data

Energy sources used	Average	# hrs	Rural	Urban
Electrification rate (grid)	15%	833,000	5%	55%
Generator	4%	222,000	5%	3%
Solar	15%	833,000	3%	37%
Kerosene lamps, candles	53%	2,944,000	83%	26%
None (wood)	6.5%	361,000	7%	6%

About 92% of energy in Madagascar is supplied by fuelwood, while petroleum products and renewable energies represent only 7% and 1% respectively, to meet the demand for fuel and electricity production. All consumed petroleum products are imported (ADER, 2016). Amont renewables, the largest source of energy comes from hydropower.

Net power generation has been increasing over the years. In 2016, about 58% of the country's power generation came from low-efficiency generators running on imported fuel, with the remaining 42% produced by hydropower plants. In the same year, the electricity system of the country generated 1,65 GWh with a peak demand of 34 MW (World Bank, Madagascar Power Sector Operations Improvement Project , 2018). Note that the installed capacity in 2016 was 681MW, yet total generation capacity is decreasing due to a general lack of maintenance. There are currently seve7 hydroelectric power plants and 11 smal-/micro hydro plants (CIF, 2016). The share of production provided by independent private producers (IPPs) has increased in recent years, reaching 29.5% in 2014 (Africa–EU Renewable Energy Cooperation Programme).

Madagascar is a least developed country with non-significant greenhouse gases emissions, as stated in its Intended Nationally Determined Contribution (INDC). The profile of emissions in Madagascar, if no actions are taken to reduce these, can be seen below in Figure 4. With mitigation, there is the potential to reduce emissions by 30 $MtCO_2$ in 2030, the equivalent of 14% (UNFCCC).

Figure 4. BAU Emissions profile in Madagascar

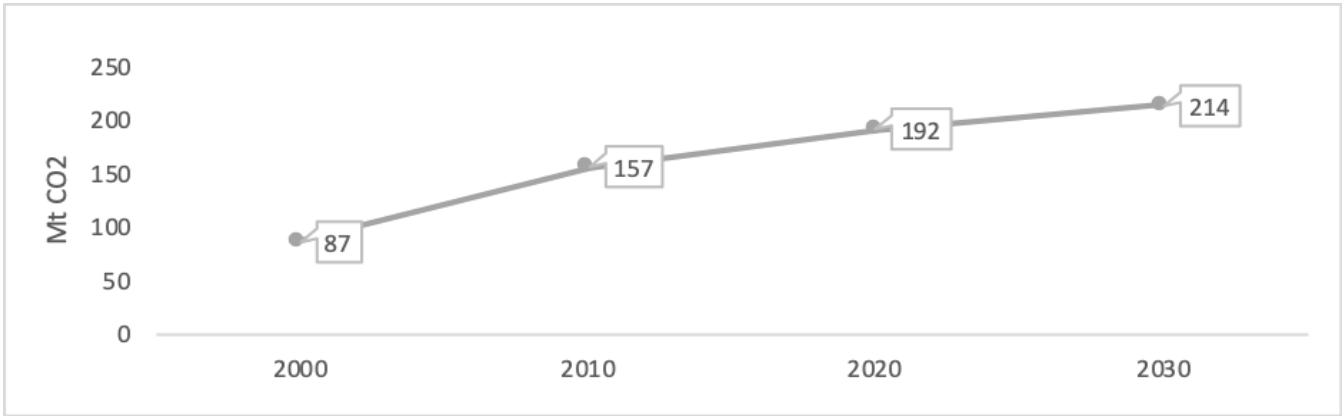
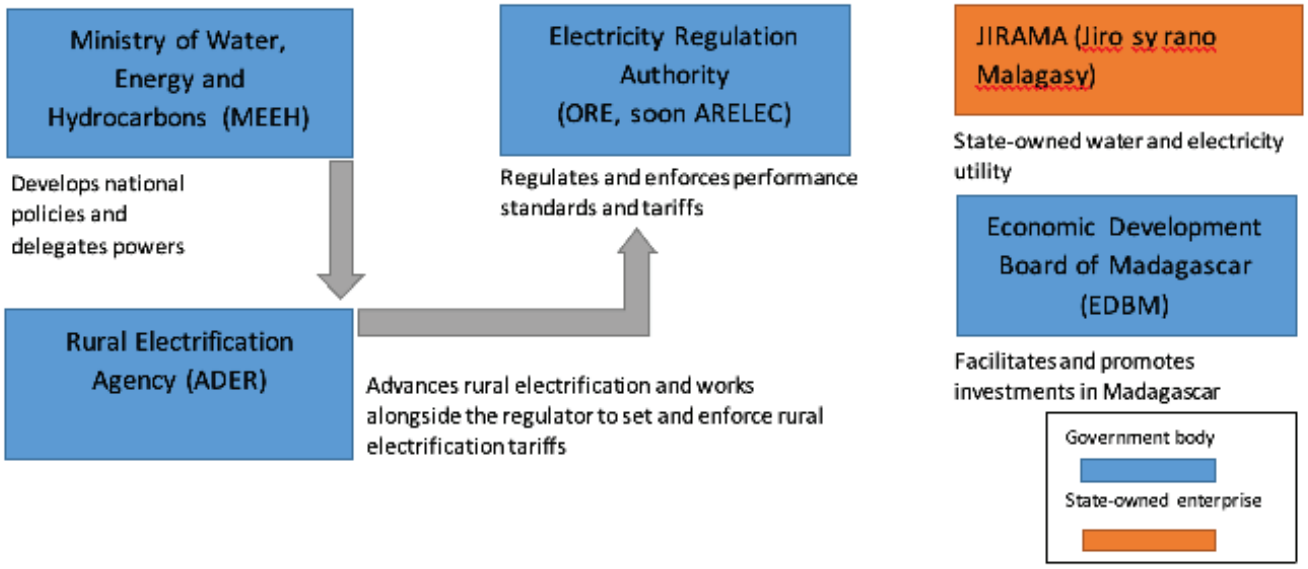


Figure 5. Government agencies playing a key role in the energy sector in Madagascar



The Ministry of Water, Energy and Hydrocarbons (MEEH) and its respective Directorate develops and implements policies for the provision of adequate and reliable power supply in Madagascar. The policies influence generation, transmission and distribution projects in the sector, provide general direction and facilitate the emergence of a private sector towards a competitive and efficient electric power industry. To implement its general renewable energy development and rural electrification policies, MEEH can delegate its powers to the rural electrification agency, especially in the context of launching calls for projects.

The Rural Electrification Agency (ADER) was established in 2002 to advance rural electrification. The focus was to promote access to basic electricity services for the rural population, primarily through renewable energy sources. Operational since 2004 following the Decree 2002–1550, ADER's main activities include: identifying potential sites for rural electrification, managing the competitive tender process and supervising concessions, writing and commissioning market studies, and quality checking project works. ADER works closely with MEEH, executing national policy, influencing new policies and modifying existing policy based on what it observes on the ground.

ADER's technological rural electrification priorities in order of importance are hydro, solar, biomass, wind and hybrid systems. With the technical and financial support from donors, ADER seeks to connect foreign and local partners with the relevant resources. In conjunction with the private sector, it aims to provide support to projects and establish a platform for public-private exchange.

The Electricity Regulatory Authority (ORE, soon ARELEC) is the regulatory body of the electricity sector. ORE was established in 2002 and is composed of the Council of Electricity, in charge of regulation, and of an Executive Secretariat, which executes the decisions taken by the board. Under the 2017 Electricity Code, the Council of Electricity will be renamed as the College of Commissioners. ORE's three principal missions are to agree, publish and oversee price tariffs and their application, oversee the quality of the services being offered on the grid (through licences, norms and contracts), and oversee free market competition. The 2017 Electricity Code explicitly mentions 14 mission as natural extensions of the three cores focal areas previously mentioned. At present, ORE's operational budget is drawn entirely from fees (1.2% of sales) levied on electricity operators.

JIRAMA (*Jiro sy rano Malagasy*) is the vertically integrated state-owned water and electricity operator created in 1975 following a merger between the old Malagasy Society of Water and Electricity (SMEE) and the Malagasy Society of Energy (SEM). The company is under joint supervision of the Ministries in charge of Water, the Ministry of Finance and Budget, and the Ministry in charge of Energy and Hydrocarbons. JIRAMA generates, purchases, transports and distributes electricity in Madagascar. Since the liberalisation of the electricity sector in 1999, JIRAMA is no longer the only operator in the market, yet the company still has the transport and distribution monopoly for the main grids. As of 2016, MEEH counted 22 private operators in the market (see **Error! Reference source not found.** in Appendices).

In 2016, the World Bank approved an International Development Association (IDA) loan worth $65 million to help the Madagascan Government improve its electricity sector operations. The Madagascar Electricity Sector Operations and Governance Improvement Project (PAGOSE) aims to improve the operational performance of JIRAMA and improve the reliability of electricity supply. The restructuring programme should also include standardising tariff rates across the country as well as increasing the tariffs, so they become more cost reflective. In June 2018, the World Bank announced an additional US$40 million of funding for this programme (World Bank, Madagascar Electricity Sector Operations and Governance Improvement Project, 2018).

JIRAMA has continuously received subsidies from the Government of Madagascar to pay for fuel purchase invoices and energy purchases to IPP, amounting to approximately US$141 million in 2017. The Government increased the average tariff of JIRAMA by 7.5% in July 2017, and again by an average of 10% in January 2018, to increase the utility's revenue and contribute to the objective of attaining financial equilibrium by 2020 (World Bank, Madagascar Electricity Sector Operations and Governance Improvement Project, 2018). A more detailed analysis of JIRAMA's challenges is presented in chapter 2.3.

The Economic Development Board of Madagascar (EDBM) is an agency of the Government (more specifically the presidency) that facilitates and promotes investment in Madagascar, acting as an interface between the private sector and the public sector. It was established under the 2007 Law on Investments in Madagascar which created an enabling environment for private investment. EDBM has three principal missions:

- Promoting investment and improving the business environment in Madagascar, working in close relationship with the Presidency of the Republic and contributing to policy reforms;
- Promoting a positive image of Madagascar as investment destination; and
- Providing a one-stop shop for investors, helping them to set up their companies and implement their projects.

Energy is one of the six sectors of focus that EDBM promotes. Through its large national and international network, and by working more closely with ADER, EDBM is putting efforts into identifying and attracting investors to the Malagasy energy sector. While ADER, working with ORE principally focuses on policy and regulation, EDBM can provide information centred on local procedures. It has for instance developed guidelines for investors to access the energy sector (e.g. how to register a company in Madagascar, obtain the necessary permits, information on labour and tax law, etc).

The 1999 Law on the Reform of the Electricity Sector formed the basis of the energy sector's legal framework. Though JIRAMA still dominates the market, the law set out to liberalise the electricity market, and promote private sector involvement through public tenders and/or the processing of unsolicited applications. The Electricity Law also established ADER under the Decree 2002–1550 and ORE as part of the terms of the law. We provide further detail in subsequent sections of this report.

In November 2017, the Government introduced a new Electricity Code for Madagascar (Law 2017-020) that will overwrite the 98-032 law on the Reform of the Electricity Sector. This milestone was achieved following extensive stakeholder engagement among all local organisations in the market.

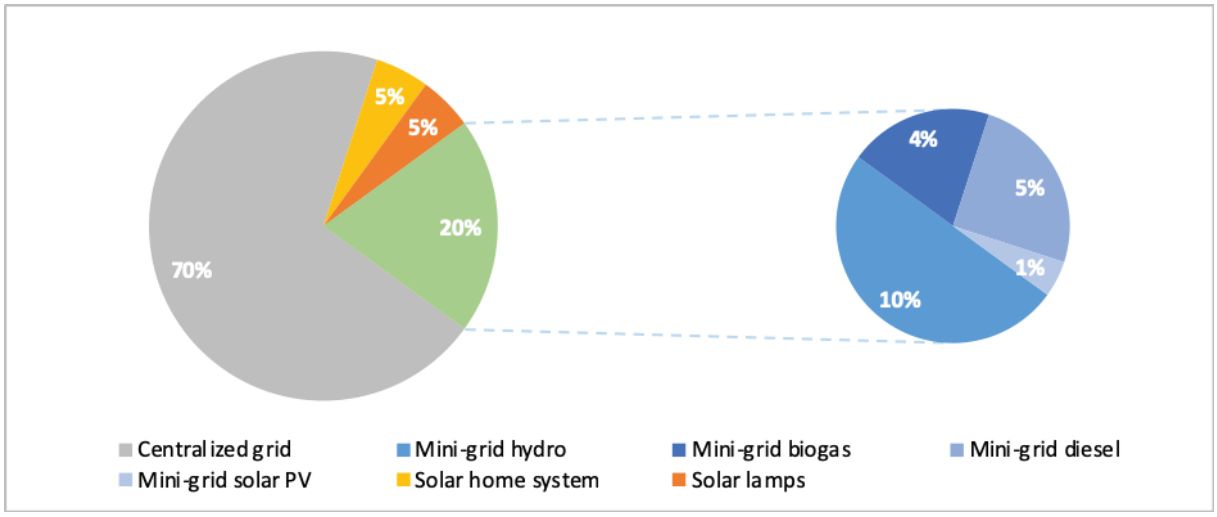
The new Electricity Code aims to simplify procedures and further liberalise the market, particularly on transport and distribution. It is also the basis for the creation of the new National Sustainable Energy Fund (FNED) as replacement for the old National Electricity Fund (FNE) to finance rural electrification programmes, including mini-grids. Additional changes include a new sub-heading on renewable energy (article 10 to article 17), defining for example what is considered as renewable energy and introducing fiscal advantages for goods and services aimed at production and operation of renewables. The new code also stipulates the name change for the Electricity Regulator.

Until recently there was no renewable energy policy, but with help from the European Union Energy Initiative (EUEI), Madagascar has developed the New Energy Policy (NEP) for 2015 to 2030 under the framework of the National Development Plan for 2015 to 2019. The NEP has four main objectives:

1. Ensuring universal access to modern energy services
2. Improve overall energy efficiency
3. Reducing dependency on fuel imports
4. Providing long-term funding for the energy sector

The NEP sets energy targets including increasing the energy access rate to 70% by 2030 (requiring approximately 7,900GWh of electricity production). Further, the policy aims to produce 85% of power from renewable sources by 2030 (75% hydro, 5% wind, and 5% solar) (MEEH, 2015).

Figure 6. Technology mix for achieving 70% electrification by 2030 in line with the NEP



The policy also sets the national target to be achieved for the deployment of mini-grids. It outlines that of the 70% of electrified households by 2030, 20% are expected to be connected to an off-grid renewable energy supply; 50% of which will be hydropower, 20% biogas from rice husks, 25% diesel, and 5% solar. The remaining 80% will be powered by solar stand-alone systems (5%), solar lamps (5%) and the interconnected grid (70%). This means the NEP has a goal of 49% grid connected population. Given the state of the 'main grid' today, we note that this seems a very ambitious policy.

The new presidency has reinforced this ambitious vision by launching in 2018 its flagship development programme l'Initiative pour l'Emergence de Madagascar. This programme is in the process of developing its action plan, entitled Plan Emergence Madagascar, which would see an electrification rate of 50% by 2023, and a doubling of the installed capacity by theis same date.

2.3. OVERVIEW OF THE POWER SECTOR

As of 2016, the installed electricity generation capacity in Madagascar was 680MW, rising to nearly 840MW in 2019, consisting of 23% renewable sources and 77% fossil fuel-based sources (ORE, 2016). About 58% of the country's power generation came from low-efficiency generators running on imported fuel, with the remaining 42% produced by hydropower plants (World Bank, Madagascar Electricity Sector Operations and Governance Improvement Project, 2018). The country has one national utility, JIRAMA, and more than 20 independent power producers (IPPs) that account for an increasing percentage of the total electricity production (around a third).

Around 86% of the electrified population receives their service from the three major national grids, RIA in Antananarivo, RIF in Fianarantsoa and RIT in Toamasina (RECP, 2015). JIRAMA delivers electricity to around 114 population centres, 22 of which are connected to the two interconnected networks of RIA and RIF. JIRAMA also operates large independent grids which serve five population centres: Toamasina, Mahajanga, Antsiranana, Toliara and Nosy Be. The remaining 87 population centres are served by small and medium-sized grids (World Bank, Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Madagascar, 2015). There are plans to connect the RIA with the RIT and RIF, through the PAGOSE programme.

Madagascar has an electrification rate of 15%, unevenly distributed between urban areas (53%) and rural areas (6.5%) (USAID, 2016). Prior to 2000 only 1% of the rural population was electrified according to estimates (ADER). To date there remain uncertainties around the actual electrification numbers. Some satellite television providers estimate that around two-thirds of their new customers are located off-grid, suggesting the actual rural electrification rate could be higher than 5%. To collect more up-to-date numbers the World Bank is planning to conduct a 3,000+ door-to-door household survey in late 2018 on energy access. Nevertheless, Madagascar ranks 184th out of 190 countries in terms of the ability of getting electricity for businesses, considering factors such as ease of connection and supply reliability (World Bank, Doing Business: Measuring Business Regulations - Getting Electricity, 2017). A critical reason is that it takes 450 days to get a new connection, nearly four times longer than the average for Sub-Saharan Africa (GIZ, Opportunities for Solar Business in Madagascar, 2016). However, Madagascar has been progressing on these indicators compared to previous years.

Madagascar suffers from heavy network losses, with 37% of the energy produced not being billed (60% of which are because of non-technical faults according to the African Development Fund) (ADF, 2016). Data regarding the level of losses in the transmission and the distribution systems is limited. The NEP aims to reduce transmission losses as one of its objectives but has not defined targets yet. Those with electricity connections suffer from nationwide power outages, occurring six to seven times a month for an average of 1.5 hours each (GIZ, Opportunities for Solar Business in Madagascar, 2016). JIRAMA estimated 799 power outrages due to technical faults in 2015 alone, equating to more than two per day on average (ADER, 2016).

The financial situation of the national operator JIRAMA is extremely challenging and unsustainable in the medium term. Partly because of the volatile price of petrol, as well as low tariffs, JIRAMA is unable to recover its costs. Thefts of electricity have also contributed to the problem. With the extensive losses attributable to non-availability of the installed capacity and a very high occurrence of significant technical and non-technical issues, the power supply value chain of the country's energy sector could be deemed as being in crisis. However, supported by the World Bank (PAGOSE programme), JIRAMA is undergoing a restructuring programme that has the potential to facilitate access to energy for consumers and recovery of costs for JIRAMA. According to the World Bank (World Bank, Madagascar Electricity Sector Operations and Governance Improvement Project, 2018), the financial turnaround of JIRAMA could be achieved with, among others:

- A 10% increase of tariffs;
- A system loss reduction from 35% to 24%; and

- A 5% reduction in specific consumption of generation plants.

The AFDB has also been supporting JIRAMA for a number of years in co-ordination with World Bank through its PARSE programme (Programme d'appui à la réforme du secteur de l'énergie - Energy Sector Reform Support Programme), which aims to improve JIRAMA's governance, its financial management by reducing electricity generation costs and increasing its revenue recovery rate; improvement of electricity generation efficiency by contributing to better management of the thermal park and encouraging production diversification.

Despite the low electrification figure in conjunction with the significant issues undermining power supply in the country, demand for electricity keeps increasing roughly 5% a year (USAID, 2016). At present however, the annual consumption of electricity per capita is among the lowest in Africa. Further, average consumption in rural areas is 150 kWh/ year compared to 600 to 900 kWh/year in areas served by JIRAMA. Most of the unserved people rely on candles, flashlights and batteries for lighting. To achieve 70% access to electricity by 2030, Madagascar would need to add roughly 2,500MW to its power generation capacity and produce 7,900GWh p.a. This is highly challenging considering JIRAMA's electricity production was 1,650 GWh in 2016, and that access infrastructure in much of the country remains poor (FES, 2017). The implication is that rural areas will require a large emphasis on mini-grids and stand alone solutions.

As the main grid is not meeting electricity demand reliably, IPPs have started generating power. Since 2013, some 20 operators, mainly small and medium-sized companies, have installed approximately 80 renewable energy, hybrid renewable energy/diesel and diesel systems in rural areas. JIRAMA has approximately eight to 10 different subcontractors whom they have as IPPs. Not all have proved successful because of the limited financial capital and business experience. Due to JIRAMA's financial situation, private operators remain hesitant to enter power purchase agreements (PPAs) and sell their electricity to the utility. It is also a risk that once the operator has negotiated the PPA, it will have to resolve all the permitting issues on its own, with no assistance from JIRAMA.

JIRAMA's financial situation is exacerbated by several badly negotiated IPPs under which JIRAMA is obliged to 'take or pay' energy from IPPs at very expensive rates. This situation is compounded by the fact that in some circumstances JIRAMA is responsible for providing the fuel[1], the supply of which isn't always certain, and must honour its payments even when the energy isn't being produced. Part of the World Bank's PAGOSE project is to look at how many of these IPPs can be renegotiated, many of which appear to have been signed in the run up to political elections.

As part of its mission, the electricity regulator ORE oversees determining national 'ceiling' tariffs. The tariffs are differentiated according to the voltage (high, medium and low), the type of consumers (residential or industrial), the time of day and the source of production (hydro, fuel and petrol). Based on the source of production, tariffs are differentiated according to three zones: Zone 1 is for consumers powered by a hydropower system, Zone 2 is for cities with fuel as primary production input, and Zone 3 refers to areas powered by petrol stations. The structure of the tariffs includes: a fixed prime to cover investments, a price depending on the consumption in kWh to cover utilisation costs, and a fee covering the service costs (distribution and billing).

Based on the above differentiations consumers across the country are being asked to pay significantly different prices for their energy. The average selling price in 2016 was Ar380/kWh, or the equivalent of US$ 0.11/kWh (ADER, 2016). As of October 2017, the national ceiling tariffs were the following (Table 2):

1 This is a common set-up in many countries, designed for embezzlement in procurement.

Table 2. National ceiling tariffs as of October 2017, ORE (fixed prime expressed in Ar/kW and price of energy in Ar/kWh).

Category		Tariff Components	Zone 1	Zone 2	Zone 3
High Voltage (HV)	HV time of day	Fixed prime	60 018		
		Peak tariff	726		
		Day tariff	343		
		Night tariff	88		
Medium Voltage (MV)	MV time of day	Fixed prime	71 910	57 357	37 423
		Peak tariff	862	898	1 093
		Day tariff	429	829	1 011
		Night tariff	280	644	997
Low Voltage (LV)	LV General	Fixed prime	17 050	12 193	9 382
		Energy price	686	1 092	1 251
	LV Eco Ps < 3KW	Energy price – T1 <25kWh	481	481	481
		Energy price – T2 >25kWh	1 840	2 457	2 662

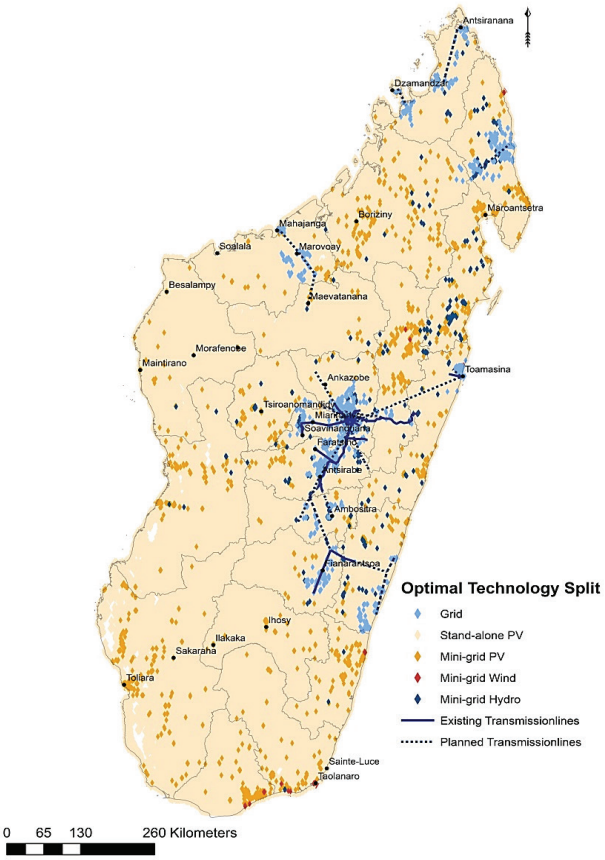
In 2014, JIRAMA's cost of production was MGA 633 ($0.25) per kWh versus a selling price of MGA 382 ($0.15) (GIZ, Opportunities for Solar Business in Madagascar, 2016). The national utility JIRAMA sets tariffs which are well below the ceiling rates (seeAappendices for a full list of JIRAMA tariffs as of April 2018 in Table 11). TheGgovernment increased the average tariff of JIRAMA by 7.5% in July 2017 and again by an average of 10% in January 2018 to increase the utility's revenue and contribute to the objective of attaining financial equilibrium by 2020. Indeed, a tariff study requested by MEEH and JIRAMA is presently underway in order to understand how this can be achieved. However, presenty, tariffs remain below ceiling rates, ant JIRAMA is presently not rising tariffs further to avoid political unrest, despite being loss-making.

The most suitable grid expansion options in line with the NEP are principally in the central and northern part of the country. The three main grid infrastructure lines (RIA, RIF and RIT) currently cover the central areas, and serve around 86% of the electrified population. RIA is the largest system which alone covers about 70% of the total electricity consumption. Future expansion plans concentrate in the northern areas (Mahajanga, Antsiranana, Nosy Be, Sambava etc.) (KTH, 2018). It is estimated that 96% of the population living within 25km of the grid in 2015 is found in just five of the 22 regions of Madagascar around Antananarivo, Fianarantsoa and Toamasina, and that population growth in these regions will be higher than in the rest of the countr. AFDB is presently funding the PRIRTEM project (Projet de Renforcement et d'Interconnexion des Réseaux de Transport d'Energie Électrique à Madagascar - Project for the Strengthening and Interconnection of Electric Power Transmission Networks in Madagascar), which is a feasibility study and the development of construction TORs to upgrade a number of the transmission lines, and eventually interconnect the three main grids.

The Government (MEEH), in collaboration with the World Bank, has been developing a Least Cost Power Development Plan (Plan de développement de l'électricité au moindre coût - PDMC). This ambitious project delivered by Athelia is essentially looking at densification and grid extension in the areas operated by the national operator JIRAMA and will support conversations within government to decide how to reach electricity access targets.

The results of the PDMC show that an additional capacity of 339MW (generating about 1,649GWh/year), is needed in the RIA by 2035 to balance the expected 2.5 times increase in demand. This increase is underpinned by the high rate of population growth (about 2.8% per year), public works, and industrial activities (World Bank, Madagasacr Power Sector Operations Improvement Project, 2018). Figure 7 illustrates the planned transmission and off-grid expansion opportunities, in accordance with the NEP, as modelled by the Royal Institute of Technology in Stockholm (KTH) and the World Bank. It is worth noting that the same study also produced several different electrification scenarios in addition to the NEP, which arguably might seem more realistic. Table 14 showing the planned transmission lines in Madagascar is presented in the Appendices.

Figure 7. Optimal technology split in accordance with the NEP, sourced from KTH



2.4 OVERVIEW OF THE OFF-GRID SECTOR

ENERGY ACCESS POLICY AND PLANNING

The three main public institutions involved in the off-grid sector are MEEH, ADER and ORE, and the main private actors in the market are AXIAN, Henri Fraise & Fils, EOSOL, and BETC Nanala. Several international agencies and donors such as GIZ, the World Bank, AFDB, UNIDO, the EU, AFD, and USAID are concentrating efforts to work with the Government to reform the energy sector. For an overview of each actor, refer to chapter 2.2 '*overview of the energy sector*' or chapter 4.3 '*stakeholder list*'.

The rural electrification authority ADER has an ambition of quadrupling the country's rural electrification rate to 20% by 2020, and 30% by 2030. It also aims to fulfil the NEP to ensure that of the 70% of rural and urban households to have electricity access by 2030, 20% will be connected to an off-grid renewable energy supply.

To advance rural electrification ADER has been developing regional electrification masterplans, called Indicative Regional Development Plans (Plans de développement régional indicatifs – PDRI) with the support of GIZ. At present ADER has completed 14 out of 22 PDRIs and is working on completing the remaining regions. The plans identify and prioritise the villages and zones to be electrified, and provide information on the available resources, and any pre-existing assets present. These areas are then cast into 'lots' to be put out to tender. Further, the development of these plans aims to:

- Help local decision making with regards to rural electrification;
- Promote a fair access to energy services amongst the 22 regions;
- Optimise rural electrification subsidies, considering an existing resource crunch; and
- Facilitate the links between developers and donors to speed-up funding requests.

The new article 4 of the electricity code states that MEEH will develop a national plan of the means of production (national electrification strategy) based on the above indicative plans drawn up by ADER, ORE and network managers. This national plan will include means of renewable energy production, as well as plans for the development of electricity networks over a 15-year period, to be reassessed every two years.

The World Bank has also financed the development of a National Electrification Plan for Madagascar (as part of the PAGOSE programme). The plan developed by Tractebel reunites the rural electrification plans with the national grid expansion plans and presents several scenarios for electrification in Madagascar. These scenarios essentially try to model electrification in line with the NEP, or according to least cost electrification. The Government is at the stage where it will have to decide which one of the scenarios to adopt as its masterplan. This is politically sensitive since a different choice may mean that the MEEH is obliged to recognise that the target in the NEP and the proposed Plan Emergence Madagascar is too ambitious.

In 2010, ADER developed a new approach to mini-grids to accelerate electrification at the regional level, and in 2015, it started issuing calls for projects to electrify the country's regions. The approach includes:

- Developing electrification plans for each of the 22 regions, with technical assistance from GIZ (14 out of 22 already completed, with completion of the remaining through to end 2018) with the aim of identifying specific areas, or lots to be electrified in each region;
- Issuing calls for projects for individual regions. ADER has completed two rounds of calls for projects covering eight of the 14 regions for which plans have been published, with a third round currently being planned in conjunction with GIZ and MEEH (expected to be issued Q1 2019);
- Allocating sub-areas/lots to developers. At present 11 out of the 20 tendered lots have been allocated to project developers. One project is already being built in the Sava region.

The novelty of this approach consists in the prior development of regional plans, and in issuing calls for projects in which tenderers are required to propose technical solutions within a certain perimeter, rather than simply providing a quote based on a predetermined solution presented by ADER. At the same time, under the guidance of GIZ, the tendering process is evolving. Where the first two rounds were launched to develop a specified number of projects within the tendered lots, with an explicit focus on mini-grids, the third round will look for operators able to provide access to energy in a certain zone by combining different systems to increase the overall level of electrification e.g. mini-grid plus solar home systems (SHS). In addition to increasing energy access more generally, the new process will give operators the liberty to use different technologies to optimise project viability (e.g. cross subsidising mini-grids with SHS returns).

When assessing a tender response, ADER seems to be considering three main factors: the number of connections proposed, the nature of the infrastructure proposed for installation, and the minimum tariff suggested by the developer. ADER first makes a choice based on the project with the greatest potential to meet the needs of the area. As a second criterion, ADER assesses the level of subsidy being requested (to meet affordability). Finally, the financial standing and implementation capabilities of the developer are assessed.

The new approach by ADER is positive in that it:

- Provides the information required to develop projects, therefore providing improved visibility on market opportunities;
- Introduces a formal tendering process over a more informal way of allocating sites;
- Is increasingly leaving the technology optimisation to the market, assessing merits based on a whole range of project benefits;
- Gives developers more freedom to propose a project rather than solely providing a quote for a predefined opportunity.

Despite this more formal approach, it appears that sites for mini-grids are also still being allocated through unsolicited applications from larger conglomerates. A small number of large, local, multi-sector private companies have started seeing renewable energy as a future expansion market, and one which can unlock markets for ancillary

services in which they are already active, e.g. provide electricity to develop markets for financial services, telecoms, agro-markets, etc. Based on relatively limited experience of rural electrification, they have therefore conducted their own market analyses to identify their preferred sites, and approached either ADER, or the Presidency, to apply for the development rights of these villages. One company, also owner of one of the larger mobile networks in the country, is basing its approach (and request for villages) by using base stations as anchor loads. Requests can include hundreds of villages, which have subsequently been allocated to these companies. It is not clear how the villages are being allocated, nor does there appear to be a timeframe within which projects must be developed.

Spontaneous applications must be accompanied by an economic, social and environmental impact studies. Studies include an in-depth economic and demographic mapping exercise looking at economic activity such as agricultural sites, mobile coverage, schools roads, etc. Once potential areas of interest are identified, companies reach out to ADER or the Presidency to 'reserve' their preferred sites and obtain rights to electrify.

Donors are using their influence to try to limit direct concession awards. As an example, the AFDB, has set as a condition of its budgetary support programme to the MEEH (PACE, Programme d'Appui à la Compétitivité Economique) that all concessions for development and operation of sites be done through formal calls for proposals.

While unsolicited applications are permitted, and it is positive to see a trend from private companies willing to invest to electrify rural villages and therefore release pressure from ADER, this informal approach carries risks. Theoretically, reserved villages will not be part of ADER's future calls for projects, distorting what should be a competitive market. This is especially true if one considers that only the most attractive sites in the country will be the object of spontaneous demands. Further, of the hundreds of villages that have been reserved for these conglomerates, only a handful of pilot projects have been started. Rightly, these companies have approached the projects as pilot studies, and are testing different electrification solutions (e.g. 12v dc vs 210v ac) and payment systems. However, none have attained financially sustainable projects yet, and report that prior to developing new sites, subsidies will need to be identified. The reserved villages could therefore act as a block to successful procurement for ADER.

Tracking of mini-grids in Madagascar is limited, and a significant portion is believed to be out of order. Overall, there are an estimated 136 operating and 30 non-operating mini-grids in Madagascar. Of the 136 in operation, 96 are supposedly run by JIRAMA, eight have a community ownership model, and the remaining 32 have a Public Private Partnership (PPP) ownership model. Of the 32 PPP-owned, 17 are either renewable or hybrid mini-grids (Table 3).

Table 3. PPP-owned renewable or hybrid mini-grids per county

Location (County)	Year	Generation source	kW
Andriatsiazo	2010	Hydro	40
Ambohidreny	2012	Hydro	40
Andriatsemboka	2010	Hydro	40
Ankadinandriana	2011	PV	
Ambaravaranala	2010	Hydro	40
Fandriana	2014	Hydro	560
Sahamadio	1986	Hybrid PV/Diesel	440
Soavina - Ilaka centre	2015	Hydro	60
Andriba		Hybrid Hydro/Diesel	140
Antsiafabositra		Hybrid Hydro/Diesel	50
Mahatsinjo		Hybrid Hydro/Diesel	30
Anjijia	2009	Biomass gasification	110
Manerinerina	2009	Biomass thermoelectric	110
Ifotaka	2015	PV	10
Tanandava	2016	PV	20
Mahatalaky	2015	PV	20
Mahaboboka		Hybrid PV/Diesel	30

LICENSING

Article 8 of the new electricity code states that separate authorisations or concessions are granted for each of the generation, transmission and distribution activities. A same operator may hold authorisations or concessions for the three activities. Licences are accorded based on the size of the project (see regimes below), and vary from declarations to authorisation, to full concessions. Articles 49 to 53 of the new electricity code also regulate licences for the supply of electricity, stating that any person wishing to carry out a supply activity must hold a supply licence. However, the holders of distribution or transmission concession/authorisation are exempted from this extra supply licence. Mini-grid operators need a generation and a distribution licence.

- **Declarations are required for:**
    - **The establishment and operation of power generation facilities of the following sizes (table 4):**

Table 4. Declaration regime for generation

Hydro	P ≤ 500kW
Wind	P ≤ 250kW
PV Solar	P ≤ 150kW

- Authorisations are required for:
    - The establishment and operation of distribution facilities, with a peak power ≤ 5MW
    - **The establishment and operation of power generation facilities of the following sizes (table 5):**

Table 5. Authorisation regime for generation

Thermal	P ≤ 500kW
Hydro	500 kW < P ≤ 5MW
Wind	250 kW < P ≤ 5MW
Solar thermal	P ≤ 5MW
PV Solar	150 kW < P ≤ 5MW
Biomass	P ≤ 5MW
Geothermal	P ≤ 10MW
Marine	P ≤ 10MW
Waste	P ≤ 5MW

- Concessions are required for:
    - The establishment and operation of distribution facilities, with a peak power > 5MW
    - The establishment and operation of transmission facilities
    - The establishment and operation of power generation facilities of the following sizes (table 6):

Table 6. Concession regime for generation

Thermal	P > 500kW
Hydro	P > 5MW
All other	P > 5MW

Declarations must be filed with the Ministry of Energy in accordance with the terms and conditions laid down by decree. For PV solar power plants below 10kW, customers must complete a simplified form available from ORE.

Authorisation contracts are obtained from the Ministry in charge of energy, or of ADER in case of power delegation. ORE oversees reviewing the authorisation application prior to submission. The same three-party deliberation occurs in the context of concessions.

Holders of concession, authorisation or declaration licences for generation must transmit signed contracts to ORE proving an agreement to connect to the networks has been reached with the holders of the relevant transmission and distribution licences. When obtaining a concession to operate, the developer becomes the owner of the installation until the end of its concession, then ownership is transferred back to the state.

Distribution licences can be divided up into distributor or provider licence. While a distributor distributes directly to the end customer, the provider can be an intermediary. ORE can eventually authorise distributers to conclude contracts of direct provision of electricity with producers, yet this will have to be approved by the Ministry and by ORE.

At present generation, transmission and distribution in urban areas is under the monopoly of the state utility JIRAMA, where it has at least one existing power plant. JIRAMA, acting as a transport concessionaire, can launch calls for offers to delegate transmission and generation if the capacity of the grid allows for it (and there are a number of IPPs supplying JIRAMA in the larger towns). JIRAMA is therefore entitled to extend its grid, add new connections and more generation capacity, yet will not be able to create a new independent grid without applying for a licence to do so.

MINI-GRID TARIFFS

When responding to calls for projects issued by ADER, operators are entitled to propose tariffs for their projects. In reviewing the proposals, ADER can decide to offer grant subsidies with the aim of bringing tariffs down. Once finalised, but before being formalised, tariffs are approved by ORE. The regulator will approve these tariffs to be a ceiling tariff for the lifetime of the project, based on the business model of the applications submitted by the operator to ADER.

There are no 'capped tariffs' in the off-grid sector per se. 'Ceiling tariffs' are determined on a project by project basis according to a business plan over 15 years for electricity demand, as well as the development plans provided to ADER by the operators. Adjustment formula based on the future economic outlook of the country are also used. There is therefore no 'market' ceiling tariff, although it appears that ORE and ADER have in the past refused certain applications featuring exceptionally high tariffs. Operators are then held to account for the tariff ceilings they've received from ORE. ORE has proven to take a flexible approach to tariffs setting, having recently approved multi tariffs based on time of use (i.e. day, night and base tariff).

Going forward the aim is to arrive to a uniform level of tariffs between each lots/areas being the objects of the tendering process. This could also mean realigning JIRAMA's tariffs if any new mini-grid projects lie within the pre-electrified area. The future desire is to make tariffs uniform throughout all the licensed areas but considering the diverse nature of the country this might not be practicable.

The largest challenge in the market however remains the affordability of electricity tariffs. Ability to pay for the majority of the population remains extremely low, which means subsidising of on and off-grid provision is required for sustainable provision of electricity services.

Since the enactment of the electricity sector law in 1999 private investments in the energy sector became legal, yet commercial Independent Power Producers (IPP) are not regulated. ORE, however, keeps a close look on those IPPs from the outset to ensure they align with other tariffs defined by ORE.

SUBSIDIES AND INCENTIVES

ADER has been providing subsidies for rural electrification projects through the management of the National Electricity Fund (Fond National de l'Electricité – FNE). The FNE has been operational since 2004, aiming to provide grants for up to 70% of CAPEX to ensure rural electrification becomes an accessible market option. It is estimated that around 20 to 25 diesel mini-grids have been financed through this fund, which is not much. The aim of the grant was for ADER to reduce the cost of services provided by the developers and hence lower tariffs.

The process was supervised by ADER during tender evaluation, as well as by the Ministry of Finance. Many of the international donors such as the EU, GIZ, and KFW, etc. have provided funding for the projects, although financing has not gone through the FNE.

The FNE is not viewed as having been especially successful. The principal complaint is centred on the financing elements of the fund. The FNE was supposed to be funded by treasury through an element of return from the electricity sold by operators, with the state utility JIRAMA therefore being indirectly the main contributor to the FNE. However, JIRAMA's delicate financial situation means that this allowance has not historically been passed back on to treasury.

Therefore, while the FNE was supposed to be the main rural electrification instrument, it has no funding and hasn't had for a number of years. Moreover, because the FNE is effectively a public account, donors have been wary of channelling their funding through this mechanism for fear the money would be redirected towards other state issues. Donors therefore started financing rural electrification on a project-by-project basis, outside of what was the main fund.

The new energy policy (NEP) aims to replace the FNE with a new National Fund for Sustainable Energy (Fond National de l'Energie Durable – FNED). While FNE was essentially a treasury 'bank account' upon which ADER could call, the new FNED is anticipated to become a fully independent, multi-instrument fund, with a more independent and transparent procedure (i.e. outside of government) and hence be more closely aligned to the needs of buyers in the market. The FNED is being pitched as a completely new fund and credit line, administered by an independent financial institution. As a multi-instrument fund, the FNED should be able to provide both grant subsidies as well as different forms of credit. The process will remain similar as to the present process, whereby ADER will continue to launch calls for projects, and where selected bids require financial assistance then the project promoter will be able to make an application to the FNED through ADER. The administrator of the fund will then have the right to accept or to refuse the application. Public and private technical organisations and financiers should, it is hoped, find it easier to invest in this new independent multi-instrument fund. Rather than finance rural electrification on a project-by-project basis, financiers could arguably have a greater impact by contributing to a more cohesive development of the energy access market. However, with the FNED being set up more like a bank than a fund[2], some donors have expressed concerns over their ability to pay into the FNED (due to governance issues).

The new FNED is also raising some concerns. While the Ministry expects it to be up and running within six to 12 months, stakeholders are wary that its setup may take considerably longer. At this stage, government stakeholders appear to agree that the fund, and its management institution will be set up from scratch, rather than housing it in an existing financial institution. While this may assure the fund's independence, the time to set it up will be considerably lengthened, and the exercise is likely to be quite costly. For instance, the fund will need to obtain a banking agreement, and be accepted by the Ministry of Finance. This will be a timely and costly endeavour.

It also remains unclear how the FNED will be financed. Just like the old FNE, an element of returns from electricity sold by operators is expected. Additionally, financiers have responded positively to announcements of this new fund. However, full details will only be known upon the issuance of the relevant government decree, and the ministry will need to determine the new guidelines for the implementation of the policy. In the meantime, it also remains uncertain how projects that are being awarded under the current calls for project will be financed, considering the current FNE has no funds. These projects will likely be financed on a project-by-project basis by donors and other financiers. Despite the many outstanding questions, it is hoped that the new electrification fund will be able to unlock the investment required.

The new article 12 of the electricity code states that the Government sets, in the General Tax Code and the Customs Code, the tax and customs benefits relating to goods and services intended for the Production and Exploitation of renewable energies. The Malagasy Government in the 2015 Tax Code introduced incentives for companies investing in the production and distribution of renewable energy. These include a corporate income tax reduction allowance equivalent to 50% of investments in qualifying equipment and VAT exemptions for renewable energy equipment. The Government has also introduced exemptions on import taxes for specific goods such as solar PV equipment (panels, batteries, inverters, etc), although uncertainties remain about the size of exempted equipment, and the reality on the ground may mean that payments are still being requested at customs.

Discussion within the Ministry of Finance are ongoing to try to extend this approach to other renewable technologies including turbines for centralised hydro stations. There are no feed in tariffs for renewable energy.

2 Which sounds very similar to the new Sustainable Energy Fund for Africa (SEFA) design

POWER PURCHASE AGREEMENTS

The new electricity law does make provisions for integration when allocated zones include a pre-existing concession, such as an existing JIRAMA site, or indeed a site owned by another, private operator. In ADER's last call for projects for example out of 96 localities, four were already being electrified by JIRAMA**.** In case of overlap, it appears that JIRAMA will be required to respect the concession attributed to the new operator by ADER and ORE. Should JIRAMA be operating a thermal mini-grid within the area being attributed for concession, JIRAMA will be asked to halt generation and purchase the electricity produced by the concessionaire, i.e. mini-grid operators have the right within their concessions to sell electricity to the main grid. However, JIRAMA can decide to continue distributing the electricity. On the other hand, JIRAMA could also decide to 'abandon' its existing site all together and hand over operation to the new operator. The market is still awaiting the décrets d'application, or regulation of the law in order to clarify how the above will be implemented practically, since it remains a source of concern.

ARRIVAL OF THE GRID

The arrival of the grid does not resonate as a likely scenario among local stakeholders. The state utility JIRAMA is channelling efforts into intensifying its client base in existing grid lines and seems interested in privatising some of its existing stations, especially the most decentralised ones. That said, it has recently embarked on the PRIRTEM (Projet de Renforcement et d'Interconnexions des Réseaux de Transport d'Energie Electriques à Madagascar) with AFDB financing, which will see reinforcement, and eventually interconnection of the three main grids.

Despite a current lack of unifying plans between the grid-extension and the rural electrification plans, separate plans are being developed and presented to the MEEH and ORE. Theoretically, these organisations will ensure that no conflicts exist between the plans, although the chances of conflicts arising seem slim. A table of planned transmission lines is presented in the Appendices (Table 14).

TECHNICAL RULES

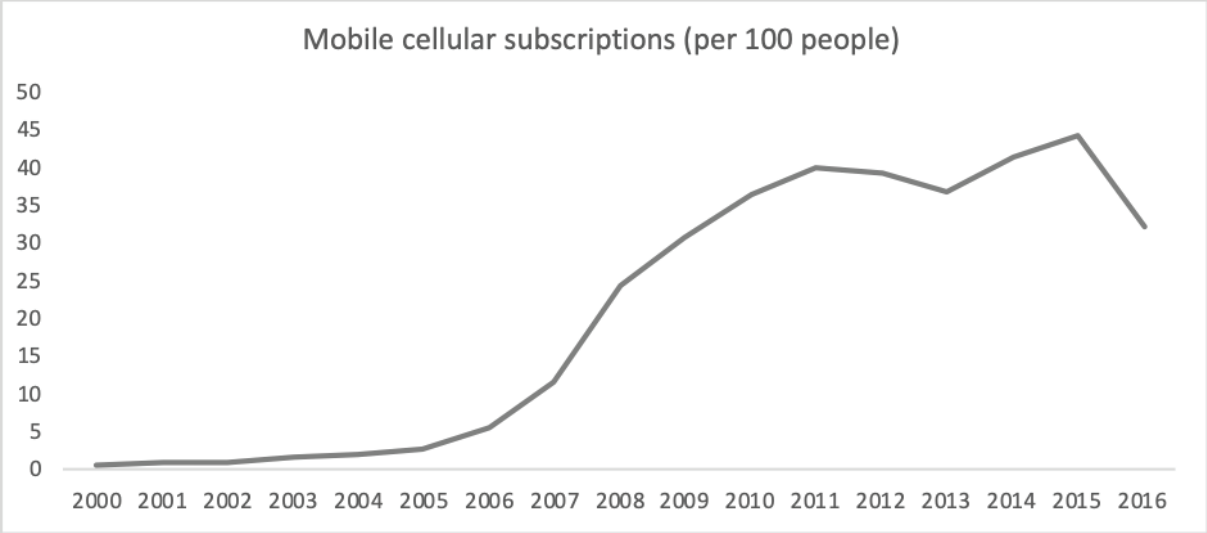
Off-grid systems need to adhere to the same technical norms and standards as those imposed to the national grid. All electricity providers must observe national norms from the Bureau of Norms (BNM), and installations are inspected by ORE once a project goes live. Existing mini-grid projects are aligned to international standards, while national minimum standards (a grid code) are being developed and published in the new electricity code. It is expected that the code will be more complete yet simplified compared to the old law and define a technical framework regardless of the source of generation. The work, funded by GIZ, is being developed in collaboration with ADER, ORE, MEEH and an external consultant, and will apply to the whole market rather than being off-grid specific. It should be published in spring 2019.

At present, minimum required standards for mini-grids are defined by calls for projects in each tender round. Funders/buyers can place their own restrictions and specifications, typically aligned to international requirements. The large operators trialling projects in the reserved villages are trialling and developing technical specifications (but nevertheless must meet BNM's technical standards).

MOBILE SERVICES

The addressable market for electrification in zones of mobile coverage remains substantial. Although there are many mobile coverage black holes in the country, a large proportion of the population without access to electricity resides in areas of coverage. Mobile network coverage is complete in the main towns of Madagascar but remains poor in the countryside. On average 30% of the population owns a mobile phone: 21% in rural areas and 68% in urban areas (Enclude, 2018). A study by the World Bank assumes that if people share phones and/or have access to a phone in the household/ family circle, then about 75% of the population has access to a mobile phone.

Figure 8. Mobile subscriptions per 100 people, World Bank figures



BARRIERS TO MINI-GRID DEPLOYMENT

While many projects are being assessed, local organisations fear that few are being implemented. A non-exhaustive list of barriers is presented below (Table 7).

There is a need to strengthen and enforce the legal and regulatory energy framework. While there is a structure with associated processes being developed, the legal and regulatory framework remains in its infancy. Some elements are still missing (e.g. FNED) and others lack the strength of enforcement (e.g. ADER permitting reserved villages, on-the-ground customs exemptions not being realised, JIRAMA not providing funding to FNE, etc).

The existing financial framework is not conducive to investment in the energy environment. There is a need to create a more enabling and favourable environment to investments due to past weaknesses of the FNE and more generally of ADER, future uncertainty of the FNED, and the financial insecurity and lack of transparency of JIRAMA. The state utility needs to recover from its current delicate financial situation if it wants to be part of the future electrification trends in Madagascar. Moreover, it will be essential that both ADER and the FNED have sufficient funds to support access to rural electrification. Lastly, the Government needs to ensure private operators receive timely reimbursements for their services.

Sharing of information on the local market needs to improve. Investors lack the required level of information on real needs of villages to produce accurate business models for investment (e.g. size and patterns of consumption). Local developers might be well-prepared to install, maintain and operate mini-grids, yet they do not have reliable access to information on the most efficient technologies for instance. On the other hand, international developers have money available yet not sufficient information to develop in-country projects. With GIZ support, the MEEH recently launched a relatively comprehensive database of energy information, http://www.energie.mg/, which provides a good insight into the existing state of electrification, both on and off grid.

Access to land also remains an important challenge. Foreign investors are presently not allowed to buy land, and so to access land need to either find a local partner, rent land from the Government or receive a concession from private entities. However, much of the country land claims have not yet been assigned, making it difficult to relocate those that could be identified as squatters. A new land policy is currently being developed to respond to these challenges.

The biggest barrier remains the extremely limited ability of the local population to pay, and therefore the provision of electricity through viable projects. The rural population in Madagascar is extremely poor, and therefore even though the regulatory environment allows operators to set their own tariffs (with approval from ADER and ORE), achievable tariff levels are low. Stakeholders agree that mini-grids are unlikely to become commercially self-sufficient without subsidies in the short to medium term.

Table 7. Regulatory and policy environment in Madagascar: key takeaways of enabling and limiting factors to GMG development

	Enabling Factors	Limiting Factors
Planning and institutional setting	- New Energy Policy - Regional Electrification Masterplans - PDMC - PAGOSE programme	- Weaknesses of ADER and apparent ease of reserved villages is undermining the established procedure for rural electrification
Data availability		- Limited national GIS data
Licencing	- Public competitive tendering process - New grid code; lower required caps	- Unsolicited applications and reserved villages
Tariffs	- Operators can propose tariffs - Potential subsidies to reduce tariffs	- No 'capped tariffs' in the sector; determined project-by-project
Subsidies and incentives	- New National Fund for Sustainable Energy (FNED)	- Financial set up of FNE and FNED
Power purchase agreements	- Off-grid market steadily opening up	
Arrival of the grid	- Provisions for integration of assets - Operators can sell electricity to JIRAMA - Development of unified plans	- JIRAMA's financial difficulties - Separate rural electrification plan and grid-extension plans
Technical rules	- Same security measures as national grid - International standards - New electricity code	- Minimum required standards outlined in calls for projects
Mobile services	- Competition among suppliers spurring market growth	

3. GREEN MINI-GRID POTENTIAL

3.1 DATA AVAILABILITY

Estimating the potential for mini-grids is a challenging task that requires substantial data and assumptions. Some physical factors, such as resource availability and geographic features, can be collected remotely through satellite data, but other factors require the availability of local datasets and surveys. Certain non-physical factors, such as demand and consumption patterns, require precise settlement-level data to be collected. This data is often unavailable, out of date, or is highly resource intensive to obtain. An opportunity assessment relies upon several assumptions and criteria that are driven by the 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 services 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.

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 and planned power network.

The level of available GIS data in Madagascar remains poor. ADER is working with two GIS datasets: GEOSIM provides GIS data including demographics and economic data, and Manifold is used to map out planning. ADER has been using these two databases to develop its regional masterplans.

The main local data gathering has been done through the World Bank and GIZ. Work undertaken by the World Bank includes an extensive study on the potential for hydro under ESMAP, as well as an 'optimal technology split' analysis on the back of the new proposed energy policy. The World Bank study attempts to model different scenarios for the implementation of the NPE. GIZ has also produced regional mini-hydro studies as an extension of the World Bank study. Additionally, developers are often financing their own studies to identify suitable projects for electrification.

The Government is currently undertaking a national population census, yet the GIS outcome of this census is still uncertain. Between 2012 and 2013, the National Office of Statistics (INSTAT) realised a census for the objectives stated in the Millennium Development Goals.

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 medium voltage (MV) 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 much greater proportion of the population than for the HV lines alone (46% compared with 27%), 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 (and conservative) measure.

3.2 MINI-GRID POTENTIAL: AN ASSESSMENT

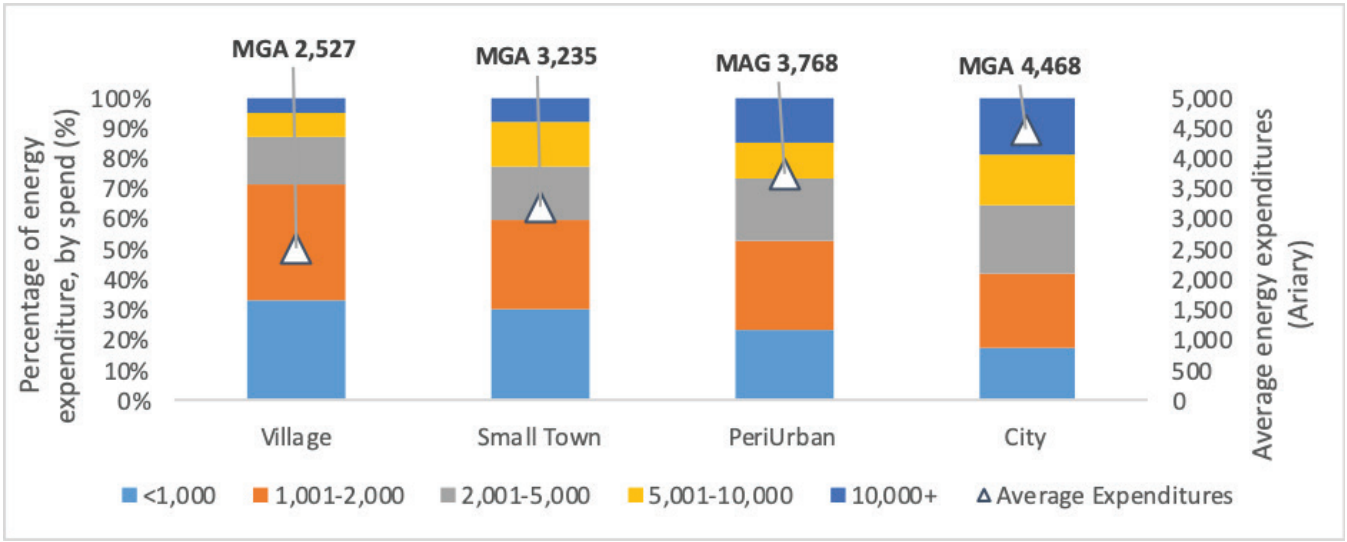
The latest available population figures from INSTAT Madagascar are from 2011, with forecasts to 2014. Data is disaggregated by region, as shown in **Error! Reference source not found.** below. With a density of 41.4 inhabitant/km², the Malagasy population is spread over the entire territory. According to the census, the average size of people per household was between four and 4.9 in 14 out of 22 regions.

Table 8. Population in Madagascar by state and region, 2014

State	Region	Density/km	Population (thousands)
Antananarivo	Analamanga	187.6	3,440
	Bongolava	26.0	470
	Itasy	32.9	753
	Vakinankaratra	102.9	1,852
Antsiranana	Diana	34.4	719
	Sava	36.4	1,007
Fianarantsoa	Amoron'i Mania	42.0	734
	Atsimo Andrefana	18.8	1,352
	Haute Matsiatra	43.1	1,232
	Ihorombe	42.3	321
	Vatovavy Fitovinany	68.5	1,455
Mahajanga	Betsiboka	9.3	301
	Boeny	24.4	821
	Melaky	7.1	297
	Sofia	23.6	1,281
Toamasina	Alaotra Mangoro	30.5	1,055
	Analanjirofo	44.7	1,063
	Atsinanana	54.9	1,305
Toliara	Androy	36.0	754
	Anosy	24.7	690
	Atsimo Atsinanana	45.1	923
	Menabe	12.2	608

Average monthly spending on energy in Madagascar is about 15,249MGA (US$4.70), or US$1.08 on a weekly basis. In rural areas, where 65% of the population lives, monthly spending is lower at 11,000MGA a month (US$3.40) (Enclude, 2018). By comparison, average rural spending on energy in Uganda lies between US$2.7 and US$5.5 (World Bank).

Figure 9. Average Energy Expenditures per Week, source World Bank



The above graph shows spending on energy per week and per location. As you move from villages to city centres, the average expenditure increases. The proportion of weekly expenditure of less than 1,000MGA is higher in villages (33.3%) than it is in cities (17.7%). Conversely, only 4.5% of weekly expenditure in villages amounts to 10,000MGA or more, compared to 19% in cities.

Figure 10. Existing electricity grid with planned network up to 2025 (dotted lines)

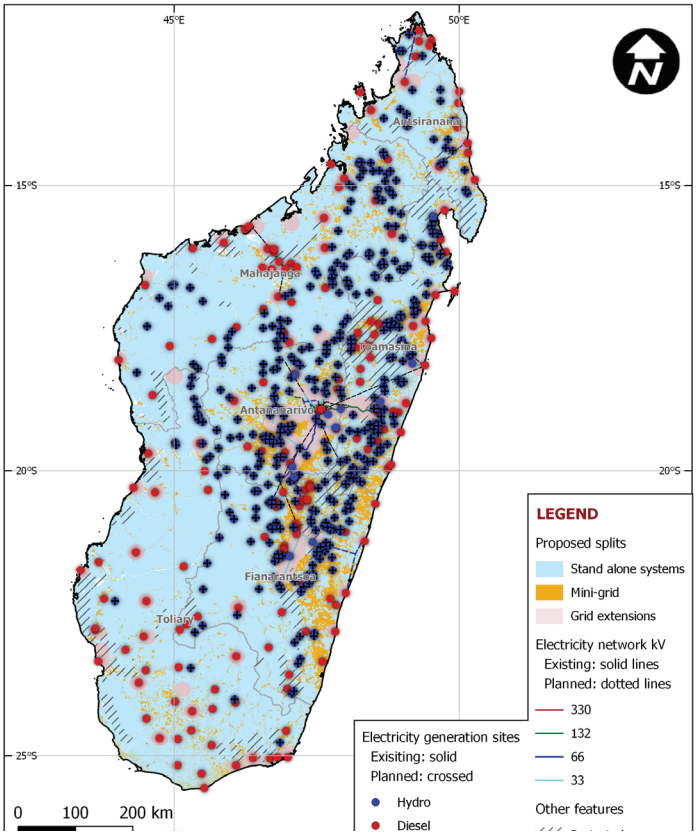
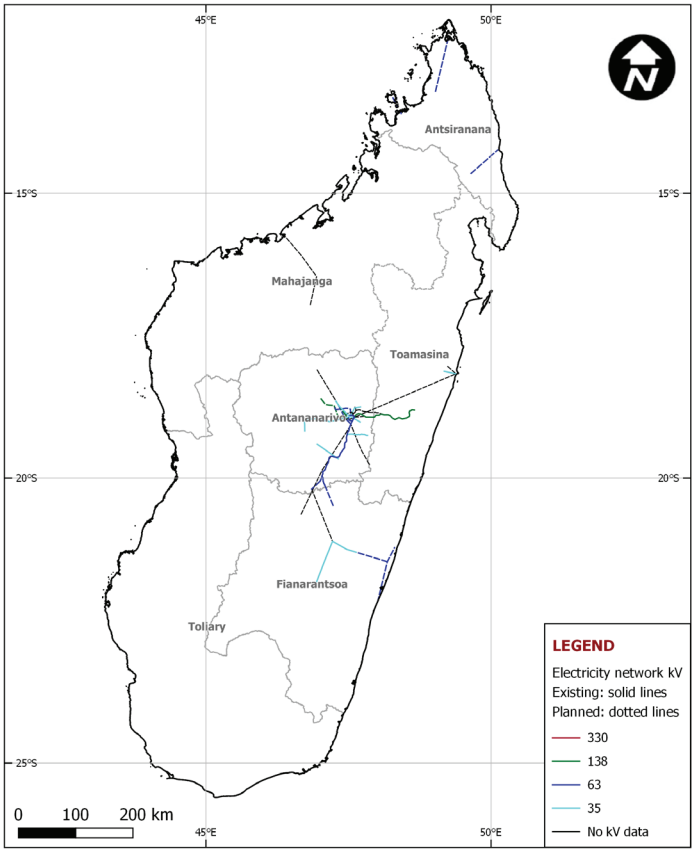


Figure 11. Regions best served by grid extension, mini-grid and standalone systems, shown with major and minor population centres. Dotted lines are planned grid extensions up to 2025. Carbon Trust analysis.

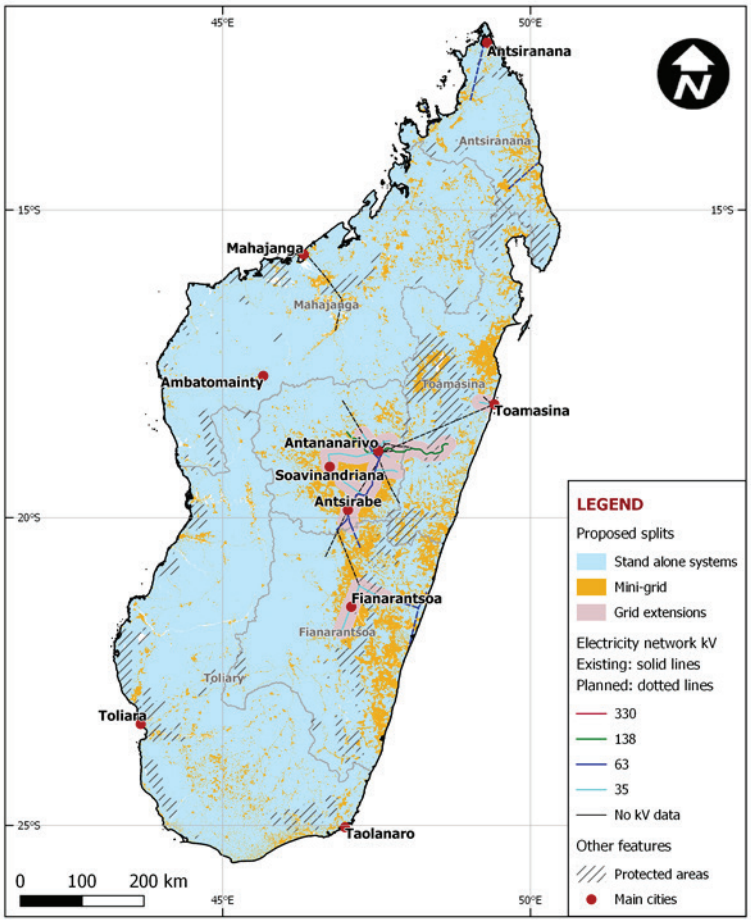


Transmission grid coverage in Madagascar is very limited. The network is comprised mainly of 35kV, 63kV and very few 138kV transmission lines. It is responsible for nearly all the current population's electricity access, which stands at 15% access nationally (53% urban, 6.5% rural). The night lights analysis conducted as part of this analysis is consistent with this figure, showing a national average of 15% electricity access.

Based on current grid coverage, this analysis of high voltage (HV) line data and satellite mapping of night lights estimates that 40% of the unelectrified population would be best served by mini-grid solutions, with the highest potential in the Fianarantsoa state. Shown in Table 9, this corresponds to 8.3 million people (33% of total population), with further 11.3 million people living within 15km of the grid and therefore being grid electrified, and lastly 4.5 million best served by solar home systems. The mean proportion (by population) within this 15km threshold for all states is 46%. These are likely very conservative estimates however, as the 15km buffer zone applied (for consistency across all produced country reports) does not reflect the low likelihood of grid expansion in Madagascar. If the analysis is only done based on HV line data, without taking into account satellite mapping for night lights, then the estimated unelectrified population that would be best served by mini-grids solutions would rise from 34% to 51%.

If we consider planned network coverage by 2025, then this analysis estimates that mini-grid electrification would be 7.5 million people, also corresponding to 40% of the of the unelectrified population. This 11% reduction in market size reflects several planned grid extensions, which takes the proportion of the total population living within 15km of the grid to 50% (12.4 million people). Fianarantsoa remains the highest potential state for off-grid solutions, with 45% best served by mini- grids and only 36% of the population within 15km of the grid. The results of this analysis is shown graphically in Figure 11 and Figure 12, including existing and planned generation sites.

Figure 12. Regions best served by grid extension, mini-grid and standalone systems, shown with existing and planned electricity generation sites. Dotted lines are planned grid extensions up to 2025. Carbon Trust analysis.



Under the present grid, the analysis estimates a total annual revenue market size of $106 million (for mini-grids). The highest potential state is Fianarantosa, with an estimated market size of $34 million and 2.7 million people most economically served through mini-grids. This reduces to a total market of $95 million when including planned network extensions up to 2025, an 11% reduction compared to the market for mini-grids under the current grid. The largest market reduction when including these extensions is in the Fianarantosa state, at -14.7% (-$5 million). The largest market however remains in the Fianarantosa state at $29 million. The actual market size may be greater than the estimates given here considering decentralised solutions could also be feasible in areas in grid proximity.

The market size estimate shown in Table 9 assumes a national average annual household expenditure on energy of $56.4, or $12.7 per person. This expenditure is derived from an Enclude BV study, which found a mean monthly expenditure of 15,249 MGA (approx. $4.70). This is $56.4 per household annually. The latest INSTAT Madagascar Census states that the average household is between four and 4.9 people in 14 out of 22 regions, averaging to 4.45 people. Therefore, this corresponds to $12.67 per person per year (41,121MGA).

Table 9. Estimated household market size for off-grid solutions. Analysis using the existing and planned network up to 2025

State	Current grid network				
	Electrification rate	Population (thousands)			Mini-Grid Market ($m)
		< 15km of grid	Mini-Grid	SHS	
Antananarivo	15%	5,692	1,189	464	15
Antsiranana	15%	821	662	364	8
Fianarantsoa	15%	1,336	2,702	884	34
Mahajanga	15%	906	909	1,049	12
Toamasina	15%	1,449	1,480	689	19
Toliary	15%	1,165	1,390	1,076	18
Total		11,369	8,332	4,527	106
State	**Planned grid network to 2025**				
	Electrification rate	Population (thousands)			Mini-Grid Market ($m)
		< 15km of grid	Mini-Grid	SHS	
Antananarivo	15%	5,931	1,006	464	13
Antsiranana	15%	971	549	364	7
Fianarantsoa	15%	1,853	2,279	884	29
Mahajanga	15%	1,001	843	1,049	11
Toamasina	15%	1,549	1,425	689	18
Toliary	15%	1,165	1,390	1,076	18
Total		12,469	7,492	4,527	95

3.3 RENEWABLE ENERGY POTENTIAL FOR MINI-GRIDS

HYDRO

Hydropower has been a cornerstone of grid-powered generation in Madagascar for decades. Around 59% of current power generation in the country is hydro-based. The country is well endowed with potential hydropower locations. There are estimated to be 1,500 untapped hydro sites ranging from 10kW to 600MW, with an estimated total capacity of 7.8GW (World Bank, Madagascar Power Sector Operations Improvement Project , 2018). Madagascar currently exploits just 2%

of this potential equivalent to roughly 160MW of installed capacity. As of June 2014, hydropower was generated across 11 plants; 80% of the generation came from by run-of-the-river plants and 20% by reservoir plants. In management terms, around 137.6MW (82%) are managed by JIRAMA, with remaining owned by IPPs. All the power plants are connected to the interconnected networks, with most of the power injected into the Antananarivo Interconnected Network: 145MW (92%) into RIA, 6.1MW (4%) into the FIR and 6.8MW (4%) into RIT.

Table 10. Existing hydropower production plants, source ORE 2014

Region	Nominal kW	Available kW
Alaotra Mangoro	24,160	20,150
Amoron'i Mania	213	130
Analamanga	14,280	12,358
Analanjirofo	2,576	1000
Atsimo Andrefana	95	5
Atsinanana	97,960	66,420
Betsiboka	85	80
Haute Matsiatra	6,050	3,840
Ihorombe	20	15
Itasy	30	
Vakinankaratra	16,720	10,890
Vatovavy Fitovinany	60	50
TOTAL MW	162.2	114.9
Percentage of total	**29.4%**	**37.9%**

A 2017 World Bank ESMAP study identified 17 highly promising small hydro sites with a total installed capacity of about 160MW (World Bank, Madagascar Electricity Sector Operations and Governance Improvement Project, 2018). GIS data is available for this study. The Government has also set a target to have renewables in the energy mix, at least 5%, 20% and 80% respectively, by 2020, 2030 and 2050, with a large emphasis on hydro. The Government's short-term plan is to launch tenders, through ADER, for 10 sites. Small autonomous power plants with a capacity below 1.5 MW will be chosen for rural electrification, where possible. These present various advantages: they can undergo technical and financial feasibility studies, and be completed within a relatively short period, one to five years, compared to larger sites.

Figure 13. Hydropower potential per region, (1-20MW), World Bank

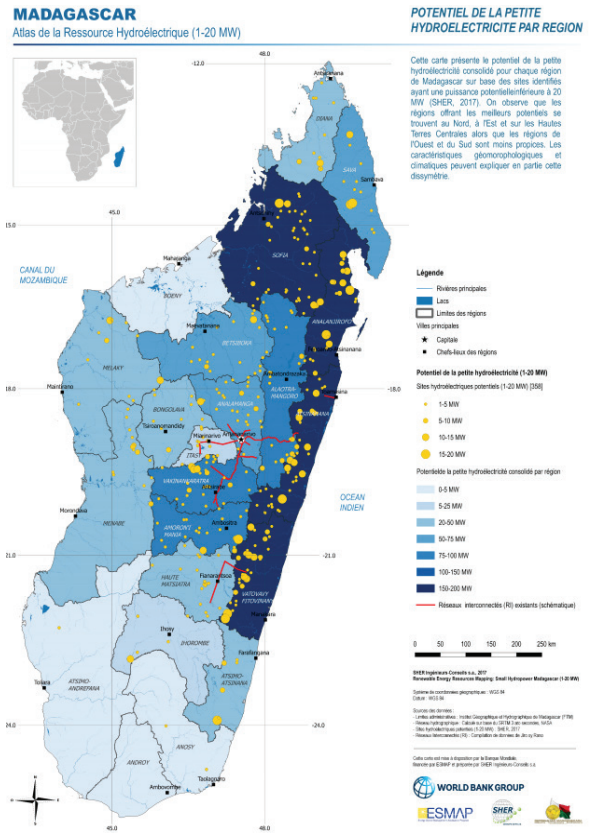


Table 11. Hydropower potential (1-20MW), source World Bank

Province	Region	Potential MW
Toamasina	Atsinanana	166
	Analanjirofo	158.4
	Alaotra-Mangoro	98.9
Fianarantsoa	Vatovavy Fitovinany	170
	Amoron'i mania	88.7
	Haute Matsiatra	48.1
	Atsimo-Atsinanana	29.3
	Ihorombe	22.4
Mahajanga	Sofia	155
	Betsiboka	59.8
	Melaky	33.1
	Boeny	0
Antananarivo	Vakinankaratra	91
	Analamanga	61.7
	Bongolava	32
	Itasy	16.6

Antsiranana	Sava	55
	Diana	39.2
Toliary	Menabe	34
	Anosy	0.3
	Atsimo-Andrefana	0.3
	Androy	0
Total		**1362.7**

BIOMASS

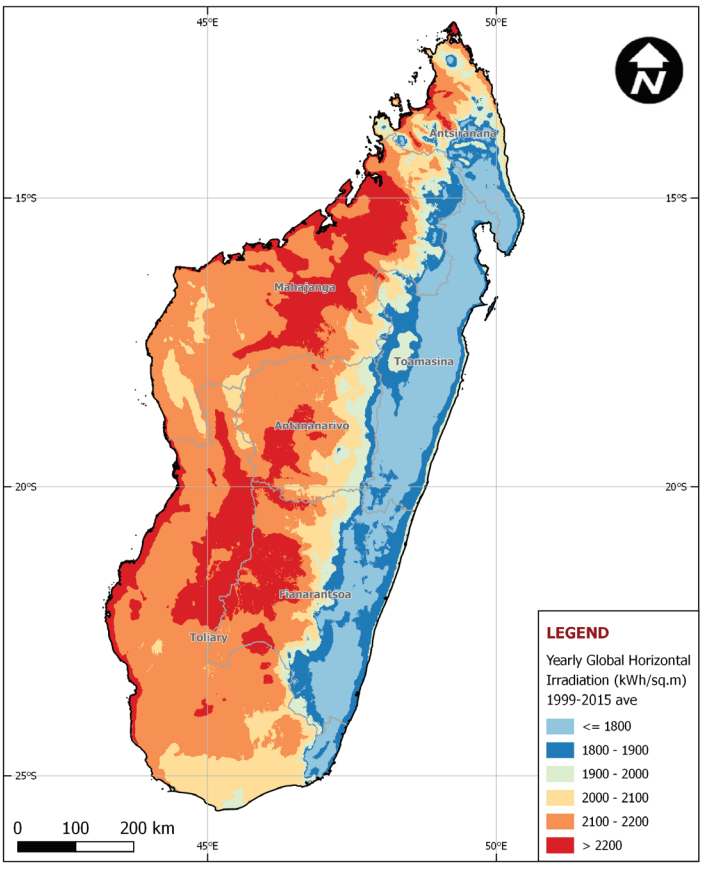
In 2013, the first biomass power station in Madagascar was launched in the rural town of Andaingo by BETC. This installation of 70 kW produces electricity using wood from local eucalyptus plantations. A second biomass power plant is operated by CASIELEC, one of the biggest and most established private operators in rural Madagascar. The plant uses rice husk as the primary fuel with a capacity of 4kW (World Bank, Evaluation of rural electrification concessions in sub-Saharan Africa, 2015).

According to estimates, the wood consumption in Madagascar is 21.7 million m³, including 42% from firewood and 40% from charcoal manufacture. The 18% remaining is devoted to wood-processing industries. In 2015, 96% of urban households and 99.6% of rural households used fuelwood, of which 82% was firewood, while charcoal is consumed by only 17% of households. However, the charcoal proportion rises to almost 50% in urban areas due to competitive prices and easy accessibility (ADER, 2016). As more than 70% of the Malagasy population works in agriculture, the largest biomass resources are mainly vegetable waste, though animal wastes and waste arising from municipal and industrial activities are viable sources too. Crops such as jatropha, maize, rice husk and sugarcane are the most promising feedstock for biofuel production.

Across the country, the potential varies depending on the site and materials from a couple kW to 150MW. The annual deforestation rate is estimated to be about 0.53% with 10% of forests lost in the last 20 years (GIZ, 2009). The Malagasy authorities intend to combat this by encouraging reforestation at 36,000 ha per year from 2018.

SOLAR

Figure 14.



Madagascar has enormous solar energy potential, with distributed solar radiation ranging from 1,500 to 2,000kWh/M² per year (Figure 13.). Almost all regions receive average sunshine hours of 2,800 per year or 7.6 hours per day. Daily averages span from 3 to 6 kWh/m² in June and up to 5 to 7.8kWh/m² in December (European Commission, 2016). Further, many of the highest demand centres receive high levels of solar radiation, including the capital, Antananarivo. Mahajanga, the second most important seaport, sees eight months of hot, rain-free weather, while sunny Toliara and Antsiranana have become thriving tourist destinations.

Currently, solar energy is used in:

- stand-alone systems to power lamps, charge phones;
- household solar PV systems to generate electricity;
- commercial projects for hotels and businesses as an 'energy saving' option;

- the telecommunications sector (Telma and Orange operators) have been using solar for decades to power pylons in remote areas;
- for mini-grid projects ranging from a few hundred kW to more than one MW.

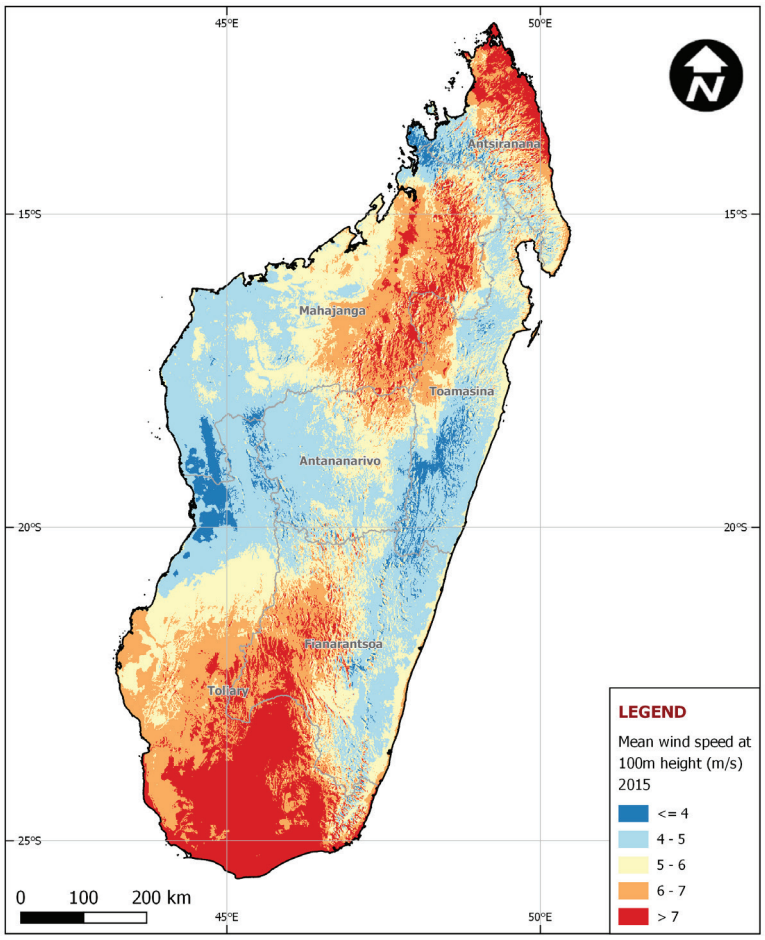
IPP-developed large solar parks are also a potential market in Madagascar. It is the third country to be supported by the World Bank's Scaling Solar initiative and has a 30 to 40MW solar park planned and supported by the International Finance Corporation (IFC). EOSOL Madagascar and MAJIKA are examples of companies that operate solar mini-grids in the south and the north, respectively. The African Development Bank (AfDB) is also undertaking a feasibility study which examines the possibility to install solar parks that fulfil the electricity demand to entire islands, specifically Nosy Be and St. Marie. As part of the NPE, the Government plans for almost 15% of households to be supplied by solar power: 5% by solar lamps, 5% by solar home systems, 1% by solar mini-grids and 3.5% by grid-connected solar (MEEH).

WIND

There are several suitable areas for wind energy generation, with a total estimated potential of 2,00MW. There is also strong potential for wind energy in Madagascar. Around Antsiranana, in the north of the island, strong winds called the Varatraza blow more than half of the year, recording an average of 6 to 8m/s at 50 meters height. In the south, around Taolagnaro, the Tsioka Tsimo winds blow with an average speed of 8 to 9m/s. In the plateau and central regions of the country, steady winds were recorded at a speed of 6 to 6.5m/s. The total capacity equates to roughly 2,000MW (UN Environment , 2017).

GIZ plans to carry out a feasibility study by 2019 for wind energy potential throughout the country and to support, where appropriate, the development of a 'wind strategy'. Some local stakeholders have expressed concerns around the incompatibility of wind generation and the capacity to inject it directly into JIRAMA's network. Currently, the main companies involved in the sale and distribution of wind power plants are Someca, Solarmad, and Ted.

Figure 15. Mean wind speed at 100m height (m/s)



4. DIRECTORY

4.1 ENERGY SECTOR POLICIES AND REGULATORY FRAMEWORKS DIRECTORY

Law no. 2017-020 (2015) Introducing the new electricity code

http://www.ore.mg/TextesDoc/Loi2017-020_CODELEC.pdf

Brief description: This new law replaces the old Law no. 98-032 (1999), reforming the electricity sector, and is part of the revision to the legal framework brought by the New Energy Policy (2015 to 2019) adopted in 2015. The new law aims to integrate provisions on the exploitation of renewable energy sources, make the electricity sector more attractive and safer for potential investors, provide consumers with a better quality of service, and improve the governance of the electricity sector, in terms of transparency and accountability. The law also introduces the new electricity code currently under development. The code will, among other things, be reviewing and simplifying thresholds for concessions, introducing the Grid Code, and promoting the connection to the grid.

Law no. 2015-039 (2015) reforming Public-Private Partnerships

http://www.ore.mg/TextesDoc/Loi-2015-039PPP.pdf

Brief description: The State has confirmed its willingness to develop Private Public Partnerships (PPP) in an approach that combines the creation of a favourable framework for the development of the private sector, the construction and rehabilitation of key infrastructure, and the capacity strengthening of local communities, while ensuring social and environmental aspects. The State wants to rely on the skills and resources of the private sector to achieve its public sector investment programmes and to improve the quality of public services provided.

Law no. 98-032 (1999) Reforming the electricity sector

http://www.ore.mg/TextesDoc/Loi%20ELEC%2098-032.pdf

Brief description: In the context of a new economic policy oriented towards the liberalisation of production activities, the Malagasy State wished to implement a reform of the Electric Power Sector. The aim of this reform was to give new operators the possibility of intervening within the sector to foster competition and promote the efficiency and quality of service offered, while releasing some pressure on the Government to finance new electricity infrastructure.

Law no. 2002-001 (2002) Creation of National Electricity Fund (FNE)

http://www.ore.mg/TextesDoc/Loi%20FNE%202002-001.pdf

Brief description: The will of the Government to accelerate the electrification of the country, which is considered among the key factors of economic and social development, has led the State to implement a reform of the Sector of Electricity. The aim of this law was to create the National Electricity Fund (FNE) to finance the development of rural electrification projects.

The New Energy Policy 2015-2030 (NPE)

Brief description: The NPE has four main objectives: Ensuring universal access to modern energy services; improving overall energy efficiency; reducing dependency on fuel imports, and providing long-term funding for the energy sector. The NPE set energy targets including increasing the energy access rate to 70% by 2030. The policy aims to produce 85% of power from renewable sources by 2030.

National Policy for the Fight against Climate Change 2010

http://extwprlegs1.fao.org/docs/pdf/mad146465.pdf

Brief description: This policy was developed in response to the UN Convention on Climate Change and the Kyoto Protocol.

4.2 DATA SOURCES DIRECTORY

This methodology was developed during the first phase of this project, the Green Mini-Grids Market Development Programme - Market Intelligence business line. 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 (high voltage)

File name: MDG-RI.shp
Source age: 2017
File type: ESRI Shapefile, lines
Description: A shapefile of the electricity transmission network of Madagascar
Projected co-ordinate system: WGS_1984 (EPSG: 4326)
Source: ESMAP Small Hydro GIS Atlas
Link: https://energydata.info/dataset/madagscar-small-hydro-gis-atlas-2017

Madagascar electricity power plants

File name: MDG-CentralesThermiquesExistantes.shp; MDG-CentralesHydroelectriquesExistantes.shp; Madagascar_Small-Hydro-Mapping_DATABASE_WB-ESMAP_Feb2017
Source age: 2017
File type: ESRI Shapefile, points
Description: A shapefile of power plants in Madagascar, as well as potential hydro sites
Projected co-ordinate system: WGS_1984
Source: ESMAP Small Hydro GIS Atlas
Link: https://energydata.info/dataset/madagscar-small-hydro-gis-atlas-2017

Nightlights

File name: SVDNB_npp_20150101-20151231_00N060W_vcm-orm-ntl_v10_c201701311200.avg_rade9
Source age: 2015
File type: Raster
Description: Nightlights data, annual average for 2015. Adjusted to remove clouds, outlier lights and data noise
Projected co-ordinate system: WGS_1984 (EPSG: 4326)
Data Source: Earth Observations Grou at NOAA
Spatial Resolution: 15 arc seconds
Link: https://energydata.info/dataset/world-night-light-annual-composite-2015

Woldpop Population Density

File name: MDG_pph_2015_adj_v2.tif
Source age: 2013
File type: Raster

Description: 2015 estimates of numbers of people per grid square, with national totals adjusted to match UN population division estimates (http://esa.un.org/wpp/).
Projected co-ordinate system: WGS_1984 (EPSG: 4326)
Data source: World Pop data portal
Spatial resolution: 100m
Link: http://www.worldpop.org.uk/data/data_sources/

Madagascar Administrative Layers (National and Province Boundaries; Main cities)

File name: MDG_adm0.shp; MDGadm1.shp; Cities_and_Towns.shp
Source age: 2017
File type: ESRI Shapefile, polygons and points
Description: Shapefiles of State and Local Government Area boundaries
Projected co-ordinate system: WGS_1984 (EPSG: 4326)
Source: ECOWAS observatory for Renewable Energy and Energy Efficiency (ECOWREX) database
Link: https://energydata.info/dataset/nigeria-administrative-boundaries-2017

Wind

File name: MD_wind100m.tif
Source age: 2015
File type: Raster
Description: Mean wind speed at 100m height
Co-ordinate system: WGS_1984 (EPSG: 4326)
Source: DTU, IRENA
Link: https://irena.masdar.ac.ae/gallery/#gallery

Solar

File name: MD_GHI.tif
Source age: 2015
File type: Raster
Description: Annual total Global Horizontal Irradiation (GHI) (kWh/sqm) averaged over 1994-2015
Co-ordinate system: WGS_1984 (EPSG: 4326)
Source: DTU, IRENA
Link: http://globalsolaratlas.info/downloads/nigeria

4.3 STAKEHOLDER DIRECTORY

GOVERNMENT AND AGENCIES

Rural Electrification Agency (ADER)

Contact: **Mamisoa Rakotoarimanana, Executive Secretary**
Email: se@ader.mg
Telephone: +261 33 23 537 95

Link: https://ader.mg/

Brief description: The Rural Electrification Agency (ADER) was established in 2002 to advance rural electrification in Madagascar. The focus was to promote access to basic electricity services for the rural population, primarily through renewable energy sources. Operational since 2004, ADER's main activities include: Identifying potential sites for rural electrification, managing the competitive tender process and supervising concessions, writing and commissioning market studies, and quality checking project work. ADER works closely with MEEH, executing national policy, influencing new policies and modifying existing ones based on what they observe on the ground. ADER's technology priorities in order of importance are rural electrification through hydro, solar, biomass, wind and hybrid systems. With the technical and financial support from donors, ADER seeks to connect foreign and local partners with the relevant resources. In conjunction with the private sector, it will provide support to projects and establish a platform for public-private exchange.

Electricity Regulator (ORE, soon to be ARELEC - Autorité de Regulation de l'Electricité)

Contact: **Aimee Andrianasolo, Executive President**
Email: ore@ore.mg
Telephone: +261 20 22 641 91

Link: http://www.ore.mg/

Brief description: ORE is the regulatory body of the electricity sector. Its principal mission is to agreeing, publishing and overseeing price tariffs and their application, overseeing the quality of the services being offered on the grid (through licences, norms and contracts), and overseeing free market competition. The newly promulgated electricity code explicitly mentions 14 mission as natural extensions of the three cores missions mentioned before. ORE is composed of an electricity board, in charge of regulation, and of an executive secretariat, which executes the decisions taken by the board. Under the upcoming electricity code, the electricity board will be renamed as the college of commissioners.

JIRAMA, National utility

Contact: **Olivier Jaomiary, Director General**
Email: dg@JIRAMA.org

Link: http://www.JIRAMA.mg/

Brief description: JIRAMA is the state-owned water and electricity operator created in 1975 following a merger between the old Malagasy Society of Water and Electricity (SMEE) and the Malagasy Society of Energy (SEM). JIRAMA generates, transports and distributes electricity in Madagascar.

The Economic Development Board of Madagascar (EDBM)

Contact: **Johary Rajosefa, Director of Investor Services**
Email: johary.rajosefa@edbm.mg
Telephone: +261 20 22 670

Link: http://edbm.mg/

Brief description: EDBM is an agency of the Government (more specifically the presidency) that facilitates and promotes investment in Madagascar, acting as an interface between the private sector and the public sector. It was established under the 2007 Law on Investments in Madagascar which created an enabling environment for private investment, property rights' guarantees, state commitment to stability, and freedom of capital and financial transactions. EDBM has three principal missions:

Promoting investment and improving the business environment in Madagascar, working in close relationship to the Presidency of the Republic and contributing to policy reforms

Promoting a positive image of Madagascar as an investment destination

Providing a one stop shop for investors, helping them to set up their companies and implement their projects.

Energy is one of the six sectors of focus that EDBM promotes. Through its large national and international network, and by working more closely with ADER, EDBM is trying to identify and attract investors. While ADER principally focuses on policy and regulation, EDBM can provide information centred on local procedures. It has for instance developed guides for investors to access the energy sector.

Ministry of Water, Energy and Hydrocarbons (MEEH)

Contact: **Marc Auguste Rakotofiringa**
Email: meeh.dge@gmail.com
Telephone: +261 34 49 661 11

Link: http://www.meeh.gov.mg/

Brief description: MEEH develops and implements policies for the provision of adequate and reliable power supply in Madagascar. The policy influences generation, transmission and distribution projects in the sector, provides general direction and facilitates the emergence of a private sector towards a competitive and efficient electric power industry.

BILATERAL AND MULTILATERAL DONOR ORGANISATIONS WITH ENERGY ACCESS PROGRAMMES

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

Contact: **Monika Rammelt, Energy Concessions Coordinator**
Email: monika.rammelt@giz.de

Telephone: +261 (0) 20 22 209 03

Link: https://www.giz.de/en/worldwide/322.html

Brief description: The German Cooperation provides both technical and financial assistance, in the form of GIZ and KfW, for renewable energy development. GIZ operates under “Promotion de l’Electrification Rurale par les Energies Renouvelables” (PERER) framework, which works closely with the Ministry of Energy and Hydrocarbons, ADER and ORE to create an enabling environment. Part of this collaboration includes consulting services for financing mechanisms, implementation of energy policies, capacity building for the private and public sector, and assisting with PPP-models and calls. Its main goals are to ensure efficiency, effectiveness, and the quality of implementation of rural electrification projects. GIZ will intervene in four key areas: strategy and policy for electrification of rural areas; improvement of regional energy planning; development of a planning process; promotion and monitoring of private sector activities through market enablement and consulting services for fund raising, capacity building and general assistance.

World Bank

Contact: **Jan Friedrich Kappen, Senior Energy Specialist**
Email: jkappen@worldbank.org
Telephone: +1 (202) 458 9145

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

Brief description: The World Bank has been supporting the following large projects: the PAGOSE project - focused on restructuring JIRAMA, Scaling Renewable Energy Program (SREP) – through the Climate Investment Fund (CIF), and Energy Sector Management Assistance Program (ESMAP) providing a comprehensive assessment and geospatial mapping of potential small scale hydropower energy resources. Project PAGOSE aims to support JIRAMA and the Ministry of Energy in developing national strategy and providing technical support. It will also tackle institutional, technical, and financial constraints limiting the electrification of the country. SREP is a program funded by the Climate Investment Fund. Like PAGOSE it plans to help tackle institutional, technical, and financial constraints that hinder electrification.

UNIDO

Contact: **Louis Tavernier**
Email: l.tavernier@unido.org
Telephone: +261 20 23 365 40

Link: https://www.unido.org/who-we-are/unido-worldwide/africa/offices/madagascar

Brief description: UNIDO supports ADER to implement mini-hydropower projects via financial and technical support. Most of its financial support constitutes of co-financing subsidies from the Global Environment Fund (GEF). UNIDO's main area of support is technical assistance to develop the legal framework for rural electrification. The technical support will provide training for technicians, policy studies, and consulting services to authorities. UNIDO is also working with smaller operators that have more problems accessing finance to ensure these operators develop a good business plan and technical fiche for their projects.

European Union

Contact: **Frederic Fourtune, Infrastructure Programmes Lead**
Email: Frederic.fourtune@eeas.europa.eu
Telephone: +261 20 22 245 85

Link: https://eeas.europa.eu/delegations/madagascar_en

Brief description: the EU's main intervention has been through the Energy Facility, now terminated, where over the course of 10 years the EU was able to co-finance off-grid energy investments, predominantly mini-grids. The facility provided essentially grant funds up to 75% of the project value. Roughly, 10 projects were financed, for a total value of €40 to 50 million. Today the intervention has been replaced by ElectriFI, which is an EDFI multi-donor fund providing a range of financial instruments (debt capital, guarantees, etc) and technical assistance for the development of mini-grids. The EU is monitoring the progress of the ADER-led mini-grid concession programme, which is being supported predominantly by the GIZ and UNIDO.

French Development Agency (AFD)

Contact: **Jerome Bertrand-Hardy, Director**
Email: bertrand@afd.fr
Telephone: +261 20 22 200 46

Link: https://www.afd.fr/en/our-agency-madagascar

Brief description: AFD is principally involved with and supporting two NGOs: GRET and another group of NGOs led by FONDEM including Electriciens Sans Frontieres (ESF). Between 2008 and 2015, GRET led the rural electrification project Rhyviere. FONDEM and ESF did the 'Café lumiere' concept, centred on PV and mini-grids (less than 50 connections), and a battery recharge service. ESF also developed the Pamela project, a small scale PV project. AFD's primary instrument in many circumstances is the SUNREF programme, which provides concessional debt through local banks. They are currently exploring this in Madagascar.

Power Africa Southern Africa Energy Programme (SAEP)

Contact: **Rija Rakotoson, Country Manager – Madagascar**
Email: rrakotoson@southernafricaenergy.org
Telephone: +261 34 02 736 71

Link: https://www.usaid.gov/powerafrica/madagascar

Brief description: SAEP's work stream in Madagascar is around rural electrification via renewables. SAEP is working essentially with the ADER to rehabilitate old abandoned diesel sites and transform them into green mini-grids to make the projects more attractive to the private sector. Their role is to support ADER to develop these projects, without actually providing upfront capital, but just technical assistance to redesign and restructure the projects to make them technically and financially attractive.

WWF

Contact: **Solo Thierry Randriamanalina, Technical Assistant for the Energy Programme**
Email: strandriamanalina@wwf.mg

Link: http://wwf.panda.org/knowledge_hub/where_we_work/madagascar/

Brief description: WWF is not currently active in the mini-grid sector, yet it has a Barefoot College that aims to promote SHS in very rural and isolated areas. They have a local college in Antananarivo that aims to train women to assemble and install solar kits. To date they have covered seven villages (c.100 to 200 homes), having trained 27 women. This means they've installed roughly 1,500 kits so far and want to scale it up to reach 630,000 million households in 2030.

MAJOR MINI-GRID PRACTITIONERS OR PRODUCT DEVELOPERS

AXIAN

Contact: **Veronique Perdigon, Secretary General**
Email: veronique.perdigon@axian-group.com
Telephone: +261 20 22 368 68

Link: http://www.axian-group.com/

Brief description: AXIAN is a family group that was started in Madagascar 150 years ago. Two years ago, a comprehensive restructure brought a number of the various offerings closer together. The company now has four main clusters: financial, energy, telecoms, and property management. The energy cluster is made up of Jovena and EDM. The telecom business is Telma, one of the largest telecoms operators. AXIAN has only recently moved into rural electrification through their EDM business and are currently developing and operating a small number of mini-grids.

BETC Nanala

Contact: **Paul Rakotondralambo, President and CEO**
Email: betc_nanala07@yahoo.fr
Telephone: +261 033 11 436 31

Link: https://betc.mg/

Brief description: BETC Nanala owns several electricity supply sites, mainly focused in the Alaotra-Mangoro region. It is among others, the owner of the Andaingo biomass site as well as the thermal power plant of Imerimandroso, which will become a hydraulic power station.

EOSOL

Contact: **Camille Andre-Bataille, General Manager & Shareholder**
Email: camille@eosol.mg
Telephone: +261 34 02 060 46

Link: http://www.eosol.mg/

Brief description: EOSOL is a Madagascar registered company created in 2008 that employs 25 people. EOSOL's main activities are rural electrification through mini-grids (mainly solar), consultancy services, and grid connected solar PV systems. Their economic model is focused around **s**ustainability**,** reducing their need for grants, increasing the development of socioeconomic factors by stimulating consumption and by helping small businesses increase their revenue. They focus on productive uses to create employment, more revenue and modernisation.

Henri Fraise & Fils

Contact: **Charles Van Der Straeten, Managing Director**
Email: Charles.vanderstraeten@hff.mg
Telephone:

Link: http://www.henri-fraise.com/

Brief description: The Henri Fraise Fils & Cie Company became the exclusive dealer for Caterpillar in Madagascar and its Dependencies in 1945. Originally in the agriculture sector (vanilla production mainly), the business has diversified strongly into construction, and subsequently the provision of equipment and is now active in the energy sector. The company has approximately 60MW of thermal (i.e. diesel or heavy fuel) generators, spread across 10 or so projects. It is now working on the development of two small scale rural electrification hydro projects, notably through ADER.

For a full list of organisations in the renewable energy and electricity sector, please refer to the newly published EDBM directory: http://edbm.mg/wp-content/uploads/2018/05/ANNUAIRE-SECTEUR-ENERGIE.pdf

Table 12. List of private operators as of the first semester 2016, sourced from MEEH

Nom du fournisseur	Type de contrat
AF POWER LIMITED	Location
AGGREKO	Location
CIMELTA MADAGASCAR	Location
COGELEC	Location
ELECTRICITE DE MADAGASCAR	Location
Entreprise DAHEL	Location
EPICES DES ILES	Location
ERMA	Achat
FIRSTENERGY	Location
HENRI FRAISE FILS & CIE	Achat
HENRI FRAISE FILS & CIE	Location
HYDELEC MADAGASCAR S.A	Achat
MADA 4X4 PIECES	Location
MADAGASCAR RENEWABLE POWER	Location
MADAGASCAR UTILITIES LTD	Location
QIT MADAGASCAR MINERALS SA	Achat
SOCIETE ENELEC	Location
SOCIETE TSARAMANDROSO	Location
SOGEOI	Location
SYMBION POWER	Achat
TAMATRADE	Location
TARTINE SARL/FIRST ENERGY	Location
VISION MADAGASCAR	Location

ANNEXES

Table 13. JIRAMA tariffs as of April 2018

Voltage	Client	Utilisation	Components	Unité	Zone 1	Zone 1bis	Zone 2	Zone 3
High Voltage (HV)		Hour	Fixed prime	Ar/kW/month	40 108			
			Peak tariff	Ar/kWh	710			
			Day tariff	Ar/kWh	160			
			Night tariff	Ar/kWh	88			
			Fees	Ar/month	269 472			
Medium Voltage (MV)	MV Industrial	Long Utilisation	Fixed prime	Ar/kW/month	51 004	42 213	33 423	27 574
			Energy price	Ar/kWh	245	386	524	865
			Fees	Ar/month	208 892	208 892	208 892	208 892
		Short Utilisation	Fixed prime	Ar/kW/month	51 004	42 213	33 423	27 574
			Energy price	Ar/kWh	333	454	573	911
			Fees	Ar/month	208 892	208 892	208 892	208 892
		Hour	Fixed prime	Ar/kW/month	40 943	37 184	33 423	27 574
			Peak tariff	Ar/kWh	716	778	838	1 084
			Day tariff	Ar/kWh	158	337	515	838
			Night tariff	Ar/kWh	141	270	420	788
			Fees	Ar/month	242 316	242 316	242 316	242 316
	MV Others	Long Utilisation	Fixed prime	Ar/kW/month	53 221	44 049	34 876	28 773
			Energy price	Ar/kWh	417	596	775	1 145
			Fees	Ar/month	217 975	217 975	217 975	217 975
		Short Utilisation	Fixed prime	Ar/kW/month	53 221	44 049	34 876	28 773
			Energy price	Ar/kWh	455	619	782	1 183
			Fees	Ar/month	217 975	217 975	217 975	217 975
		Hour	Fixed prime	Ar/kW/month	47 955	41 416	34 876	28 773
			Peak tariff	Ar/kWh	862	880	898	1 093
			Day tariff	Ar/kWh	330	532	732	1 011
			Night tariff	Ar/kWh	206	459	644	997
			Fees	Ar/month	252 851	252 851	252 851	252 851
Low Voltage (LW)	LW General	Other	Fixed prime	Ar/kW/month	4 040	3 758	3 476	2 091
			Energy price	Ar/kWh	370	466	589	795
			Fees	Ar/month	10 455	10 455	10 455	10 455
		Residential PS > 3 kW	Fixed prime	Ar/kW/month	3 371	2 768	2 164	1 586
			Energy price <= 130 kWh	Ar/kWh	370	391	413	550
			Energy price > 130 kWh	Ar/kWh	370	460	548	737
			Fees	Ar/month	7 641	7 641	7 641	7 641
		Residential PS = 3 kW	Fixed prime	Ar/kW/month	3 371	2 768	2 164	1 586
			Energy price <= 70 kWh	Ar/kWh	236	324	413	550
			Energy price > 70 kWh	Ar/kWh	500	524	548	737
			Fees	Ar/month	7 641	7 641	7 641	7 641
	LW Economy	Non Residential (PS < 3 kW)	Energy price <= 25 kWh	Ar/kWh	165	165	165	165
			Energy price > 25 kWh	Ar/kWh	764	809	853	916
			Fees	Ar/month	922	922	922	922
		Residential (PS < 3 kW)	Energy price <= 25 kWh	Ar/kWh	141	141	141	141
			Energy price> 25 kWh	Ar/kWh	764	808	849	909
			Fees	Ar/month	922	922	922	922

Table 14. Planned transmission lines in Madagascar

Line extent	Voltage (kV)	Length (km)	Cost (Million USD)	Type of power plant
Volobe Amont - Toamasina - Tana-Nord 2	220	290	132	Hydropower
Sahofika - Tana-Sud 3	220	90	40	Hydropower
Tana-Sud 3 - Tana-Sud 2	63	20	4	-
Antetezambato - Antsirabe - Tana-Sud 3	220	200	90	Hydropower
Mahitsy Farahantsana - Tana-Sud 2	63	30	6	Hydropower
Andranomamofona - Antsiranana - Ambilobe (RIDA)	63	170	34	Hydropower
Lokoho - Sambava - Andapa (RISA)	63	105	21	Hydropower
Namorona II - Fianarantsoa - Manakara - Mananjary (RIFMM)	63	160	35	Hydropower
Ambodiroka - Anjiajia - Ankazomborona - Mahajanga	220	170	130	Hydropower
Mahavola - Ampanotokana	220	120	54	

Source: KTH-dESA, World Bank and the Artelia Group, ORE, and NEWJEC Inc.

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