Mini-Grid Market Opportunity Assessment: Mali

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

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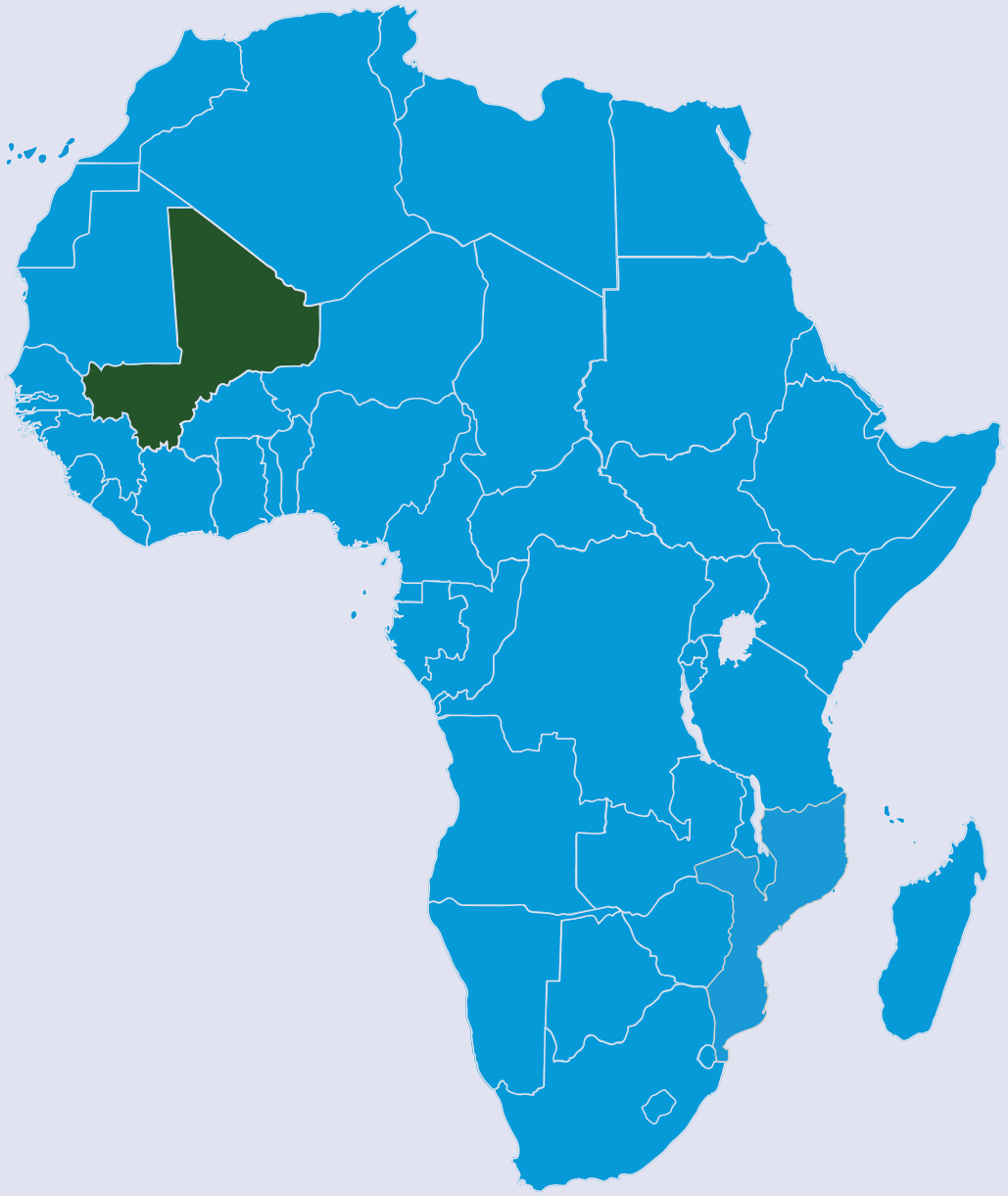

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The African Development Bank has an overarching objective to spur sustainable economic development and social progress in its Regional Member Countries (RMCs), thus contributing to poverty reduction. The Bank Group aims to achieve this objective by 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.

SNV is a not-for-profit international development organisation, working in Agriculture, Energy, and Water, Sanitation & Hygiene. SNV aims to alleviate poverty by enabling increased income and employment opportunities and increasing access to basic services. The organisation currently works in 38 countries in Africa, Asia, and Latin America.

The Carbon Trust would like to thank Mali's Ministere de l'Energie et de l'Eau (CREE), the Direction Nationale de l'Energie (DNE), the Agence des Energies Renouvelables du Mali (AER Mali), Société Energie du Mali (EDM-SA), the Agence Malienne pour le Développement de l'Energie Domestique et de l'Electrification Rurale (AMADER) for their contributions which made this report possible. The Carbon Trust would also like to thank members of the following businesses and institutions for further input and support: Agence Française de Développement (AFD), Swedish Aid, the European Development Fund (FED), World Bank, USAID Mali, KAMA Group SA, Sonikara Solar Electro Sarl, Yandalux Mali Sarl, Yeleen Kura.

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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 Mali. Green-mini grids include mini-grids powered by renewable energy resources – solar radiation, wind, hydropower or biomass – either exclusively, or in combination with diesel generation.

Mini-grids are not a new phenomenon in Africa. Almost all national utilities own and operate diesel-powered generating facilities not connected to the main grid, which supply electricity to secondary towns and larger villages. This solution to rural electrification often results in significant financial losses for the utility, required to sell power at prices significantly below the cost of production and delivery. Moreover, it leaves the most remote towns and villages unelectrified. The latest Sustainable Energy for All (SEforALL) Global Tracking Framework estimates that the urban-to-rural divide in access to electricity in Africa is as high as 450 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.

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

In response to these challenges, the SEforALL Africa Hub at the African Development Bank (AfDB) designed and launched Phase 1 of the GMG MDP in 2015 with grant funding from the AfDB's Sustainable Energy Fund for Africa (SEFA)[1]**.** The GMG MDP is a pan-African platform that addresses the technical, policy, financial and market barriers confronting the emerging GMG sector. It is part of a larger Department for International Development (DFID) funded GMG Africa Programme, which also includes GMG initiatives in Kenya, Tanzania, DRC, Sierra Leone, etc.; 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, aim to contribute to falling costs, technological advancements and more efficiencies in GMG development through a variety of interventions aimed at improving enabling environments, and providing technical assistance to public and private sector actors to encourage deployment, and in so doing will help ensure that up to two thirds of this supply is powered by renewables.

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

This report was prepared by the Carbon Trust and SNV at the request of the AfDB. It was written by Micol Salmeri and Benjamin Curnier of Carbon Trust and Michel Samaké from SNV. Carbon Trust is a mission-driven organization helping businesses, governments and the public sector accelerate the move to a low carbon economy.

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

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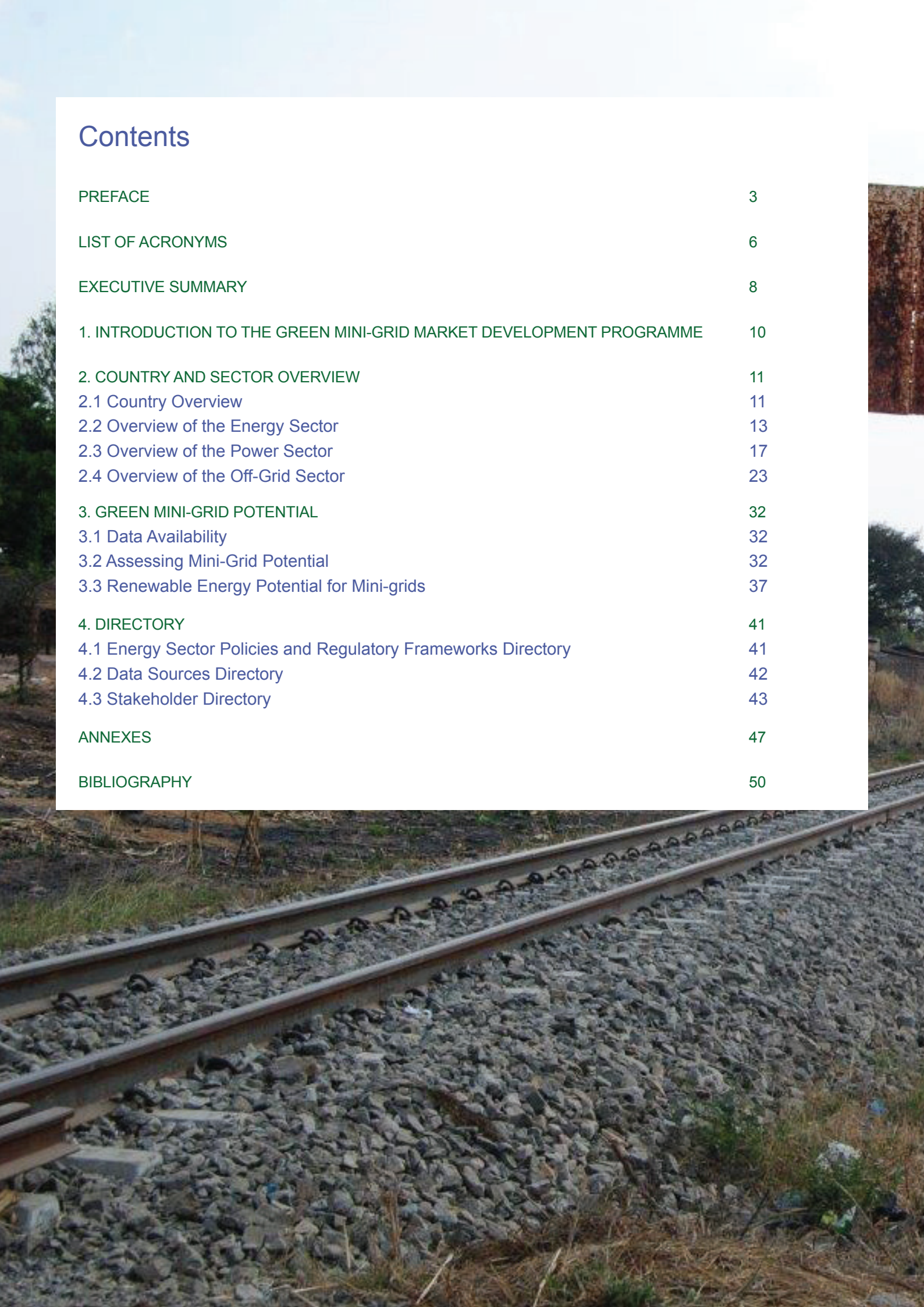
1 The SEforALL Africa Hub partnership includes the African Union Commission, the New Partnership for Africa's Development (NEPAD), the United Nations Development Programme (UNDP), and the Regional Economic Communities (RECs), which are represented on a rotating basis. http://www.se4all-africa.org

Contents



List of Figures

List of Tables

LIST OF ACRONYMS

AER	Agence des Energies Renouvelables du Mali/ Renewable Energy Agency of Mali
AFD	Agence Française de Développement
AfDB	African Development Bank
AMADER	Agence Malienne pour le Développement de l'Energie Domestique et de l'Electrification Rurale/ Malian Agency for the Development of Domestic Energy and Rural Electrification
ANADEB	Agence Nationale de Développement des Biocarburants/ National Agency for Development of Biofuels
BADEA	Banque Arabe pour le Développement Economique en Afrique/ Arab Bank for Economic Development in Africa
BID	Banque Islamique de Développement/ Islamic Development Bank
CMDT	Compagnie Malienne pour le Développement des Textiles/ Malian Company for the Development of Textiles
CREE	Commission de Régulation de l'Electricité et de l'Eau/ Regulatory Commission for Electricity and Water
DFID	Department for International Development
DNE	Direction Nationale de L'Energie / National Directorate of Energy
ECF	Extended Credit Facility
ECOWAS	Economic Community of West African States
EDM	Energie du Mali
ESMAP	World Bank's Energy Sector Management Assistance Program
FER	Fond d'Electrification Rurale/ Rural Electrification Funds
FONGIM	Le Forum des ONG Internationales au Mali/ International NGO Forum in Mali
GDP	Gross Domestic Product
GMG	Green Mini-Grid
GIS	Geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HIO	High Impact Opportunities
HV	High Voltage
IEA	International Energy Agency
IG	Interconnected Grid
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
INSTAT	Institut National de la Statistique du Mali/ National Institute of Statistics
IPP	Independent Power Producer

MDP	Market Development Programme
MEE	Ministère de l'Énergie et de l'Eau du Mali/ Ministry of Energy and the Environment
MINUSMA	United Nations Multidimensional Integrated Stabilisation Mission
NEPAD	New Partnership for Africa's Development
OMVS	Organisation pour la mise en valeur du fleuve Sénégal/ Senegal River Basin Development Authority
ON	Office du Niger
OSER	Association des Opérateurs Privés du secteur de l'Electrification Rurale/ Association for Rural Electricification Private Sector Operators.
PAPERM	Projet d'appui à la promotion des énergies renouvelables au Mali)/ Project for Scaling up Renewable Energy in Mali
PASE	Projet d'Appui au Secteur de l'Energie / Mali Energy Support Project
PDER	Roadmap for Rural Electrification/ Plan Directeur d'Electrification Rurale
PDIO	Plan Directeur des Investissements Optimaux/ Optimal Investment Roadmap
PEN	Politique Energétique Nationale/ National Energy Policy
PHARE	Production Hybride et Accès Rural à l'Electricité/ AFD Hybrid Power Generation and Rural Access to Electricity Project
PPP	Private Public Partnership
PV	Photovoltaic
RMC	Regional Member Countries
RRA	Renewable Readiness Assessment
SEforALL	Sustainable Energy for All
SEFA	Sustainable Energy Fund for Africa
SHER	Projet Systèmes Hybrides d'Electrification Rurale/ World Bank Rural Electrification Hybrid System Project
SHS	Solar Home Systems
SIDA	Swedish International Development Authority
SSA	Sub-Saharan Africa
UEMOA	Union Economique et Monétaire Ouest Africaine/ West African Economic and Monetary Union
UN	United Nations
UNDP	United Nations Development Program
WADB	West African Development Bank

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 GMGs where they represent a technically and economically better option than the extension of the main grid. The Market Intelligence business line aims to provide comparable, actionable data on the potential for GMGs across countries in Sub-Saharan Africa (SSA). This report focuses on Mali. 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.

Mali is a landlocked nation in West Africa that spans 1,246,814 km^2, of which ~65% is either desert or semi-desert. It borders seven countries: Algeria, Niger, Burkina Faso, Ivory Coast, Guinea, Mauritania, and Senegal. Mali is divided into eight administrative regions and the district of Bamako.

Mali has an estimated population of 18.9 million people (growing 3.5% annually), with ~62.5% living in rural areas. Life expectancy at birth is 68.2 for women and 65.7 for men. Despite the persistence of a precarious security situation, Gross Domestic Product (GDP) has continued to increase year on year. The economy registered a 5.3% increase in GDP in 2017. It is mainly driven by the primary sector i.e. agriculture which accounts for 40.9% of GDP and employs about 80% of the active population.

The energy mix has considerably shifted over the years from hydro dominated generation to a nearly equal split between hydro and thermal (fossil) power. On average, installed capacity has increased by 8.1% year on year over the 2005-2015 decade. Despite this, there remains an ongoing electricity supply deficit of ~150MW due to rising electricity demand.

Despite uncertainties in the sector, significant progress has been made in increasing electricity access in Mali, with access to modern energy services reaching ~40.5% nationally in 2017, with an electricity access rate of ~83% in urban areas and 17% in rural areas. However, the interplay between on and off-grid electricity provision remains very unclear, and is an active hindrance to future electrification causing uncertainty for donors, operators and government institutions alike. Price differences remain high, with the price of mini-grids estimated at 250-280 FCFA/kWh ($0.44-$0.49/kWh), compared to an urban price charged by the national utility of ~130 FCFA/kWh ($0.23/kWh).

The key institutions in the rural electrification sector are the Ministry of Energy and Water (MEE), the Rural Electrification Agency (AMADER), the Renewable Energies Agency of Mali (AER) and the state utility Energie du Mali (EDM). AMADER serves as the energy regulatory authority outside of urban centers. At present neither AMADER nor EDM have issued clear electrification plans. There are concerns about the responsibilities of all actors. Whilst AMADER has nominal responsibility for rural electrification, lack of agency funding means both AMADER and AER chase funding from donors to implement projects. Further, with a lack of clarity over on and off-grid environments, and political interference, AMADER is regularly pushed out by EDM, despite EDM being under serious financial difficulties.

The energy sector in Mali is therefore undergoing a high number of reforms which will be critical to the mini-grid sector. Under the World Bank's technical assistance project 'Projet d'appui à la promotion des énergies renouvelables au Mali' (PAPERM)/ Project for Scaling up Renewable Energy in Mali, Tractebel is reviewing national policies and strategies including the National Energy Policy as well as Decree N°00-09 and N°00-021, which govern the electricity sector and

define the powers of the national electricity regulator Commission de Régulation de l'Electricité et de l'Eau (CREE). Suggested revisions include, amongst others, a change in licensing thresholds, an extension of the regulator's jurisdiction to rural electrification to validate mini-grids tariffs, and a clear and simplified processes for connection to the grid.

Although diesel mini-grids have been used in Mali for some time in rural contexts, their profitability has historically been a major challenge, which has resulted in poor performance, low acceptance, and in many circumstances, project cessation. Hybridisation through solar technologies has increasingly become a discussion topic within the sector in the hope of improving service delivery, and reducing costs. A number of donor-funded projects are underway, the largest of which are being funded by the World Bank's project Systèmes Hybrides d'Electrification Rurale (SHER) / Rural Electrification Hybrid System Project, and the Agence Française du Développement (AFD) PHARE project (Production Hybride et Accès Rural à l'Electricité / Hybrid Power Generation and Rural Access to Electricity Project). These projects are implemented by AMADER, and are expected to upgrade ~108 previously diesel-only mini-grids. Additional mini-grid projects are also being funded by the Islamic Development Bank, and the Abu Dhabi Fund, both of which are also implemented through AMADER.

Our analysis estimates that 3.9 million people (21% of the unelectrified population) will be best served by mini-grid solutions in Mali. The highest potential for mini-grid is in the region of Mopti (note that Mopti lies on the edge of what is considered the safe zone of southern Mali and the less secure North). A further 4.3 million people (27% of the unelectrified population) will be best served by solar home systems (SHS) and 1.6 million people (7% of the unelectrified population) will be best served by grid extension, based on proximity to the existing grid. This calculation is based on the current grid coverage only[2] ; any planned grid extensions will reduce the estimated market size.

In summary, this report estimates an annual mini-grid market size of ~$211.5 million in Mali, based on an average mini-grid tariff of $0.44/ kWh, and average household demand per day of 2.2kWh. This implies per capita annual electricity expenditure of $54.4 within the population best served by mini-grids. Considering the average mini-grid tariff of $0.44 is slightly above the cost-reflective tariff of $0.4/kWh across SSA, in theory, **project costs would not need to be covered by subsidies**, and the market should already be to developers.

2 High voltage lines plus lights seen from satellite, which are used to infer the presence of medium and low voltage lines (note: this method may camouflage a significant existing off-grid contribution from diesel gensets, meaning that this mini-grid market size result is likely to be conservative; further studies in-country are required)

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 aids a range of stakeholders in overcoming the challenges for widespread and sustainable implementation of Green Mini-Grid (GMG) projects, by:

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

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

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

The development of clean energy mini-grids is also the primary objective of the Mini-Grid Partnership, for which the Bank is playing a lead role for Africa. The Partnership 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

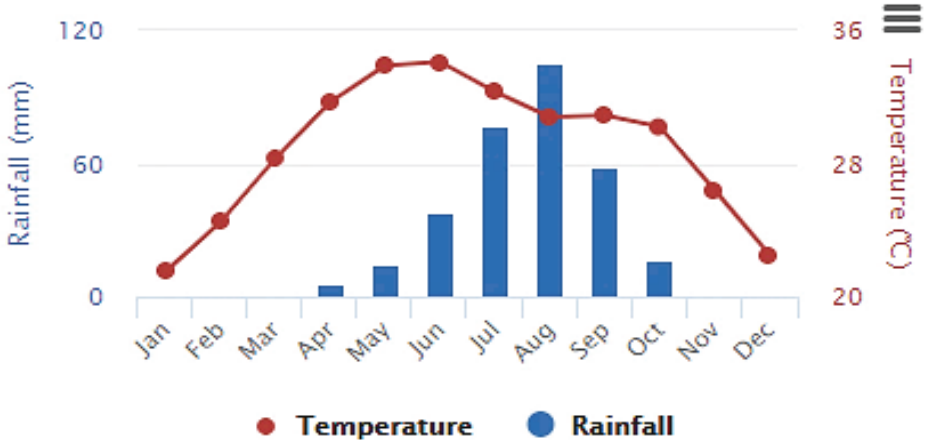
2.1 COUNTRY OVERVIEW

Figure 1. Map of Mali

Mali has an estimated population of 18.5 million people, with ~62.5% living in rural areas. Mali is a landlocked nation in West Africa that spans 1,246,814 km^2, of which around 65% is either desert or semi-desert. It borders seven countries: Algeria, Niger, Burkina Faso, Ivory Coast, Guinea, Mauritania, and Senegal. Mali is divided into eight administrative regions and the district of Bamako, capital of the country that encompasses six communes. The eight regions are: Kayes, Koulikoro, Sikasso, Ségou, Mopti, Tombouctou, Gao, and Kidal. Two additional regions, Taoudénit and Ménaka, are currently being created. The eight regions are managed by Regional Councils.

Mali is amongst the hottest countries in the world, with an average annual temperature of 27°C, and average highs of over 40°C in March-July period. An historical analysis shows that average annual temperatures have risen by 0.7°C since 1960. The climate, highly variable, is characterised by a long dry season and a rainy season averaging one month in the north and up to five months in the south. Precipitation ranges between 200 to 1,200mm/ year. Mali's average annual rainfall has dropped by 30% since 1998 with droughts becoming longer and more frequent. The increase in temperatures and diminishing precipitation demonstrate Mali's growing vulnerability to climate change.

Figure 2. Average monthly temperature and rainfall for Mali 1991-2015 (World Bank, Climate Change Knowledge Portal, n.d.)



Currently almost all large urban centres are interconnected by a paved road network that also serves the borders of most neighbouring countries, thereby helping to open up the country. Towards the central plateau of the country, road infrastructure is rural and little developed. The rail network, which is limited to a single link between Bamako to

Dakar, is in poor condition and in need of overhaul. River navigation is becoming challenging due to falling precipitation. A single airport (Bamako) allows for international air traffic. Following insecurity in the northern regions in 2012, aid and development partners have set up an air transport network servicing Sévaré / Mopti, Gao and Timbuktu airports.

Mali has a challenging geography for the provision of telecommunication services, with large areas of the country dominated by sparsely populated desert. Additionally, Mali's landlocked location has made it dependent on neighbouring countries for international fibre bandwidth.

Despite this, like many African states, Mali has experienced massive mobile telephone take-up. The number of mobile connections in Mali has grown substantially, up from just 406,000 in 2004 to more than 18.1 million in 2013, meaning that most of the population owns at least one mobile phone (Telecom Advisory Services, 2013). The telecommunication sectors are served by the main operators Malitel (Morocco TELECOM and Malian State) and Orange Mali, and their related services such as mobile money and mobile data. Mobile money services are expected to grow substantially (KEN Research, 2017). Fixed-line subscribers remain a small proportion of total telecommunication users.

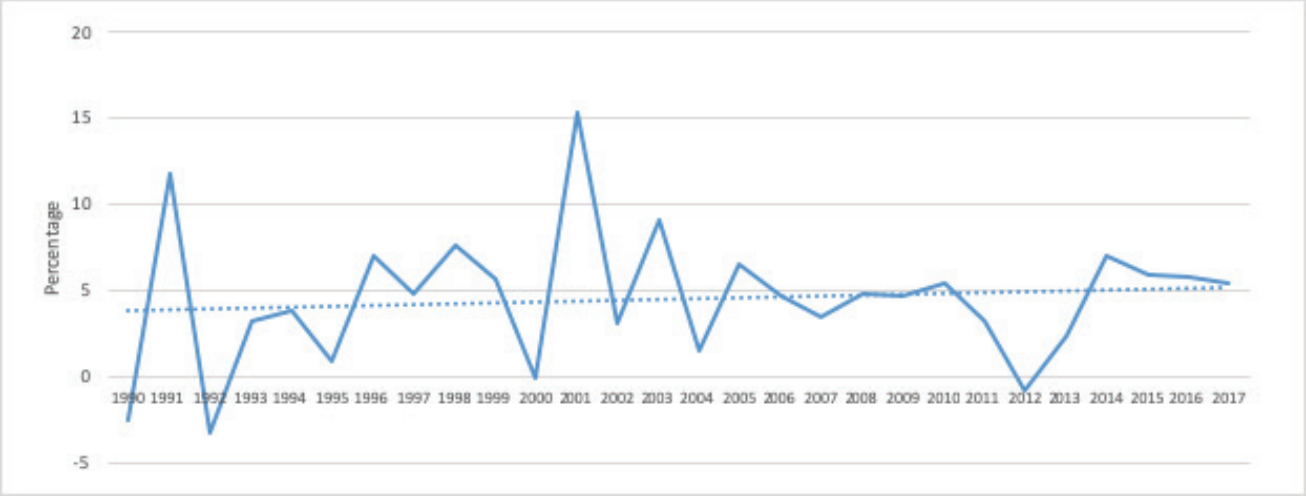
The political history in Mali is one of unrest and multiple coup d'états. From Mali's independence in September 1960, through until November 1968, a socialist tendency regime defined the broad outlines of the country's development through a five-year planning policy. The advent of a second republic in November 1968 following a military coup d'état gave the country's political and economic life a new orientation, establishing a one-party government from 1978. In March 1991, another coup d'état overthrew the regime, paving the way for what was called the "democratic era" enshrined in general elections in 1992. After 20 years, the country was hit by a multi-faceted crisis which included the armed rebellion by Islamists in the north that led to another coup in March 2012. After a period of transition, the country returned to normal constitutional life in 2013 following presidential and legislative elections. However, the security situation remains precarious, in particular in the North (regions of Gao, Tombouctou, Kidal and Menaka) and the centre of the country, where an UN-led peace keeping force remains in place.

The United Nations Multidimensional Integrated Stabilisation Mission in Mali (MINUSMA) was established in 2013 to support the transitional authorities of Mali as well as national political dialogue and reconciliation. In 2014, it was further expanded to ensure security, stabilisation and protection of civilians. As of July 2018, the total uniformed personnel amounted at 15,209 (UN Pacekeeping, 2018). In 2017, MINUSMA had the highest number of fatalities of any UN peacekeeping mission for the fourth year running. The security situation in the country therefore remains concerning, especially north of Gao and in Tombouctou where peacekeeping troops suffer regular attacks. In Bamako, security is better.

Despite the persistence of a precarious security situation, GDP has kept increasing at an average of 4.5% year on year. 2014 saw an increase in GDP compared to the previous year of 7.1%, and GDP increased by 5.8% between 2015 and 2016 (INSTAT, Le Mali en Chiffres, 2018). In 2017, the economy registered a 5.3% increase in GDP (Tractebel, 2018). GDP per capita was estimated in 2017 by the World Bank at $824.5, comparable to the GDP per capita in the same year of Benin and Guinea. Projections for 2019 suggest a 4.6% growth (Figure 3). Mali is a member of the Economic Community of West African States (ECOWAS) and the West African Economic and Monetary Union (UEMOA).

The economy in Mali is mainly driven by the primary sector which accounts for 40.9% of GDP and employs about 80% of the active population, supported by the tertiary sector i.e. services (40.2% of GDP) (INSTAT, Annuaire Statistique Mali, 2016). Mali's great potential wealth lies in mining, with the sector representing ~5.8% of GDP in 2014 (MEADD & MEF, 2014). However, primary sector growth fell from 7.6% to 4.8% between 2016 and 2017, due to decreased rainfall, while tertiary (services) sector growth has been robust (~6% since 2014) following renewed dynamism in the ICT sector according to World Bank data. The secondary sector (manufacturing) only grew by 0.4% between 2015 and 2016.

Figure 3. Annual GDP Growth in Mali between 1990 and 2017, World Bank data



Macroeconomic indicators remain steady in Mali, suggesting an element of economic stability. Inflation stood at 1.2% in 2018 (projected at 1.1% in 2019), and the overall fiscal deficit was 3.2% in 2018 (projected at 2.5% in 2019). The population is growing at an average annual rate of 3.6%, and 43.6% of the population remains below the poverty threshold and 11.3% in unemployment. On May 23, 2018, the International Monetary Fund (IMF) completed the Eighth and Ninth Reviews of Mali's performance under the program supported by an Extended Credit Facility (ECF) arrangement. Completion of the reviews enables the disbursement of ~ $89.7 million (IMF, 2018).

2.2 OVERVIEW OF THE ENERGY SECTOR

2.2.1 ENERGY MIX, EMISSIONS AND TRENDS

Mali has limited domestic energy supply and increasing energy demand (with electricity demand alone increasing 7.8% per year from 2005-15). An annual growth of 15% is expected between 2015 and 2025, mainly driven by low and high voltage clients (Climatescope, 2018). Biomass makes up ~77% of Mali's primary energy supply mix, with imported oil making up ~18% and electricity at 5% according to latest government figures (MEE, 2017). To meet increasing demand for electricity, Mali has been relying on thermal fuel imports from neighbouring countries; typically expensive diesel for generation. Annual energy imports are in the region of $1 billion. Total installed electricity capacity was ~450 MW in 2017 (Climatescope, 2018).

Energy consumption is dominated by the residential sector, which was responsible for 72% of final consumption in 2014. Consumption in the residential sector relies for 96% on biomass (Tractebel, 2018). The residential sector also emits the most (82% of significant sector emissions in 2012) according to PNUD figures. Going forward it is expected that a large proportion of growth in emissions will continue to come from residential energy consumption driven by population growth. As biomass is currently still the largest source of energy nationwide, increased green energy access should therefore be an important part of Mali's mitigation actions.

In September 2016, the Government of Mali deposited with the Office of Legal Affairs of the United Nations its Intended Nationally Determined Contributions (INDC). The baseline scenario shows that GHG emissions will increase by an annual average of 6.9% between 2015 and 2030. The GHG reduction ambition level of the mitigation scenario compared to the baseline scenario is 31% for Energy (29% for Agriculture and 21% for Land Use Change and Forestry) (UNFCCC, 2015).

2.2.2 KEY ENERGY AND ELECTRICITY SECTOR STAKEHOLDERS

The main public sector on-grid actors in the energy sector in Mali remain the government, through the Ministère de l'Energie et l'Eau (MEE), the Direction Nationale de L'Energie (DNE), the state utility, Energie du Mali (EDM), and the Société de gestion de l'énergie de Manantali (SOGEM) which runs the Manantali and Felou dams (noting that SOGEM public ownerships is split with the other OMVS country governments). Table 1 below shows key public sector actors in the energy sector.

Table 1. Key public sector actors of the energy sector in Mali

State utility	• Energie du Mali/ Energy utility (EDM-SA)
Public administrative bodies	• Agence Malienne pour le Développement de l'Energie Domestique et de l'Electrification Rurale/ Malian Agency for the Development of Domestic Energy and Rural Electrification (AMADER) • Agence Nationale de Développement des Biocarburants/ National Agency for the Development of Biofuels (ANADEB)
Public scientific bodies	• Agence des Energies Renouvelables du Mali (AER-Mali)/ Renewable Energies Agency of Mali
Ministries	• Ministère de l'Energie et l'Eau (MEE)/ Ministry of Energy and Water ○ Direction Nationale de L'Energie (DNE)/ National Directorate of Energy (subset of MEE)
Independent bodies	• Commission de Régulation de l'Electricité et de l'Eau/ Regulatory Commission for Electricity and Water (CREE)

A number of private sector actors are active in the on-grid market (e.g. OMVS, Yeleen Kura, Horonya, and Zed SA). Section 4.3 Stakeholder directory gives a more complete overview of the key actors.

Within the Ministry for Energy and Water (MEE), the DNE implements the government vision for the energy sector by setting strategies and policies. Once those are set, the DNE ensures the coordination and technical supervision of regional and sub-regional departments. It monitors the implementation of the policies, in particular by the main energy agencies working under the umbrella of the Ministry of Energy. These agencies are primarily CREE, AER-Mali, AMADER, and ANADEB. Each of these agencies must report key performance information to the DNE, who is then in charge of verifying the coherence in the intervention of all the agencies and ensure each of them is respecting their given mandate. This includes ensuring that AMADER and EDM, who are both active in the rural electrification and mini-grids sector, respect their rural electrification perimeter and concessions. DNE is also in charge of planning grid extension in accordance to these concession areas.

The Regulatory Commission for Electricity and Water (CREE) is responsible for regulating the electricity sector and the public service of drinking water in urban centers. It was created in 2000 (ordonnance No. 0-021/P-RM[3]) as an independent body with legal personality and financial autonomy. It is composed of an executive secretariat and a council. The general mission of CREE is to support the development of the public electricity and water service, defend the interests of users and the quality of public service, and promote and regulate market competition between operators. It approves and controls market tariffs and supervises tenders and the granting of concessions. CREE verifies that tenders prepared by the DNE or EDM are compliant with national legislation. Once contracts are signed, CREE takes over technical, economic and financial control. More specifically, CREE monitors the transactions between operators in the electricity sector, and serves as arbitrator of conflict[4]. An overview of the tariff setting process is covered in section 2.3.

3 This is one of the two ordonnances that have been substantially amended under the World Bank's technical assistance project PAPERM. One of the objectives of PAPERM was to improve the political, legal, regulatory and institutional framework conducive to the promotion of renewable energy investments. The project is estimated at ~ US$ 2.6 million.

4 Note: CREE presently only has jurisdiction over the on-grid market, although it is expected that this be extended to the off-grid sector if the proposed Politique Energétique Nationale (PEN - National Energy Policy) is adopted. See section 2.2.3.

Energie du Mali (EDM-SA) is the state-owned Malian utility responsible for the generation, transmission and distribution of energy in urban and peri-urban areas. It was created in 1960 (ordonnance No. 26 / PGP) by the Malian state. It owns an agency more specifically dedicated to the production of electricity, named Electricity of Mali. Through its concession contract, the company EDM-SA has accepted the development responsibility and the operation of electricity generation, transmission and distribution services in a geographical perimeter composed of 98 localities. The geographical perimeter is defined by the Concession Act, a fluid and regularly reviewed document. Within the perimeter of its concession, EDM has monopoly over power transmission and distribution, while generation is open to the private sector. EDM is therefore the single buyer for power supplied by independent power producers (IPPs)[5]. Section 2.3 (overview of the power sector) covers EDM's perimeter and issues with IPPs.

The Renewable Energies Agency of Mali (AER-Mali) is a Public Scientific and Technical Establishment (EPST) with a mission to promote renewable energies for their large-scale use. It was created in 2014 (ordonnance No. 2014-012/P-RM). As a government agency of the DNE, AER's mission includes contributing to the definition of national energy strategies and monitoring the implementation of renewable energy projects for the benefit of stakeholders. AER-Mali is also responsible for evaluating the country's potential for renewables, informing and educating promoters and users of renewable energy equipment and developing and strengthening their capacities, testing, quality controlling and labeling of renewable energy equipment, and conducting studies. AER-Mali acts as a research institution who looks to test innovative new technologies and business models. Once proven, these successful models are then replicated at scale by the Agence Malienne pour le Développement de l'Energie Domestique et de l'Electrification Rurale (AMADER)/ Malian Agency for the Development of Domestic Energy and Rural Electrification.

The DNE's main agency for rural electrification is AMADER, which also serves as the energy regulatory authority outside of urban centers (e.g. verifying proposed tariffs for mini-grids, issuing permits for mini-grids, supplying electricity to rural areas through public-private partnerships (PPPs) etc.). It was created in 2003 (Law No. 03-006). AMADER works alongside EDM-SA and oversees the domestic energy sub-sector, as well as electricity access in rural and peri-urban areas. AMADER oversees collating necessary resources for feasibility studies and supervising the correct implementation of rural electrification programmes. AMADER therefore regulates and controls the developments within the rural electrification sector. Whilst on paper AER and AMADER's roles would appear distinct, in practice both organisations are involved in developing rural electrification projects, an overlap created as both organisations look to justify donor support[6]. These complications are covered in section 2.4 (overview of the off-grid sector).

The government has a third agency, the National Agency for the Development of Biofuels (ANADEB) mission who implements the national strategy for the development of biofuels. ANADEB will be shortly changing its name to the National Agency for the Development of Bioenergy. Since its establishment in 2008 (ordonnance No. 09-006/ P-RM), ANADEB is working on developing several bio-energies such as Jatropha oil. ANADEB has an MoU with AMADER for the pre-electrification of sites through the installation of equipment running on biofuels. This means that ANADEB and AMADER often end up closely working together despite having two completely distinct approaches and business models with regards to rural electrification.

The multi-functionality of these platforms has been one of the key problems to the effective development of the mini-grids market in Mali.

At the Bilateral and Multilateral Cooperation level, there are several actors active in the energy sector in Mali: the World Bank, the African Development Bank (AfDB), the Agence Française de Développement (AFD), the European Union, the German Society for International Cooperation (GIZ) etc. For a full description of the actors involved in the energy sector in Mali, refer to section 4.3 Stakeholder directory.

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5 Elements of EDM's monopoly are due to change under the pending reforms.

6 Reviewing the multiplicity and overlap of government agencies was another objective of the PAPERM work and the object of another ordonnance that has been amended.

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

Whilst each government actor within the sector has a given mission, it became evident that the sector needed to be harmonised and the mission of the multitude of actors revisited. The AfDB commissioned Tractebel to review and update a number of key energy policies and legislative and regulatory texts on behalf of the national Ministry of Energy and Water, under the PAPERM. Though Mali has several existing legal texts governing the energy sector, these are no longer suitable to the current context (new energy needs, growing demand, need for harmonisation of the sector etc.), and in nearly all cases stakeholders agreed that the existing texts were largely defunct. Current work led by the AfDB and carried out by Tractebel through the PAPERM focuses on a review of most of the national policies and strategies governing the energy sector in Mali.

Table 2. Policy, legislative and regulatory texts of the energy sector currently under revision

Policy, legislative, and regulatory framework	Description
La Politique Energétique Nationale (PEN)/ National Energy Policy	Mali's energy sector is governed by the PEN, adopted in 2006. The overall objective is to contribute to the country's sustainable development through the provision of affordable energy services in order to increase access to electricity and promote of socio-economic activities. The PEN was subsequently revised in 2013, spelling out the Policy's objectives of "developing new and renewable energies to reduce the share of thermal heat production and ensure access to energy for all".
La stratégie nationale de développement des énergies renouvelables/ National Strategy for the Development of Renewables	Adopted in 2006, the strategy is aimed at: (i) promoting the widespread use of RES technologies and equipment to increase the share of RES in national electricity generation; (ii) developing the biofuel sub-sector for; (iii) creating better conditions to sustain RES services; and (iv) searching for sustainable and suitable financing mechanisms for RES. Subsequently a Renewable Energy Action Plan 2013-2033 has been developed with the objective of "increasing the share of Renewable Energies in the energy balance from 1% to 10% by 2033".
La stratégie nationale de développement des biocarburants/ National Strategy for the Development of Biofuels	The National Strategy for the Development of Biofuel was adopted in June 2008 and it aims, firstly, at enhancing affordable local energy production through the development of biofuels to meet the country's socio-economic needs. Secondly, it aims to reduce the country's dependency on oil imports.
La stratégie nationale pour le développement de la maitrise de l'énergie 2010/ National Strategy for the Utilisation of Energy	The strategy issued in 2010 looked at ways to manage energy consumption, including an optimisation of the electricity generation mix (through a greater proportion of renewables).
l'Ordonnance N°00-09/P-RM du 15 mars 2000	This decree is the core of the electricity market in Mali, laying down precise rules for its application.
l'Ordonnance N°00-021/P-RM du 15 mars 2000	This decree established the national regulator CREE.

The Strategic Framework for the Economic Recovery and Sustainable Development of Mali (CREDD) 2016-2018 is at the heart of all development policies in Mali, including the Strategic Framework of Growth and Reduction of the Poverty (CSCRP) 2012-2017 which aims to make renewable energy the country's main energy source. In addition to the above, other policies and strategies have been developed which are more or less linked with the sector, including **the Strategic Framework for a Green and Climate Resilient Economy** (EVRCC) for the 2025 horizon, which advocates, among other things, the development of renewable energies (solar, wind, bioenergy, etc.) and the improvement of energy efficiency. It would be beneficial to see the EVRCC lead to a comprehensive strategy and a related investment plan like the SEforALL Investment Prospectus; and the **National Climate Change Strategy** (SNCC) with a 2012-2017 National Climate Action Plan.

AER-Mali is currently working with the International Renewable Energy Agency (IRENA) on the Renewable Readiness Assessment (RRA) for Mali. The RRA is a country-led consultation process developed by IRENA to determine appropriate policy and regulatory choices and ensure the broadest possible buy-in from stakeholders.

2.3 OVERVIEW OF THE POWER SECTOR

2.3.1 CONTEXT

EDM is the main actor involved in the power sector, responsible for power generation, transmission and distribution in urban and peri-urban areas. Generation is open to competition, although there is currently only one state-owned IPP, Sogem. The generation market is concentrated.

Progress has been made in increasing access to energy in Mali, with access to modern energy services reaching ~40.5% nationally in 2017 (IEA, 2017). The electricity access rate is ~83.1% in urban areas. Electrification in rural areas is still low, but grew from 1% in 1995 to 17% in 2017, mainly through the deployment of diesel-backed mini-grids operated by private local players (Climatescope, 2018). The government is aiming for 70% access rate to electricity by 2036. Approximately 10% of rural energy services are provided using RES, including mainly small-scale applications such as Solar Home Systems (SHS) (AfDB, 2015).

2.3.2 GENERATION

The electricity generation mix has considerably shifted over the years from hydropower dominated generation to a near even split between hydropower and fossil thermal power. The latter has seen an annual average growth in production of 15.8% driven by growth in demand, met by a combination of electricity imports from neighbouring countries and domestic diesel-based electricity generation. Going forward, the share of imports will continue to increase as demand increases faster than local supply can cater for. It is important to note that Mali imports 100% of its hydrocarbon fuels.

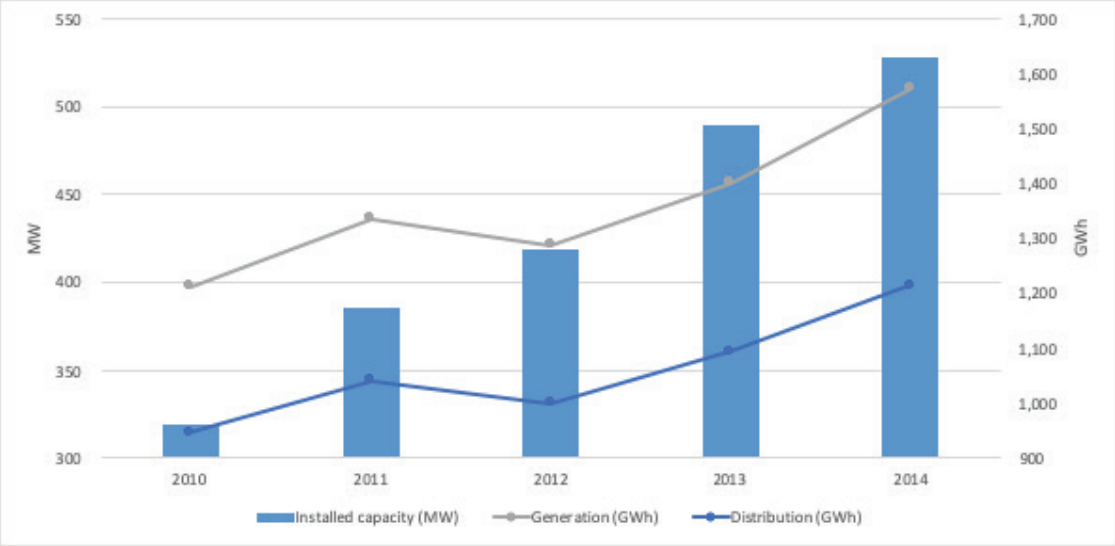
Table 3. Evolution of the electricity generation mix 2005-2015, (CREE, 2015)

	2005		2015		2020[7]	2025[7]
	GWh	%	GWh	%	%	%
Hydro	642	79.8	766	44.8	25.5	18.4
Thermal	161	20.0	700	40.8	26.3	38.1
Imports	1.9	0.2	247	14.4	45.8	41.3
TOTAL	**804**		**1,712**			

Electricity generated (including imports) amounted to 1,773 GWh in 2016 (up from 1,712 GWh in 2015), with an average annual growth rate of 7.8% between 2005 and 2015 (CREE, 2015). In 2018, generation was forecasted at 2,197 GWh. Of the 1,773 GWh generated in 2016, only 586 GWh (33% of the total) was generated by the main electric utility EDM. The remainder (including hydro) was supplied by local electricity companies (OMVS) and imports from the interconnector with the Ivory Coast (Tractebel, 2018). With regards to Independent Power Producers (IPPs), the hydro power station in Manantali, run by the state-owned Société de gestion de l'énergie de Manantali (SOGEM) was the most important contributor, supplying 26% of all electricity across the interconnected network. On the other hand, supply from isolated (off-grid) centres has only marginally increased over the 2005-2015 decade, passing from 94 GWh to 118 GWh. Looking ahead the government anticipates total generation of 6,057 GWh by 2025, requiring a 254% increase in generation capacity (CREE, 2015).

7 Solar PV is expected to account for ~2.5% of the energy mix in 2020 and 2025

Figure 4. Installed capacity, generation and distribution, historical data 2010-2014



Source: CREE from EDM data

Renewable power generation on the interconnected network is entirely from hydropower and amounted to 766 GWh or 66.2% of total generation. Grid-scale renewable capacity (excluding hydro which accounts for 40% of the current capacity) was negligible as of 2014 but it is expected to grow to around 4% by 2019/20. The country's target for 2020 and 2030 is also 60% of the total capacity, hydro included, with an increasing share planned for PV (Climatescope, 2018). EDM has had historical difficulties with renewable energy IPPs, especially linked to complicated tariff negotiations. The only grid-scale clean power plants commissioned since the 1980s are two hydro plants developed by Sogem, the only IPP in Mali (Climatescope, 2018). According to EDM, one of the principal issues is price increases between the signature of the convention and the actual provision of electricity[8].

Installed capacity has increased by 8.1% year on year from 2005-2015 (8.1% on the interconnected network and 7.8% on the isolated centres) (CREE, 2015). The estimated installed capacity of the network was 590MW in 2016, composed of hydro (37.7%) and thermal (62.3%). It is estimated however that in 2016 only about 250MW was available, principally due to lack of maintenance of existing generation facilities (World Bank, Mali Electricity Sector Emergency Project (MESEP), 2018). The largest hydro-dam in Mali is the Manantali dam, which is run by SOGEM. SOGEM is a public entity part owned by the governments of the OMVS (Organisation pour la Mise en Valeur du Fleuve Sénégal), which also runs the Felou hydro dam. Approximately half of the dams capacities are exported to neighbouring countrues (e.g. Manantali is a 200MW dam, of which 104MW is 'retained' by Mali).

To date there is an electricity generation capacity deficit of ~150MW due to rising electricity demand. Electricity demand met by EDM-SA, the state-owned utility, increased by 10% year on year (or 7.8% year on year between 2005 and 2015 due to the 2012 crisis). In 2015, EDM was providing energy to ~400,690 connections, up from 160,200 in 2005 (CREE, 2015). This rise in demand is due to urban expansion and population growth, activities in the mining sector, and a rise in SMEs amongst others. According to estimates, meeting the current deficit will necessitate an increase in available capacity by around 7% on average a year. Therefore, the additional electricity generation capacity required over the next decade is estimated at 450MW.

8 One example is the Segou solar project. The project was initially supposed to be developed in the Mopti region, but following a political and security crisis in the country it was moved to Segou. The IPP that had signed a convention with EDM incurred a considerable delay in providing electricity. In the meantime, prices of PV have evolved and the IPP has been reluctant to adjust the selling price of electricity according to market factors. To date a new agreement has been signed and the project is in its starting phase.

Table 4. Evolution of the number of EDM electricity subscribers from 2012 to 2016

	2012	2013	2014	2015	2016
Low voltage	288,382	311,952	345,141	398,760	460,696
Medium voltage	1,660	1,669	1,837	1,930	2,065

Source: (INSTAT, Annuaire Statistique Mali, 2016)

Table 5. Forecasted growth in demand, 2020-2035

	2020	2030	2035
Electricity consumption (GWh)	3,140	5,461	7,024
Capacity (MW)	416	1,031	1,344

Source: (Tractebel, 2018), from Artelia forecasts

2.3.3 TRANSMISSION AND DISTRIBUTION

The national network in Mali is composed of a so-called interconnected network, connecting 35 localities including the capital Bamako[9], of 33 isolated centres of autonomous generation and distribution[10], and of two centres connected to Ivory Coast's medium-voltage network. The interconnected network provides 87% of the installed power capacity (CREE, 2015). Isolated centres are generation centres that are not connected to the main interconnected network. The interconnected network on the other hand is constituted of different transmission and distribution networks which are connected to each other via one or more interconnectors.

Table 6. Key transport and distribution network figures (2016)

	2012	2013	2014	2015	2016
Length of transport network (km)	1,200	1,329	1,589	1,366	1,477
Length of distribution network (km)	5,316	5,439	5,468	6,895	7,888
Density of transport network (m/'000 people)	74	72	79	77	79
Density of distribution network (m/'000 people)	326	333	316	387	423

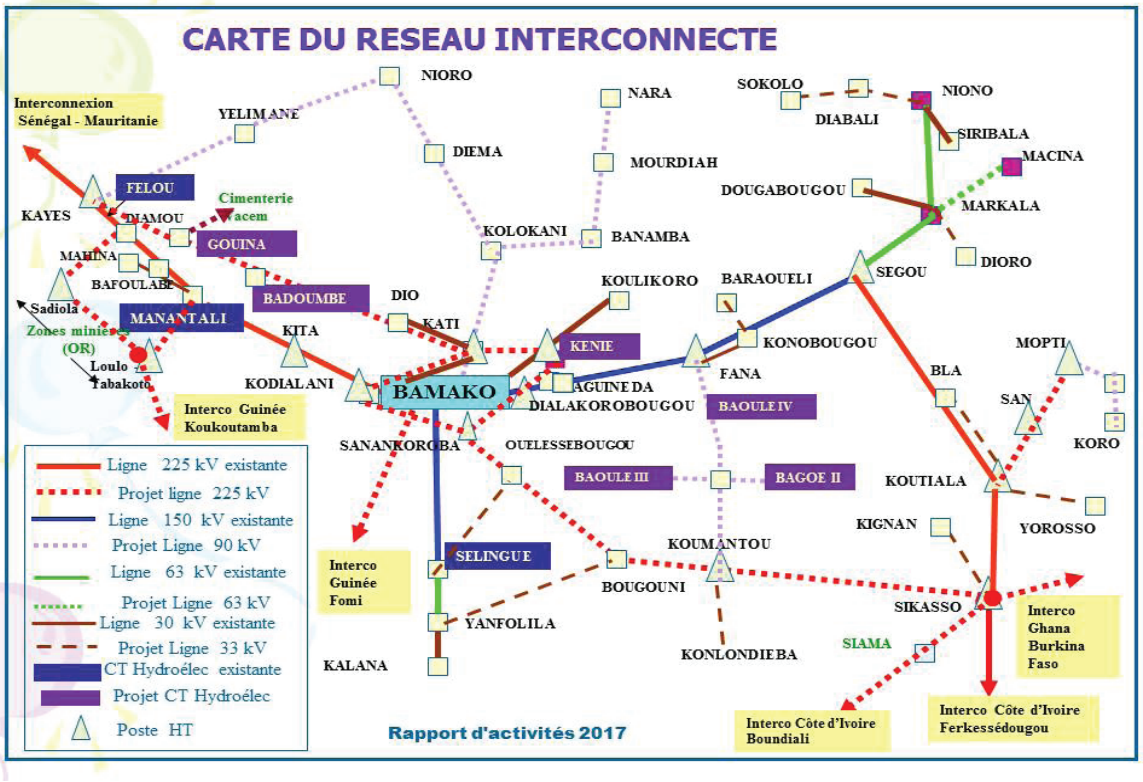
Source: (INSTAT, Annuaire Statistique Mali, 2016)

Figure 5 below gives an overview of the existing interconnected power network and its assets. Table 18 in the Appendices presents the number of electricity subscribers for each of the isolated centres.

9 The interconnected network feeds the capital Bamako and the cities of Kati, Koulikoro, Fana, Dioïla, Ségou, Pelengaga, Sebougou, Markala, Sélingué, Kayes, Kita, Yanfolila, Kangaré, Manantali, Bafoulabé, Mahina, Konobougou, les villes en périphéries de Bamako (Moribabougou, Kalabancoro, Baguineda, Sanakoroba, Tienfala, Banankoroni), Kalana Koutiala Sikasso, Niono, Sansanding, Molodo, Kambila, Dio, Dougabogou, Baraoueli et Siribala.

10 The isolated centres are essentially diesel mini-grids that serve the following cities: Bougouni, Mopti, Sévaré, Djenné, Gao, Tombouctou, San, Kangaba, **Ouélessébougou**, Bandiagara, Douentza, Diré, Niafunké, Goundam, **Tominian**, Kidal, Nioro du Sahel, Ké-Macina, **Koro**, **Bankass** et Gourel (alimenté par Nioro du Sahel), **Nara**, **Diéma**, Téninkou, **Siby**, Bla ,Bourem, **Ansongo**, Menaka, Yelemani, Kolokani. Eight of the aforementioned sites are hybrid solar PV sites (in bold).

Figure 5. Map of the interconnected network (EDM SA)



Eight isolated centres are hybrid, and there is potential for the hybridisation of others.

Table 7. Hybrid isolated centres of autonomous generation and distribution

Region	Isolated centres	Power PV (kWc)	Battery (AH)	Thermal capacity (kVA)
Kayes	Diéma	646	2 x 1,400	1,325
	Nara	646	2 x 1,400	1,325
Koulikoro	Ouélessébougou	334	2 x 1,400	650
	Siby	30	-	150
Ségou	Tominian	265	2 x 1,400	650
Mopti	Koro	384	2 x 1,400	650
	Bankas	384	2 x 1,400	650
Gao	Ansongo	384	2 x 908	650
	Total	**3,073**		**5,950**

Source: EDM annual report 2017

At present, the AFD is providing relatively large sums of aid for a grid reinforcement project (€80m +€26m for interconnector reinforcement with the Ivory Coast), and is investigating the potential to reinforce the high voltage network around Bamako (potentially worth another €85 million). Page 24 covers World Bank funded on-grid projects in Mali. Section 2.4 (overview of the off-grid sector) provides an extensive treatment of donor funded programmes in the country regarding off-grid and rural electrification.

System outages have increased in recent years in both frequency and duration. Total losses (including technical and non-technical losses) increased from 19.6% in 2011 to close to 22.5% in 2018, mainly due to aging overloaded equipment, and weak customer management capacity (World Bank, Mali Electricity Sector Emergency Project (MESEP), 2018). In 2015, around 91.7% of interruptions were due to network failures, whilst only 8.3% were planned interruptions. The World Bank is currently looking into reducing both technical and non-technical network losses, and as part of this ambition is financing EDM to replace all meters of the largest consumers (the 20% consuming 80% of the country's energy consumption) with smart meters with remote monitoring.

Between 2005 and 2015, the grid had an annual expansion of 5.9% on average, reaching nearly 8,000 km in 2015. In 2025, it is estimated the network will reach 11,133km (low voltage network) (CREE, 2015). An economic and financial model (MEF-ELEC) estimating the expansion of the grid had modelled a high increase in electrified localities between 2015 and 2018, of ~15 localities a year. According to the same estimates, around 60 new localities would be electrified by 2025, reaching 113 localities electrified in 2025 (by EDM).

MEF-ELEC calculations predict the average annual growth rate of the low voltage network to be 8.6% to 2025. The high- and medium-voltage network should see an evolution of: 2,921km of HV of which 2,071km of 225kV and 846km of 90kV; 4,276 km of MV of which 540km for the extension of the Bamako network and 3,736km for the extension of the network outside of Bamako. Between 2005 and 2015, sales of energy augmented by an annual average of 7.96%. The number of electricity subscribers (within EDM's perimeter) reached 400,690 in 2015, for a total of 1,327GWh. It remains unclear how realistic these expansions plans are given EDM's delicate financial situation. A table showing the proposed network extension by voltage is provided in the Annexes.

The average price of electricity charged by the state utility EDM is 98.3 FCFA/ kWh or $0.17 / kWh (with average tariffs of 105 FCFA/ kWh or $0.18 / kWh across its low voltage network, and 77 FCFA/ kWh or $0.14 / kWh across its medium voltage network). However, EDM's cost of generation is higher, averaging at 101 FCFA/ kWh or $0.18 / kWh, and its operating cost even higher than that, at 147 FCFA/ kWh or $0.26 / kWh (Tractebel, 2018). This equates to an average cost of electricity service to the end users of $0.25/ kWh (or ~142 FCFA/ kWh) (World Bank, Guinea-Mali Interconnection Project (P166042), 2018).

Despite being officially set by CREE, electricity tariffs are extremely political in Mali. In the tariff setting process, EDM suggests tariffs to CREE who is in charge of verifying the proposed tariffs (in areas covered by EDM's concession perimeter, otherwise the verification is done by AMADER). CREE works alongside a technical working group that brings together all key players in the sector, including the DNE. A simulation of costs is made which results in, as a minimum, three scenarios. Based on those, CREE publishes a directive in the official journal, suggesting an appropriate level of subsidies and tariffs. In practice however, the government has the final say, and often very high tariffs are applied which could not have been the results of the three scenario modelling.

There are a number of complexities associated with tariffs setting in Mali. Firstly, urban and rural tariffs are highly polarised; prices charged under the EDM network and the AMADER installations raise questions of inequality, with prices in rural areas being considerable higher than those that EDM is allowed to charge[11]. This creates tension as local communities are aware of these differences in prices. Energy prices are indeed often used as a political tool, and any increases need to be done carefully given the risk is likely to cause civil and political unrest. Whilst it is understandable that a level of subsidy is necessary, it is key to shed light on the determination of that level. The World Bank is suggesting a progressive increase in tariffs to reduce subsidies, as well as a clear distinction between operation subsidies and investment subsidies (Tractebel, 2018).

CREE is commencing a study on the harmonisation of tariffs to be completed by end 2019. There has been no substantial tariff adjustment since 2004, with only very limited increases in 2009 and 2014. The review comes in light of the political and economic stakes of the energy sector, and of the price difference in rural and urban areas. One of the objectives of the study, as part of this social equity vision, is to investigate the potential for a cross-subsidisation mechanism to ensure costs can be more equitably borne between rural and urban areas, and between small/ medium households and large consumers. This would also have the advantage of reducing the large price differential between rural and urban environments. The World Bank has expressed an interest in bringing forward this study, yet considering the current precarious financial situation of EDM it remains unclear where this cross-subsidy would be sourced from.

11 The price of existing mini-grids is estimated at between 250 FCFA/ kWh ($0.44 / kWh) and 280 FCFA/ kWh ($0.49 / kWh), compared to an urban price charged by EDM in the region of 130 FCFA/ kWh ($0.23 / kWh).

Given the disparity between sale and production prices, EDM remains loss making and is heavily subsidised by the state. EDM suffers from high generation costs due to imports of hydrocarbons, and high technical and commercial losses. Losses can reach 22.5%, of which around 10% can be attributed to technical issues (Tractebel, 2018). According to recent World Bank figures, EDM was losing $0.06/ kWh in 2016 (with an average cost of service reaching $0.23/ kWh and an average pre-subsidy revenue at $0.17/ kWh). This translated into a total loss of $100 million in 2016**.**

Further, EDM is unable and unwilling to charge cost-reflective tariffs, and as such, it is estimated that in 2016 EDM received subsidies for a total of $45.5 million in the same year, translating into a subsidy of $0.06/ kWh. It is estimated that government energy subsidies are equivalent to all government spending for the health sector in Mali. Due to liquidity challenges EDM has frequently delayed payments to fuel and power suppliers, including neighbouring countries such as Côte d'Ivoire (World Bank, Mali Electricity Sector Emergency Project (MESEP), 2018).

EDM's delicate financial situation is exacerbated by stakeholder issues and political interference. It is generally understood that several public sector organisations do not pay energy bills for their usage e.g. parliament, or the military. Further, where EDM has tried to minimise losses through non-payment by the introduction of pre-payment, and smart meters, EDM has been experiencing stakeholder pushback from those customers, often because of a perceived malfunctioning of the recharge systems.

EDM set up a new organisational framework in 2017 to restore its profitability as well as an emergency programme (*Le Programme d'Urgences Sociales d'Accès à l'Energie 2017-2020***) to improve the quality of the electricity supply and increase access to electricity in urban and rural areas of the country.** More detail is provided below in Table 8.

Table 8. EDM organisational framework and emergency programme

Organisational framework	Emergency programme 2017-2020
- Fight electricity thefts and create a new internal audit position - Strengthen strategic planning and reinforce the Studies and Strategic Planning Department - Optimise procurement of supplies, assets and fuel and set up a Procurement Department - Strengthen data security and create an Information System Department - Improve revenue collection and establish a dedicated Department - Phase out diesel rentals to increase security of supply	- Rehabilitation of several power plants: Sirakoro (56 MW), Balingue (33 MW), Sélingué (49 MW) and Sotuba (6 MW) - Rehabilitation and upgrade of transmission and distribution system - Improvement of billing and revenue collection - Increase in capacity of existing interconnection with Ivory Coast (from 40MW to 75MW) and Senegal and Mauritania (from 20MW to 60MW) - Replace all meters of largest consumers (20% consuming 80% of the energy) with smart meters with remote monitoring

The World Bank is supporting EDM to improve its operational performance through Development Policy Operations (DPO) and investment project financing. In the form of technical and financial assistance, the World Bank is working on the following programmes and initiatives:

- Le Projet d'appui au secteur de l'énergie (PASE)/ The Mali Energy Support Project which focuses on institutional support, rehabilitation of the distribution and transmission network of EDM, and expanding access to energy services offered by the EDM network[12];
- The IDA-funded Mali Energy Support Project, which aims to improve the access and efficiency of electricity services in Bamako and other targeted (grid-connected) areas in the country;
- Two regional projects to connect 100,000 households to the grid from regional substations and to promote off-grid access through Solar PV systems;
- A Public-Private Infrastructure Advisory Facility grant to the government to support the private sector participation in the energy sector in Mali;

12 Including the hybridisation of failed mini-grids that had been financed by the World Bank

- An ESMAP grant supporting the government to conduct a tariff and cross subsidy study (see paragraph below on CREE's study to be completed by end of 2019);
- A Global Infrastructure Facility operation to provide support to the development of hydro connected Solar Generation systems[13] in Mali; and
- A Mali Electricity Sector Emergency Project (MESEP) (P166796) to address the utility reform, management improvement challenges and support the Government in sector planning.

2.4 OVERVIEW OF THE OFF-GRID SECTOR

2.4.1 ENERGY ACCESS POLICY AND PLANNING

At present neither AMADER nor EDM have issued clear electrification plans to date. There is hence a need for a solid electrification strategy, which should ideally be put in place by the DNE.

To respond to the above challenges AfDB through the PAPERM programme is financing a substantial overhaul of the current energy policy landscape, delivered by Tractebel. The review looks at all actors of the Malian energy sector and their missions, at policies and regulatory mechanisms governing the sector, and at how to ensure renewable energy and rural electrification become an integral part of the policy landscape. Suggested revisions include a new target for rural electrification of 61% by 2033, as well as the new mechanisms such as net-metering, clear and simplified processes for connection to the grid, procedures for self-production, collection of surplus and limits to the energy being absorbed by the grid (Tractebel, 2018).

Figure 6. Examples of suggested revisions to the functioning of the off-grid sector as proposed by (Tractebel, 2018)

Grid code	Establish a grid-code to govern the technical conditions and procedures for connecting generation facilities to the main EDM grid. At the very least this should be done for renewables generation (Tunisian model). This will allow developers to have a clearer idea of the technical requirements to meet when developing their projects, such as the criteria under which EDM will allow connection to its network.
Net-metering	To be able to deduct from your consumption the energy injected into the network over an exact period of time, even if the consumption and the injection occurred at different points in time.
Concession areas	Concessions and authorisation for the construction of mini-grids could be allocated across the whole country, and legislation would establish the consequences of the grid arriving. The mini-grid operator could then either (a) sell its distribution infrastructure and generation to EDM, (b) sell its distribution infrastructure to EDM and become a producer selling electricity to EDM, (c) retain the ownership and management of the infrastructure, buying electricity at a wholesale price from EDM and re-sell it to subscribers at a regulated higher tariff, or (d) choose a combination of option (b) and (c).

A Roadmap for Rural Electrification (Plan Directeur d'Electrification Rurale 2007-2020 – PDER) has been in place since 2007, but is widely regarded as out of date. The first draft of the PDER was funded by the AfDB in 2005 and subsequently produced by LAHMEYER International. The PDER identified potential sites for development and divided Mali into multi-sector electrification zones (Zones d'Electrification Multisectorielle – ZEM). However, despite donor funding being available, private sector interest was limited, as evidenced in pilot tenders, mostly due to the very sparse distribution of the settlements within the identified regions. Instead, smaller, local diesel fuelled mini-grids were developed in agreement with local communities. Nevertheless today the Roadmap is widely regarded as out of date.

An Optimal Investment Roadmap (Plan Directeur des Investissements Optimaux 2014 -2035 – PDIO) is also in place to tackle rural electrification and develop the off-grid sector in Mali. The World Bank now aspires to finance a Least Cost Development Plan (Plan de Développement à Moindre Coût – PDMC) looking at densification and grid extension in the areas operated by the national operator, and aiming to support conversations within government to decide how to reach electricity access targets. At present however, there is no real clarity about where and what should be electrified.

13 Systems in which hydro and solar based hybrid power generation systems are connected to the utility grid.

From in-country stakeholder engagement and the review of the current energy policy landscape in Mali led by AfDB and Tractebel there are concerns about the relative responsibilities of all actors operating in the rural electrification sector in Mali. Whilst AMADER has the nominal responsibility for rural electrification, lack of agency funding means both it, and AER chase funding from donors to implement projects. Further, with a lack of clarity over on and off-grid environments, and political interference, AMADER is regularly pushed out by EDM.

AER, despite being created as a public institute with scientific character focusing on research, has become a developer of off-grid PV projects. Due to AER's considerably constrained budget, it has engaged with donors in quest for funding and has consequently become active in rural electrification, going above its original mandate. To date, AER concentrated its efforts on solar/ diesel hybrid mini-grids, but in future is aiming to trial hybridisation through wind or biomass.

Much of the rural electrification has been achieved by donor-funded programmes through AMADER, the government's rural electrification agency, which has implemented mainly diesel powered mini-grids in rural environments (96% of the total off-grid electricity generation). AMADER is the de facto regulator in rural and peri-urban areas, having a mandate to promote rural energy services and domestic energy provision. Whilst AMADER cannot implement and run a mini-grid itself, it can run the process of identifying sites, handing out the permits to exploit the site, and finding private sector concessionaires to run the projects. AMADER therefore supplies electricity to rural areas through PPPs, whereby rural electrification concessions are granted to private operators. In its time, AMADER created around 100 mini-grid projects (all diesel).

Despite this, today there is uncertainty regarding the number of mini-grids in Mali, although AMADER itself estimates ~160 mini-grids in 2015 with a combined capacity of around 15 MW. Unfortunately, it is not clear what proportion of mini-grids are still operational to date, though private sector stakeholders suggest that as few as 30 could still be operational. The reasons for installations ceasing operation are many, including poor installations, the limited technical experience of installers and operators, a probable lack of maintenance linked in part to the operators' difficulties in recovering revenues from subscribers, as well as a lack of organisation and skills of the personnel operating mini-grids. In addition, mini-grids have historically been 'gifted' for operation, with zero cost-sharing contribution. Table 12 on barriers to mini-grid deployment expands on the issue aforementioned.

In an effort to address the shortcomings of historical mini-grid installations, AMADER and donors are increasingly looking at a programme of hybridisation. The AFD, World Bank and AMADER are working collaboratively to revive the backlog of non-operational projects through hybridisation under the SHER (World Bank) and PHARE (AFD) programme. Through these programmes, the diesel installations are being supplemented with renewable technologies such as solar as well as storage to create hybrid mini-grids (~32 at present) (PwC, 2016). Recently, ECREEE, in partnership with NEPAD and the AfDB, completed a pre-feasibility study on 97 mini-grids (called PERSHY) to assess the potential for hybridisation. AMADER is now using this study to progress a hybridisation programme. AMADER hopes that the deployment of renewable into these environments will permit lower prices to rural end users.

The Rural Electrification Hybrid System Project (SHER) is a ~$45m project aimed at funding the reactivation or hybridisation of up to 50 mini-grids, implemented by AMADER and supported by the World Bank. Funding covers the cost of the new solar and storage plants, with operators expected to fund as little as 5% of capital cost to connect the plant to the existing network and expand connections. The sites have been proposed by AMADER, upon a review of existing sites, coupled with an analysis of local levels of economic activity. Due to not having a clear roadmap for rural electrification in place, it is understood that the selection process has been problematic. Further, of the final proposed list, some sites have subsequently been taken over by EDM for political reasons[14] so the final number of sites to be rehabilitated is presently 48. AMADER tendered a contract for a design engineer, who has now completed a review of the sites and developed technical terms of reference for PV installation. Tenders have been issued, and awarded for the installation

14 Under a number of occurrences EDM took over AMADER run sites (the concession act is a fluid and often re-written document). It appears that this is predominantly fuelled by political interference (rather than EDM itself) as local politicians, to obtain local support, encourage EDM to take over the site to improve supply service and reduce prices.

phase, and sites are being rehabilitated[15]. Nearly all of the sites have pre-existing operators in place, who have seen their contracts renewed to manage the new hybrid installations, after having been trained by the installer. Surprisingly, the existing operators have for the most part not been involved in the hybridisation process themselves; despite several of them having the required capacity to conduct the hybridisation, and having applied to AMADER's installation tenders. It remains unclear why this route was chosen, although operators have suggested that this may be related to political relationships or price, as AMADER hopes to reduce and therefore control rural pricing through the hybridisation programme.

A very similar project to SHER is the AFD funded PHARE project that will finance the hybridisation of, it is hoped, a further 60 sites. This project has an investment component (the hybridisation of mini-grids), as well as a technical component that aims at reinforcing AMADER's capacities. It is currently at an earlier stage, and as such, AMADER is in the process of hiring an engineering consultant to undertake the project feasibility studies for all the identified sites and thereafter develop the TORs and tender materials. The consultant will not only run the procurement process but will also manage the sign-off of projects following construction. This is to respond to concerns around the transparency of the contracting process of potential operators of the sites. As per the PHARE project, the lack of a clear rural electrification roadmap resulted in a lengthy exchange between AFD and AMADER, with the latter often being unable to explain the reasoning behind the selection of the sites. In this occasion, too, sites previously selected were then 'taken over' by EDM, forcing AFD to restart the process.

Another hybridisation project developed through AMADER, called PERSHY-32, is jointly funded by the Abu Dhabi Funds and the Arab Bank for Economic Development in Africa (Banque Arabe pour le Développement Economique en Afrique – BADEA)[16]. It aims to electrify 32 sites through hybrid solar mini-grids (22 new mini-grids and 10 hybridisation schemes). The project has a total cost of 11.83 billion FCFA over three years (~$20 million). There's been a call for installers to hybridise the 10 sites, and, contrary to SHER, one operator has won the right to install his own plants on site.

In addition to the hybridisation programmes, AMADER aims to progress a strategy of larger projects, and as an example is developing an electrification project that will see 24 communities electrified by two large-scale solar plants (~1.5MW each). The project is expected to cost 10 billion FCFA and will be funded primarily (8.85 billion FCFA) by the Banque Islamique de Développement (BID)/ Islamic Development Bank. AMADER will go to market to identify an engineering consultant to run the development process, prior to issuing tenders for operators to run the schemes. Expected timeframes for execution are 2018-2020. It is hoped that larger projects will lead to larger networks and power plants which can eventually be connected to the main grid when it arrives. This is approach has been developed alongside the National Electricity and Water Office in Morocco, who provided technical assistance to AMADER.

As previously mentioned, AER-Mali has also been developing off-grid electrification programmes with donors, with a particular focus on solar. Amongst its main projects is PENRAF (Projet Energies Renouvelables pour l'Avancement des Femmes), a renewable energy project implemented by UNDP of two 40KW solar power plants with traditional meters providing electricity to 80 households as well as community spaces and boutiques. The project was developed to empower women and advance the economic use of energy as each plant is connected to ~ten micro-businesses such as welding studios / agricultural equipment workshops.

Another large AER- Mali project is PASER-K (Projet Accès aux Services d'Energies Renouvelables à Kita). This $4.7m project, led by Plan International Mali and co-financed by the European Union, includes: 10 solar pumping systems, 30 solar kiosks, 60 solar street lights, 30 solar mills, 60 solar dryers, 5 solar water heaters, 4 solar fridges, 24 solar school lighting kits, and 8 solar lighting kits for the health centre of Kita. AER, in collaboration with Akuo Energy, also installed

15 The total cost of the first 17 conventions signed is ~2.65 billion FCFA (80.1% government, 17% private operators and remaining contribution from beneficiaries).

16 In addition to PERSHY-32 (Abu Dhabi Funds and BADEA) and the PERSHY-97 (ECREEE) projects, AMADER is developing further hybridisation projects: (1) a rural hybridisation electrification project financed by KFW and covering 14 localities; (2) a rural hybridisation electrification project financed by the BID which looks at 19 localities

a 50 MW solar farm in Kita, with an annual power supply equivalent to 91,702 households. The PEVES project (Projet d'Electrification Villageoise par Système Solaire) also provided 300 solar lighting kits, 4 solar pumping systems and 150 solar street lights in several villages.

AER-Mali and the Global Environment Fund have also launched a project to promote the productivity of renewable energy in rural areas of Mali thanks to hybrid technologies (Promotion de la Productivité de l'Electricité Durable dans les Zones Rurales du Mali), implemented through UNDP. The project aims to reduce greenhouse gas emissions by promoting hybrid solar PV mini-grids. It is a four-year project, spanning from May 2017 to 2020, costing ~$25million and covering 15 towns across the Kayes, Koulikoro, Ségou, Sikasso and Mopti regions each with a population in the range of 500 to 2,000 inhabitants. The project however has acquired a considerable delay in executing set activities due to a very slow set up of the required governance structures.

AER is also exploring the opportunity for an electrification project of 70 villages, subject to financing from the Green Climate Fund within the West African Development Bank (WADB). The WADB has conducted a study on the potential of economic activities in the villages (based on the concept of productive use of energy) for installations of 50-200kW. The project shall include micro-finance for economic activity development. The studies, which at present are not available, are based on previous work undertaken by AMADER and covering key indicators such as population density of the villages and other socioeconomic indicators. However, concerns have been expressed on the accuracy of the information provided in those studies.

Mini-grid operators and developers are reunited under the Association des Opérateurs Privés du secteur de l'Electrification Rurale (OSER)/ Association for Rural Electricification Private Sector Operators. OSER counts ~71 members, of which ~60 are actively engaged in the association. The association works to safeguard the interests of its members, and to try and find solutions to key barriers such as access to financing and the poor ability to pay of consumers. OSER works in close collaboration with AMADER, who serves as their interface to the government and DNE in particular.

2.4.2 Licensing

Electrification projects are licenced as a function of size, falling under declaration, authorisation and concession regimes as a function of the size of the project, yet in practice, the thresholds are not always being respected. This is because experts believe the current permitting limits are too small. Under 50kW the site is regulated under the declaration regime, from 50kW to 250kW under the authorisation regime, and from 250kW and above under the full concession regime. In practice, declaration and authorisation licences are being assigned to way larger projects. Part of the reason that the limits are relatively small is that at the time of them being set, off-grid projects were not really a consideration, and therefore the legislation was designed to control on-grid projects (and prevent connection of larger, destabilising projects).

As part of the review of the PEN, Tractebel is currently suggesting increasing these thresholds to 100kW for sites falling under the declaration regime, and 5MW for sites regulated under the full concession regime. For distribution (medium voltage and higher) and transport operators will be regulated under the concession regime.

Table 9. Generation licenses as per the Ordonnace N°00-019/P-RM 2000 and Tractebel's review of the documents

	Ordonnance N°00-019/P-RM 2000	**Tractebel review**
Declaration	P < 50 kW	P < 100 kW
Authorisation	50 kW < P ≤ 250 kW	101 kW < P ≤ 5 MW
Concession	P > 250 kW	P > 5 MW

Table 10. Explanation of the three different utilisation licenses

Declaration	Declarations must be submitted to the Ministry in charge of energy, alongside an environmental impact assessment. For solar PV plants below 10 kW, purchasers and users must complete a simplified form available from CREE. Resellers of PV solar installations below 10kW are obliged to have their customers fill out the form. Any application for a site with generation capacity below 5 kW or 10 kW will be subject to a simplified procedure based on a simplified form provided by the Ministry.
Autorisation	Authorisations for projects that fall within an area serviced by the main grid are issued by the Minister. Authorisations for mini-grids in areas not serviced by the main grid are issued by AMADER. The decision to grant an authorisation includes the basic terms of the operating license and in particular its purpose, duration and geographic coverage. Any significant increase (> 10%) in the power capacity of the site must result in a new authorisation request. Should the increase exceed the generation limits mentioned above, then the operator will need to request a concession.
Concession	Concessions of generation, transport, and distribution are awarded by the Ministry of Energy following a public tender procedure, or on the basis of unsolicited applications whose terms and criteria are specified by decree. Concession contracts enter into force upon signature by the Minister in charge of energy or by AMADER for mini-grids Separate or joint licenses may be granted for the generation, transmission and distribution of electricity. The same operator may hold authorisations or concessions for the three activities. The same generation, transmission or distribution concession may cover several production centers, several transmission networks or several distribution networks.

When operators work on a single site instead of electrifying an entire community they are considered as auto-producers. Normal licences cover a 'commune', or collection of households. Where a project services a single site (even with multiple customers), it is considered 'auto-production' and operators do not need an authorisation. The maximum installed capacity of the asset needs to be $P \leq 50$ kW for a free installation, or 50 kW $< P \leq 250$ kW for a declaration of auto-production. Whilst they have to be declared to AMADER, auto-producers are not subject to permitting. They can set their own tariffs which are not under obligatory review from AMADER as is otherwise the case for operators having received a declaration, authorisation or full concession license. Auto-production is therefore not considered as a public service but as a private property, and certain operators have adopted this as a practice to avoid licensing requirements.

Generation licences give operators an exclusive right of exploiting the site over the timeframe of the license. Further, the operator has also the right to be indemnified should his right to supply be affected due to reasons outside of his control. Other operators however can file a request to become active in the area if the existing operator has not yet started to equip the area for connection to a mini-grid. Once the competitor issues an expression of interest, the existing operator has approximately six months to begin works in order to maintain his license, if on the other hand this six months period elapses, the competitor will likely be given a license to operate on that site.

A lack of clarity between on and off-grid operation is an active hindrance to the market, causing uncertainty for donors, operators and government institutions alike. The geographic zones defining the concessions of AMADER and EDM are contained within the Concession Act, and these appear to be relatively well demarcated at first glance. Within this demarcation, electrified population centres were assigned to EDM, whilst rural areas were given to AMADER. However it is important to note that even in unserved areas, isolated population centres were assigned to EDM, whilst the surrounding areas were assigned to AMADER. In practice however, when AMADER came to set up mini-grids in rural environments, it

simply couldn't electrify the surrounding areas without covering the central village, more often the home of the local chief, for project viability and political reasons. Therefore, a considerable number of AMADER developed sites (which are run by independent operators) are technically on EDM concessions.

Irrelevant of the original concession allocation, there further seems to be prevalent practice of EDM taking over AMADER run sites. In cases where technically the site may be in AMADER's concession, stakeholders report that the concession agreement is simply amended by central government to allow EDM to take over the sites. For local residents, this is very attractive, since this means electricity provision is typically taken from a few hours a day to 24/7, and the price is dropped from the rural AMADER levels to EDM's heavily subsidised price[17]. Running these mini-grids 24/7 becomes extremely costly for EDM, and local rehabilitation is often needed. Additionally, as these sites are in rural environments, they are often not subsequently grid connected with EDM's arrival. AMADER does not appear to know how many sites have been affected, but stakeholders estimate that it could be as many as 30 mini-grid sites to date.

2.4.3 MINI-GRID TARIFFS

Despite not being sufficiently cost-reflective according to operators, rural tariffs are considerably higher than urban EDM tariffs, reflecting the lack of equivalent subsidy, and higher infrastructure and fuel transportation costs. The considerably higher rural tariffs than the price paid by grid-connected customers has been a limiting factor to the development of mini-grids in Mali (PwC, 2016). The price of existing mini-grids is estimated at between 250 FCFA/ kWh ($0.44 / kWh) and 280 FCFA/ kWh ($0.49 / kWh), compared to an urban price charged by EDM in the region of 130 FCFA/ kWh ($0.23 / kWh). These high tariffs are unaffordable for many in rural environments, and the differential is extremely politically sensitive, often exploited by aspiring politicians.

Rural electrification is at present the exclusive mandate of AMADER. Given that the CREE does not have mandate beyond EDM's concession, AMADER has the defacto regulatory right to set prices. Operators can propose certain prices to AMADER for approval as part of their business cases for operation or development of a mini-grids. In practice however, operators have confirmed that AMADER suggests price points based on recommendations from third-party consultant engineers whom AMADER typically hires to develop mini-grid business models. This is for instance what will happen with the 22 new mini-grids sites being developed under the PERSHY-32 hybridisation project. This means that tariffs often vary from one area to another, based on the potential economic activities of the villages. For example, in Kegneba which is a mining zone the tariff is 250 FCFA/kWh ($0.44 / kWh) and in Loloni (mainly an agriculture area) the tariff is 220 FCFA/kWh ($0.38 / kWh). Unfortunately, operators have argued that the preferred revenue models by AMADER are often based on out-of-date data, or inaccurate load factors, meaning that AMADER's price expectations are lower than those of operators. This is one of the causes for operators struggling to operate sites in the past[18].

In addition, competition for projects and the political sensitivity of headline tariffs means that developers often choose to bid too low. This results in operators running the project until the diesel generators fail, or until the price of fuel rises too high, as there's no scope to cover maintenance costs within the pricing, whereupon they are forced to stop the service. AMADER is hopeful that the hybridisation of the country's mini-grids will allow for a reduction in tariffs, yet local operators have expressed doubts over this and hope for a regulatory change.

Under the institutional review of the energy policy being developed by Tractebel, CREE's jurisdiction would be extended to rural electrification, and as such, CREE would validate mini-grid tariffs. At present, this is done by AMADER with no involvement from the regulator. It is key that CREE's role evolves under future legislative texts to ensure better, evidence-based coherence of prices charged to consumers. Whilst in theory a contract with AMADER does allow for renegotiation of tariffs, this does not actually include adjustments based on fluctuations in the price of fuel or inflation. The World Bank funded study on cross-subsidising rural tariffs from urban tariffs is a precursor to this proposal.

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17 This is an indication that mini-grids don't perform well, that they charge expensive tariffs and operate for only limited hours.

18 SOFRECO, under the PAPERM project, will likely be developing tariff calculation models.

2.4.4 SUBSIDIES AND INCENTIVES

Mini-grids project are, per national legislation, supposed to be able to claim finance through the Fond d'Electrification Rural (FER, Rural Electrification Fund) through which AMADER is able to provide an 80% capital subsidy for projects. Operators then have to contribute a minimum of 20% of capital investment**.** In practice however, the FER is simply an account controlled by AMADER, rather than a functioning fund. Theoretically funded by the government, all stakeholders affirm that no money has ever flown through this fund. All rural electrification projects have to date been funded by donors, who have preferred to fund AMADER projects directly without contributing to the FER. Even donor-funded mini-grids were historically subsidised at 80%, however, in the latest donor funded projects (e.g. World Bank and AFD) operators are only required to contribute 5% of total capital costs to cover connection costs, in the aim of reducing the cost of kWh.

In addition to capital subsides, all solar related products are exempt from VAT and import duties, once a 2.5% community levy has been paid. The exemption has been granted for a period of five years, and will need to be reviewed for renewal in 2020.

2.4.5 POWER PURCHASE AGREEMENTS

There have been instances of the state utility EDM taking over mini-grids, whether these are near the existing main grid, or deep in rural environments. Theoretically, operators are protected by contracts which stipulate that they must be paid by EDM the net value (depreciated cost) of the assets taken over, and indemnified by the government against future earnings. In reality however the payment process, if at all honoured, is a lengthy process[19]. Of course, during this period operators are still liable for any debt servicing in the project.

In AMADER's contracts with operators, provision was made for EDM to take over sites, with options for operators to become IPP providers to EDM, or local distributors of EDM electricity. However, when the situation first manifested itself, it became apparent that there was no provision made to agree suitable prices between EDM and the operator. AMADER, and EDM approached the DNE for clarification, who opined that would be easier for EDM simply to take over operation, distribution, and buy-out, and indemnify the operator.

Under the institutional review of the energy policy being proposed by Tractebel, the following arrangements are made explicit. If the operator of a mini-grid decides to connect to the main network and be a power producer, and where his request to be a producer is approved, the operator of the main grid may be required to acquire the mini-grid (except the generation asset). It is assumed that the value of the facilities is equal to the residual value of the assets. The calculation of the residual value of the eligible assets will consider: (i) the date of bringing into use of the assets and their period of operation; (ii) tariff changes occurred up to the effective date of the purchase of facilities; and (iii) tariff changes which could have been claimed by the mini-grid operator following a request submitted to CREE, but which have not been processed as of the date of buy-out.

2.4.6 ARRIVAL OF THE GRID

Irrespective of the arrival of the grid, developers have no guarantee of project continuation as they are forced to accept break clauses written into their concession contracts. At present, there is no clear harmonisation between EDM and AMADER plans, and no least cost development plan combining plans for rural electrification and expansion of the grid. In addition, irrespective of the concession zones, EDM has been taking over control of mini-grids in numerous instances, where the site is said to have stopped working, when the site lies within EDM's concession area, and if requested to do so by central authorities. This phenomenon is explored in more detail under the licensing heading.

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19 One operator reported being offered a reduced indemnity payment if willing to take payment immediately, versus the full payment at an unspecified date (with the distinct possibility of no payment).

2.4.7 TECHNICAL RULES

Mini-grid projects in Mali must adhere to international electrification standards. The technical standards relate to security of users and goods, quality of service, and respect of the environment. However, if the site is considered under the auto-production category, and is therefore seen as private property rather than a public installation, then it will most likely not be scrutinised. The country has in fact been experiencing an increase in 'kiosk models' or economic development zones, which are categorised as auto-production and hence don't fall under AMADER's rural electrification regime.

The concession contract for the first installation is quite prescriptive about the required technical specifications. However, once the installation completed, the operator is free to operate the site and expand it with very light touch minimum specifications from AMADER. The requirements of installing traditional meters, still being applied in flagship projects such as PHARE and SHER is one of the major problems of viability of mini-girds in the country, hindering a reliable collection of revenue.

Under the institutional review of the energy policy being proposed by the AfDB, all operators in a rural environment would need to respect a certain number of obligations. These include: a minimum power supply of 4 hours/ day, a supply that is aligned to the needs of the local population and that satisfies the local production of businesses or provision of services, and charged tariffs which are inclusive of certain aspects of the service such as cables, plugs and connections. Under the new proposals, AMADER would also need to comply with the *compte rendu* requirement to CREE, in addition to providing regulatory oversight over tariffs and concessions.

2.4.8 MOBILE SERVICES

Mobile penetration in Mali is relatively high, and given the sparse nature of the fixed-line infrastructure there is considerable potential for mobile broadband services. According to specialists mobile data will be the fastest-growing segment over 2016-2021 and mobile revenue will account for 92.5% of the total telecom revenue in 2021 (KEN Research, 2017).

The main operators in the mobile network market are the incumbent operator Sotelma, held by Maroc Télécom, Orange Mali, and the Planor-Monaco Télécom International consortium operating through the Malian operating company Alpha Télécommunication Mali SA (Atel-SA). Orange, as the second company to join the mobile market, still managed to maintain its leading position in this segment, with a market share of 59.3%. Orange Mali operates a 2G and 3G GSM network. At the end of 2016, Orange Mali's network covered about 95% of the population and 46% of the country and had a base of 11.3 million active mobile subscribers, of which more than 99% were prepaid customers.

Table 11. Evolution of the possession of mobile phones by region (% population)

Region	2006	2009	2011	2014	2017
Kayes	26.8	61.5	64.9	82.5	90.6
Koulikoro	16.3	70.8	62.8	83.8	79.3
Sikasso	14.3	63.8	67.8	89.2	92.1
Segou	11.4	58.8	68.9	80.9	80.9
Mopti	12.7	49.8	53.2	72.1	73.0
Tombouctou	15.5	57.6	61.1	76.1	68.7
Gao	22.2	61.6	61.7	81.8	79.0
Bamako	69.2	91.7	84.9	97.7	99.1
Mali	**22.5**	**65.3**	**66.8**	**83.6**	**83.6**

Source: (INSTAT, Consumption and well-being of households. April 2017-March 2018, 2018)

Despite the growing mobile market, operators seem constrained about their ability to install prepayment meters capable of allowing mobile-based recharging. AMADER mini-grids have mostly functioned on traditional meters which is part of the reason they have been unprofitable. Even when on prepayment meters, customers must buy credit from kiosks, meaning that collection of revenue from the kiosks for operators remains a substantial challenge (given that these are often in extremely rural and distant locations). For the on-grid sector, the situation seems to improve with around 60% of EDM low voltage customers being on pre-paid meters, and the majority being able to pay via their mobiles.

2.4.9 BARRIERS TO MINI-GRID DEPLOYMENT

The profitability of mini-grid projects in Mali has historically been defined as poor. A number of barriers to successful and profitable development persist according to stakeholders. These can be grouped under different categories as per Table 12 below.

Table 12. Historical barriers to a good functioning and deployment of mini-grids in Mali

Technical	• Project sizing based on information provided as part of tenders issued by AMADER, yet pre-feasibility studies often lack accurate or up-to-date information • Costly generators that provide often less than seven hours of service a day and miss the prime day-times for economic activities • Historical focus on old traditional meters that result in limited revenue collection and that will also mostly be retained even when sites undergo considerable modifications e.g. SHER project • Distinct lack of technical innovation in the market • Mini-grid contracts have been assigned to operators or other government stakeholders that lacked the necessary expertise to design and profitably run such an infrastructure • General lack of maintenance of the sites also due to operators' financial constraints • Lack of clear technical standards specifying for instance the voltage level and frequency required for a high quality provision of electricity to consumers
Financial	• Significant misalignment between rural and urban tariffs, with the first being considerably higher, which results in limited take-up and payment, making it also difficult to cover O&M costs • Poor revenue collection due to a lack of clear innovation towards appropriate payment solutions such as pre-paid meters and mobile money, and due to a very low ability to pay from consumers • Government subsidies that were to be redirected through the FER do not actually supply the fund • Tenderers were often required to purchase the tender documents for up to ~300,000 FCFA per lot (though it seems that this practice is slowly being abandoned) • Perceived low private sector drive in exploring new mini-grids business models • High reliance on diesel and hence exposure to price fluctuations from imports as well as high transport costs within the country
Political	• Stakeholder concerns about the political will to advance rural electrification in the country as government seems to be focussing primarily on on-grid electrification • Lack of integrated approach between programmes carried out under the auspice of the public authorities and the private sector that would support the development of an economically viable market for renewable energy • Occurrences of EDM taking over of existing mini-grids
Socio-economic	• Extremely dispersed rural populations across the country • Consumption remains low, and often lower than anticipated primarily due to a lack of economic activity in the villages • Clashes due to significant differences between urban and rural prices of electricity, which is still not being offered as a true service • Competition with the fast growing market of portable solar lamps in the country

3. GREEN MINI-GRID POTENTIAL

Estimating the potential for mini-grids is a challenging task that requires robust data and/or assumptions. Some physical factors, such as resource availability and geographic features, can be collected remotely through satellite data, but other factors require 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 highly resource intensive to obtain. In addition, opportunity assessments rely upon criteria that differ depending on the approach of the implementing agency. For example, a private developer might consider purely financial metrics, whereas a community scheme might focus on quality of services provided. Given these constraints, the opportunity assessment in this report is designed to be of relevance to all mini-grid stakeholders, but will not address the individual needs of all.

This chapter aims to give mini-grid stakeholders an understanding of the size of the opportunity for green mini-grids in Mali. Market size estimates are calculated based on a number of considerations: (1) **physical opportunity size** according to GIS datasets (population density, load centres, existing grid, etc.), (2) **existing electricity expenditure** by rural households, (3) maximum **customer affordability** and willingness to pay, and (4) **tariffs** currently allowed in-country. Comparisons will be made between an existing market size, based on affordability and in-country tariff limitations, and the theoretical market size based on cost-reflective tariffs. The difference between current and theoretical market size will allow an approximation of any subsidy requirement for opening the market (in percentage terms).

3.1 DATA AVAILABILITY

The level of available GIS data in Mali is limited but under development. AER Mali has mapped renewable energy resources in Mali under the Renewable Energy Development Programme. The resources covered by the study (not yet completed) are solar, wind and biomass. EDM has some readily available GIS data on population. The World Bank is now exploring the opportunity to do a full GIS mapping study to cover population, economic activity and renewable energy potential. A list of GIS sources used in this study is provided in section 4.2. These include sources such as the WAPP GIS database, distributed by ECREEE, the ECOWREX database, as well as the World Pop data portal.

3.2 ASSESSING MINI-GRID POTENTIAL

3.2.1 METHODOLOGY

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

- Grid extension areas: defined as areas within 15km of the grid;
- Mini-grid areas: defined as areas further than 15km from the grid , with household density greater than 50 households per km^2; and
- Standalone system (SHS) areas: defined as areas further than 15km from the grid, with household density less than 50 households per km^2.

To understand where these different areas lie, the national grid is inferred using a combination of high voltage (HV) line GIS data and satellite mapping of night-lights, buffered by 15km to produce the grid-extension area . Potential off-grid populations are outside of this grid extension area, with mini-grid populations identified based on population density greater than 50 households per km^2.

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

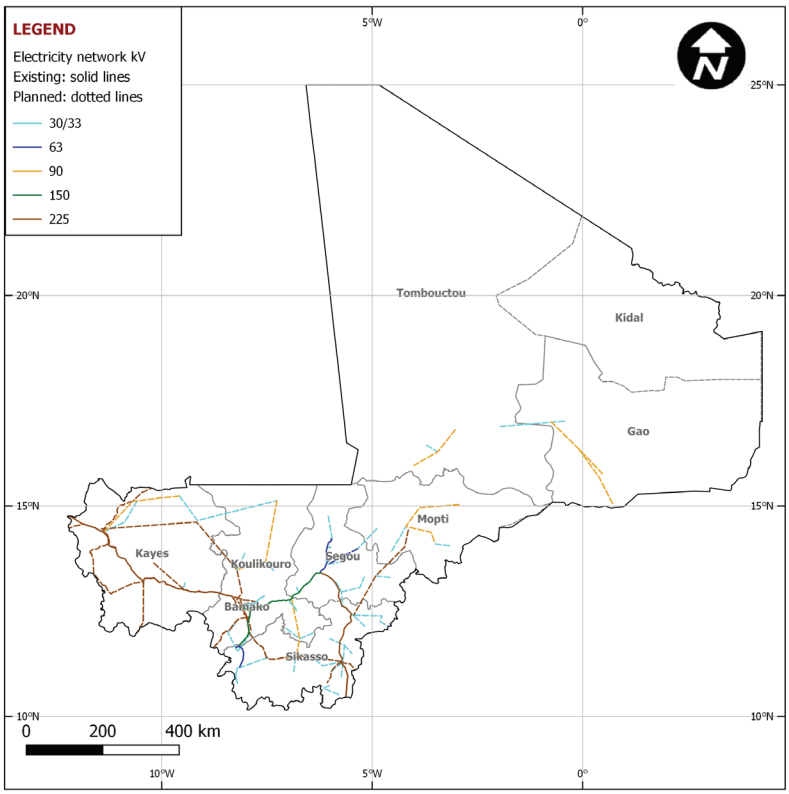
1. **Existing rural household expenditure on electricity based on the World Bank Global Consumption Database** (World Bank, n.d.)**.** This approach assumes that 60% of rural household energy expenditure is on electricity, and that household revenue comprises 60% of the total revenue of a mini-grid (when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

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

3.1.3 RESULTS

Mali has a transmission system that is concentrated in the South West of the country (Figure 7). The national network is composed of a so-called interconnected network, connecting 32 localities including the capital Bamako, of 28 isolated centres of autonomous generation and distribution, and two centres connected to Ivory Coast's medium-voltage network. The interconnected network provides 87% of the installed power capacity (CREE, 2015). By inferring the presence of MV and LV transmission lines using night lights, and overlaying population density (Figure 8) onto the resultant map, we can identify those areas best served by mini-grids (Figure 9).

Figure 7. Transmission and distribution network (excluding MV/LV coverage inferred from nightlights)



The latest available population figures state a population of 18.9 million in 2017, an annual population growth rate of around 3.4% and a population density of ~15 inhabitants per km^2. The density of the rural population is however very limited, making the provision of electricity a costly service (Tractebel, 2018). Life expectancy at birth is 68.2 for women and 65.7 for men. Table 21 in the Annexes shows the population by locality.

Figure 8. Population density in Mali

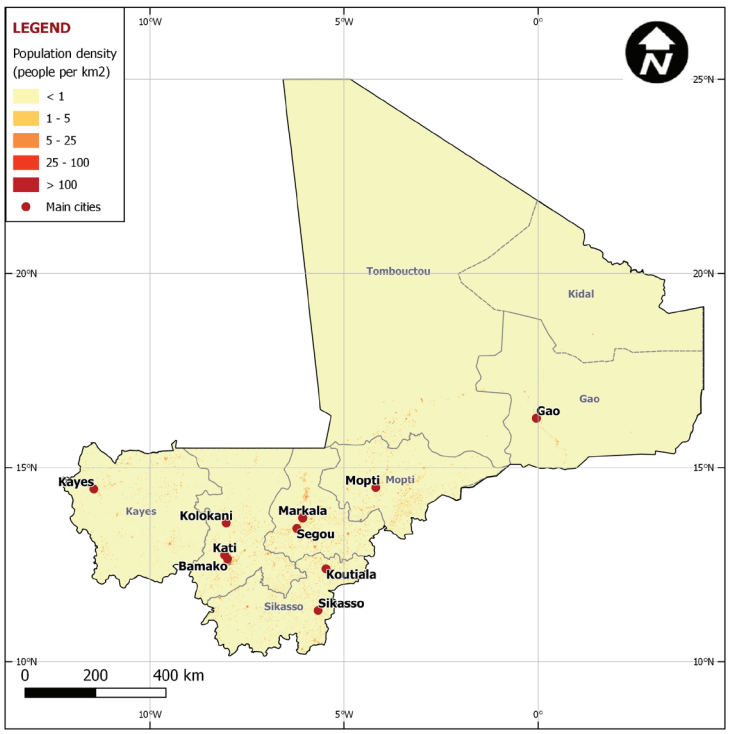
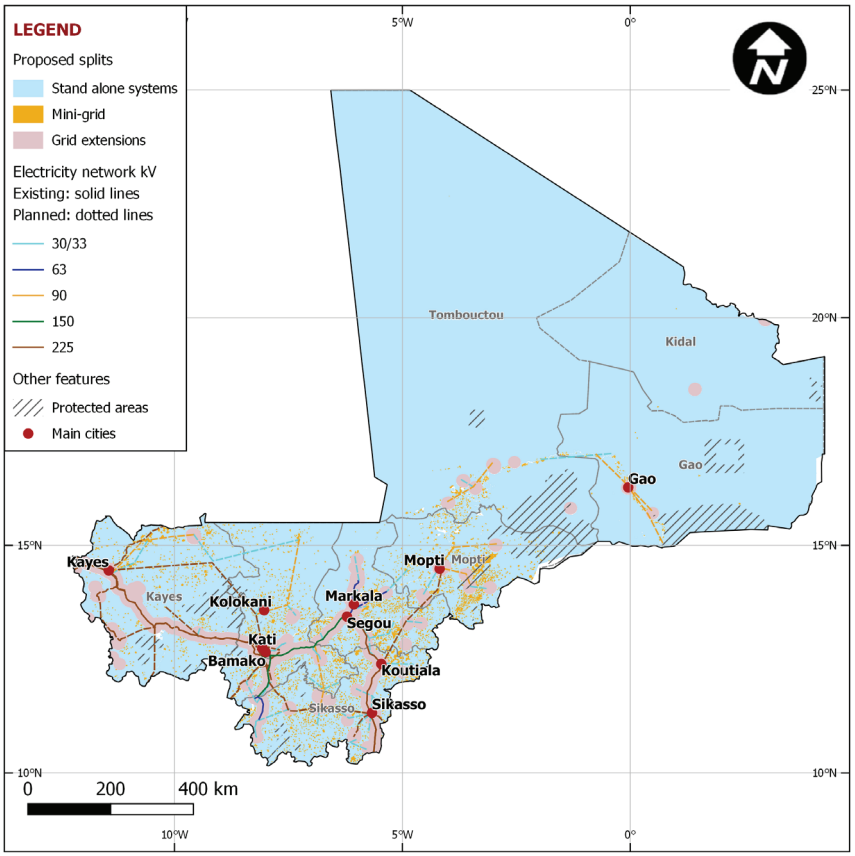


Figure 9. Regions best served by grid extension, mini-grid and standalone systems, shown with major and minor population centres. (Carbon Trust analysis)



Our analysis estimates that 3.9 million people (21% of the unelectrified population) will be best served by mini-grid solutions in Mali. The highest potential for mini-grid is in the region of Mopti (note that Mopti lies on the edge of what is considered the safe zone of southern Mali and the less secure North). A further 4.3 million people (27% of the unelectrified population) will be best served by SHS and 1.6 million people (7% of the unelectrified population) will be best served by grid extension, based on proximity to the existing grid. This calculation is based on the current grid coverage only[20]; any planned grid extensions will reduce the estimated market size. Population sizes best served by either grid extension, mini-grid or SHS are shown by region in Table 13.

20 High voltage lines plus lights seen from satellite, which are used to infer the presence of medium and low voltage lines (**note:** this method may camouflage a significant existing off-grid contribution from diesel gensets, meaning that this mini-grid market size result is likely to be conservative; further studies in-country are required)

Table 13. Estimated household market size for off-grid solutions. Analysis using the existing network

Region	Current grid network				
	Electrification rate	Population (thousands)			Mini-Grid Market ($m)
		< 15km of grid	Mini-Grid	SHS	
Bamako	60%	918	-	-	-
Gao	17%	108	77	313	4
Kayes	26%	223	567	818	31
Kidal	26%	-	3	58	0
Koulikouro	49%	-	710	736	39
Mopti	20%	109	859	793	47
Segou	43%	218	659	586	36
Sikasso	54%	-	814	675	44
Tombouctou	14%	106	201	333	11
Total	**41%**	**1,683**	**3,891**	**4,312**	**212**

Region	Planned grid network to 2025				
	Electrification Rate	Population (thousands)			Mini-Grid Market ($m)
		< 15km of grid	Mini-Grid	SHS	
Bamako	60%	918	-	-	-
Gao	17%	248	20	230	1
Kayes	26%	808	288	512	16
Kidal	26%	-	3	58	0.2
Koulikouro	49%	-	404	473	22
Mopti	20%	472	648	643	35
Segou	43%	625	396	442	22
Sikasso	54%	-	469	438	26
Tombouctou	14%	245	116	279	6
Total	**41%**	**3,316**	**2,344**	**3,076**	**128**

In terms of potential revenue, the size of the market based on 3.9 million potential customers varies according to the four electricity expenditure scenarios described in 3.2.1 Methodology:

1. **Existing rural household expenditure on electricity from the World Bank Global Consumption Database:** in Mali 98.7% of the rural population falls under the 'lowest' consumption segment, and 1.3% under the 'low' consumption segment. According to the World Bank Global Consumption Database the per capita annual spend on electricity in Mali is $12.6.
2. **Existing rural household expenditure on electricity based on other reports / literature: A** World Bank project estimates that the typical electricity consumption per household per month would be 40kWh average, and prices for rural mini-grids are ~$0.5/ kWh[21] (World Bank, Rural Electrification Hybrid System Project in Mali, 2013). This give a per capita annual cost of electricity of $36.9 and an overall annual mini-grid market size of ~$144 million.
3. Potential **rural household expenditure on electricity, estimated based on a bottom-up calculation of what would be required to deliver SE4ALL Tier 2/3 energy access nationwide, and an average allowable tariff currently used in-country:** annual cost of electricity from a mini-grid was estimated based on forward-looking household electricity consumption of 2.2 kWh per day, representing an annual per capita electricity demand of 123 kWh (6.5 persons per household[22]). An average across all tariffs was estimated around $0.44 / kWh, giving a per capita annual cost of electricity if $54.4, and a mini-grid market size of $211.5 million given a mini-grid population of 3.9 million.

21 Note that their low income example had consumption at 13kWh/month, at a tariff of $0.

22 Latest INSTAT figures in Mali state that the average household is composed of 6.5 people.

4. **Potential rural household expenditure on electricity, estimated based on a bottom-up calculation of what would be required to deliver SE4ALL Tier 2/3 energy access nationwide, and a flat tariff of $0.4 / kWh:** this tariff is assumed to be cost reflective. Based on annual electricity demand of 123kWh per capita, a tariff of $0.4 / kWh gives an average annual electricity expenditure of $49.4 per capita: an overall annual mini-grid market size of $192.2 million given a mini-grid population of 3.9 million.

Table 14. Market size estimates for the four scenarios

Scenario	Estimated per capita annual costs for GMG	Market Size given current GMG population	Market Size of GMG population (given planned grid extension)
1 World Bank Database	$12.6	$49.0m	$29.5m
2 Other Reports	$36.9	$143.7m	$86.6m
3 'Bottom-up' + existing tariff	$54.4	$211.5m	$127.4m
4 'Bottom-up' + theoretical tariff	$49.4	$192.2m	$115.8m

It is possible that the high household size is diluting energy spend in Scenario (1). Scenario (2) is based on 2013 data and is therefore considered relatively outdated. Scenario (4) is based on a theoretical tariff, whilst Scenario (3) is based on tariffs and demand levels observed elsewhere in SSA, with a 'bottom-up' calculation being the more likely (and more conservative) estimate of the likely mini-grid market size in Mali.

In summary, this report estimates an annual mini-grid market size of ~$211.5 million in Mali, based on an average mini-grid tariff of $0.44/ kWh, and average household demand per day of 2.2kWh. This implies per capita annual electricity expenditure of $54.4 within the population best served by mini-grids. Considering the average mini-grid tariff of $0.44 is slightly above the cost-reflective tariff of $0.4/kWh across SSA, in theory, **project costs would not need to be covered by subsidies**, and the market should already be to developers.

3.3 RENEWABLE ENERGY POTENTIAL FOR MINI-GRIDS

Mali has a large yet under-exploited potential for generation from renewable sources (biomass, solar, wind and hydro). A country profile study from the AfDB identified the following strengths, weaknesses, opportunities and threats related to climate change and RES in Mali:

Table 15. SWOT analysis of Mali's renewable energy potential, (AfDB, 2015)

Strengths	Weaknesses
- Hydro, solar and biomass have a great potential - Experience in hydro, biomass and some solar PV - RE available for rural access in remote areas	- Hydro maintenance needed - Unsustainable collection and use of biomass not fully addressed - Little experience in wind power
Opportunities	**Threats**
- Growth opportunities for all technologies - Great interest from private sector in solar PV IPP - Biofuels with widespread local plants promising	- Climate change and extreme weather events could - undermine RES potential, especially hydro and biomass

HYDRO

Large scale hydroelectricity potential in Mali is mainly situated on the Niger and Senegal rivers. The Niger River flows through Mali for over 1,600 km in a north-east direction, across the Mandingue Plateau, until its course is interrupted by waterfalls and a dam at Sotuba. The Senegal River and its tributaries flow in a north-west direction towards the Atlantic Ocean, cutting through Mali for 670 km.

The potential is estimated at ~1 GW, with an annual average energy generation of about 5,600 GWh (AfDB, 2015). Around 27% of this potential is currently exploited through the Sélingué and Sotuba hydro station on the Niger River, and the Manantali and Félou stations on the Senegal River.

A hydropower GIS mapping study published by Pöyry in 2017 on behalf of ECREE shows that there are a few streams in Mali that have some potential for pico/micro/mini hydropower[23]**.** A tributary to the Faleme River that forms the international border between Mali and Guinea has considerable potential for small hydropower (Pöyry, 2017). EDM, has issued a general procurement notice for the construction of the Djenné and Talo mini-hydro plants on the river Bani. These proposed plants are part of the larger « Projet de développement de mini-centrales hydroélectriques et leurs réseaux de distribution associés » (PDM-HYDRO)/ Project for the development of mini-hydro and associated distribution networks which encompasses six run-on-river projects. It is anticipated that the first two projects alone will involve the connection of ~12,500 consumers to the grid (Hydropower & Dams, 2018). PDM-HYDRO has received financial support from the African Development Group.

The table below gives an overview of existing and potential hydro power stations in the country.

Table 16. Existing and estimated hydro power potential in Mali

River	Location	Estimated/ installed power (MW)	Potential generation (GWh)	Status
	Sotuba	5.7		In operation
	Sotuba 2	6	40	Works started
Niger	Kénié	34.5	188	Feasibility study
	Markala	10	45	Feasibility study
	Taoussa	25	100	Feasibility study
	Labezanga	14	67	Feasibility study
Bani	Toubani	35	134	Recognition
	Talo	1.4	5.9	Pre-feasibility
	Djenné	7.6	17.75	Pre-feasibility
Sankarani	Sélingué	44	180	In operation
	Kourouba	2.5-5		Recognition
	Felou	60 (27 Mali)	320	In operation
Senegal	Gouina	140	560	Works started
Bafing	Manantali	200 (104 Mali)	800	In operation
	Bindougou	49.5	289	Pre-feasibility
	Boureya	161	733	Pre-feasibility
	Koukoutamba	281		Pre-feasibility
Falémé	Gourbassi	18	68.4	Pre-feasibility
	Moussala	30	160	Pre-feasibility
Baoulé	Baoulé 3	30	124	Pre-feasibility
	Baoulé 4	30	124	Pre-feasibility
Bagoé	Bagoé 2	19.5	78	Pre-feasibility

Source: (Tractebel, 2018)

23 The definition of small hydropower in Mali is 1-30 MW. The usual distinctions are: pico/micro/mini (< 1 MW installed capacity), small (1-30 MW installed capacity), and medium/large (> 30 MW installed capacity).

BIOMASS

Biomass is the most widely used form of energy in Mali, with forests under pressure to provide fuel wood to satisfy the domestic energy requirements of the growing population. Opportunities exist to develop the capacity of sustainable biomass and biofuel uses given the strong agricultural base of the economy. Opportunities exist in particular to intensify production projects of biofuel for electrification, develop the fossil fuel mix and provide energy for agricultural activities in rural areas (Tractebel, 2018).

Africa has many biofuels option including sugarcane, corn, sweet sorghum, cassava, oil palm and jatropha. Mali is one of the principal producing countries of jathropa across Africa. A local NGO referred to as the Mali-Folke Center Nyetaa offers assistance to local farmers to grow jatropha oil seeds. Additionally, communities living near the Center receive electricity generated from power plants that use the jatropha oil seeds (Patrick T. Sekoai and Kelvin O. Yoro, 2016).

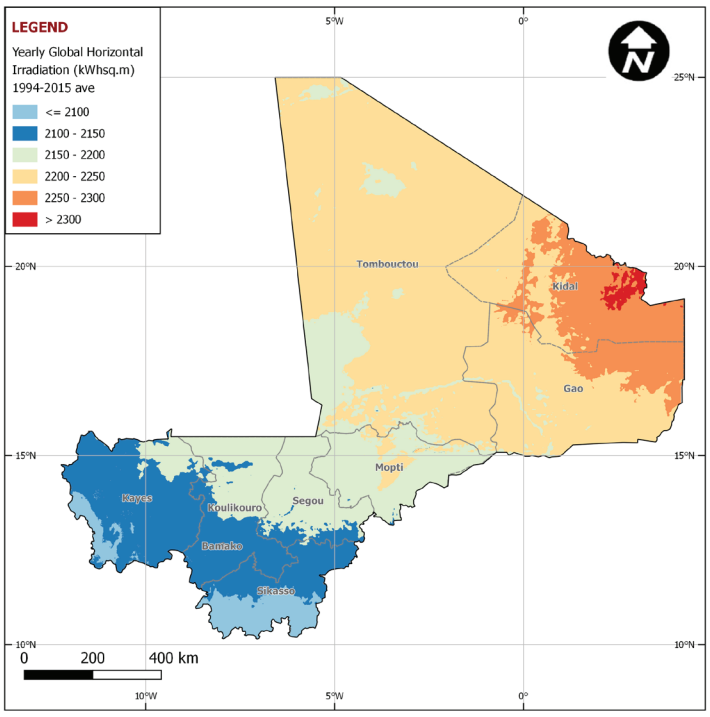
The Office du Niger (ON) located in Mali is one of the oldest and largest irrigation schemes in SSA. The ON intervention area is the western part of the central Niger Delta. The ON's irrigated perimeters are now mainly intended for **rice production** during the rainy season.

The Compagnie Malienne pour le Développement des Textiles (CMDT)/ Malian Company for the Development of Textiles is the key actor across West Africa's cotton producers. Mali's **cotton production** forecast was of 650,000 tonnes in 2016/17. The cotton harvest in Mali runs from April to April. Production begins in May-June and ends in September-October. Commercialisation starts in October-November and ends at the end of March, and there are ten different types of cotton in Mali.

In Mali there is also alcohol based biofuel primarily produced from sugar cane by the sugar company SUKALA.

SOLAR

Figure 10. Yearly Global Horizontal Irradiation, 1994-2015 average



Mali is located in a region with high solar potential and is a country particularly conducive to the development of solar technologies. The average solar radiation is estimated at 5-7 kWh / m² / day with a daily sunshine duration of 7 to 10 hours. Thus, the production potential from solar PV is estimated at 7,906 TWh / year (IRENA, 2014). Solar radiation is more important in the northern part of the country than in the southern part (though nobody lives in the northern part). According to a study conducted by ECOWAS in 2015, this potential cannot be fully exploited because it would require long lines of transport to bring the energy produced to the centres of consumption. Nevertheless, this resource can be used to supply the big cities in the North of the country (ECOWAS, 2015).

Solar thermal is mostly utilised for: individual or collective water heating; drying of agricultural products in the production areas; distillation of water, and cooking. Nevertheless, solar cookers are often considered poorly suited for culinary habits.

The solar technologies that are the most diffused in Mali are:

- Large PV parks under construction that will be connected to the interconnect grid and decentralised PV parks e.g. Kati (65 MWp), Kita (50 MWp), Ségou (33 MWp), Sikasso (50 MWp) and Koutiala (25 MWp), as well as Fana (50 MWp), the SREP Mali project (20 MWp) and Sélingué (Greenwish - 40 MWp);

- Hybrid PV/ diesel plants under the mini-grid hybridisation programmes currently underway;
- Solar PV plants with battery storage (Soufroulaye 40 kWp and Haoussa Foulane 40 kWp under construction);
- Solar PV for domestic use, including flashlights and solar kits installed mainly in households, schools and health centres, charging systems (battery charging kit, battery charging kiosk), solar water heaters (residential with sensor and a storage capacity of 200 to 500 litres), solar cookers (parabolic, box, cardboard), solar dryers and solar pumping systems (0.5 to 10 kWp).

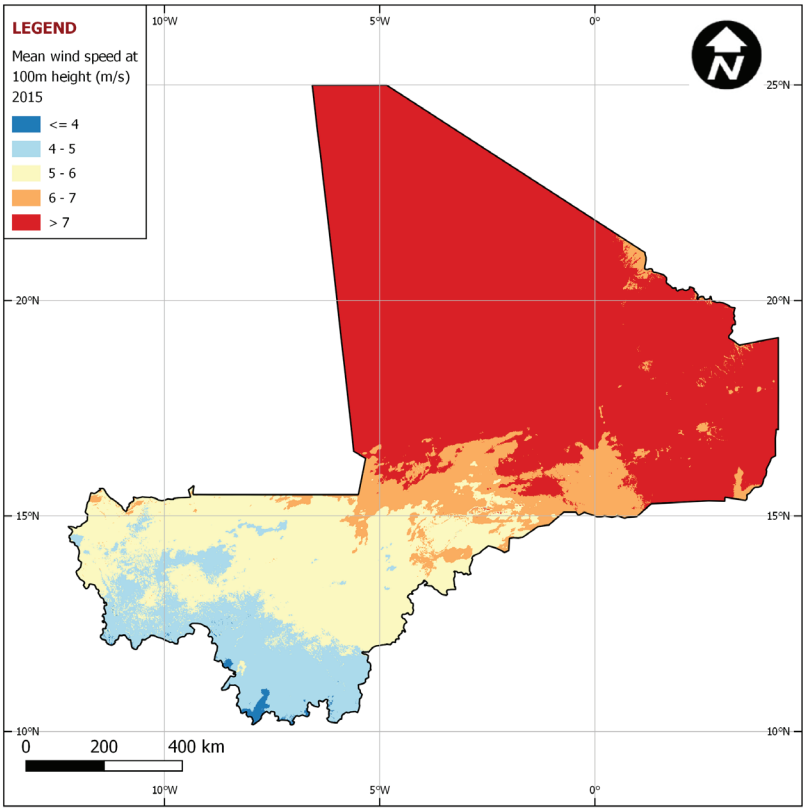
WIND

Based on a study by IRENA in 2014 the wind potential in Mali corresponds to 1,923 TWh / year. This figure is derived from the available areas in Mali for wind development by category of relevance and the average annual wind speed. In the Sahelian and Saharan zones, the annual average wind speed is estimated at 3 m/s to 7 m/s. So whilst relatively speaking there is low din energy potential in the country, wind speed in those two zones is fast enough to produce power.

Table 17. Available areas for wind development in Mali by category of relevance, IRENA 2014

Category	Limited relevance	Adequate	Very adequate	Excellent
Wind speed m/s	4-5	5-7	7-9	>9
Surface km^2	176,656	49,241	-	-

Figure 11. Mean wind speed at 100m height (m/s) 2015



4. DIRECTORY

4.1 ENERGY SECTOR POLICIES AND REGULATORY FRAMEWORKS DIRECTORY

Decree n° 99-013/P-RM April 1999, law n° 99-022 June 1999, decree n° 99-186/P-RM July 1999: creation of the Direction Nationale de l'Energie (DNE)/ National Directorate of Energy

Decree n° 00-021/P-RM March 2000 and decree 185/P-RM April 2000: organising the electricity sector and establishing the national regulator CREE

Link: http://extwprlegs1.fao.org/docs/pdf/mli49651.pdf

Decree n° 00-09/P-RM March 2000: this decree is the core of the electricity market in Mali, laying down precise rules for its application.

Law n° 03-006 May 2003 and decree n°03-226/PRM May 2003: creation of l'Agence Malienne pour le Développement de l'Energie Domestique et de l'Electrification Rurale (AMADER)/ Malian Rural Electrification Agency
Link: http://extwprlegs1.fao.org/docs/pdf/mli155478.pdf

Law n° 05-019 May 2005, modifying decree n° 00-19/P-RM on the organisation of the electricity sector

La Politique Energétique Nationale (PEN)/ National Energy Policy
Link: https://docplayer.fr/24456280-La-politique-energetique-nationale.html
Description: Mali's energy sector is governed by the PEN, adopted in 2006. The overall objective is to contribute to the country's sustainable development through the provision of affordable energy services in order to increase access to electricity and promote of socio-economic activities. The PEN was subsequently revised in 2013, spelling out the Policy's objectives of "developing new and renewable energies to reduce the share of thermal heat production and ensure access to energy for all".

La stratégie nationale de développement des énergies renouvelables/ National Strategy for the Development of Renewables
Link:
Description: Adopted in 2006, the strategy is aimed at: (i) promoting the widespread use of RES technologies and equipment to increase the share of RES in national electricity generation; (ii) developing the biofuel sub-sector for; (iii) creating better conditions to sustain RES services; and (iv) searching for sustainable and suitable financing mechanisms for RES. A Renewable Energy Action Plan 2013-2033 has been developed with the objective of "increasing the share of Renewable Energies in the energy balance from 1% to 10% by 2033".

La stratégie nationale de développement des biocarburants/ National Strategy for the Development of Biofuels
Link :
Description: The National Strategy for the Development of Biofuel was adopted in June 2008 and it aims, firstly, at enhancing affordable local energy production through the development of biofuels to meet the country's socio-economic needs. Secondly, it aims to reduce the country's dependency on oil imports.

La stratégie nationale pour le développement de la maitrise de l'énergie/ National Strategy for the Utilisation of Energy
Link:https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/%C2%B2Mali%20-%20Strat%C3%A9gie%20de%20d%C3%A9veloppement%20de%20m%C3%AEtrise%20de%20l'%C3%A9nergie_02.pdf
Description: The strategy issued in 2010 looked at ways to manage energy consumption, including an optimisation of the electricity generation mix (through a greater proportion of renewables).

Plan Directeur des Investissements Optimaux 2014 -2035 (PDIO)/ Optimal Investment Roadmap

Plan Directeur d'Electrification Rurale 2007-2020 (PDER)/ Rural Electrification Roadmap

4.2 DATA SOURCES DIRECTORY

This methodology was developed during the first phase of this project, the Green Mini-Grids Market Development Program - Market Intelligence business line. The two methodology papers are published on the AfDB's Green Mini-Grid Help Desk (http://greenminigrid.se4all-africa.org).

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

1. **Electricity transmission network (medium and high voltage)**

File Name: transmissiongridecowas2017.geojson
Source Age: January 2017
File type: Geojson, line
Description: A shapefile of the electricity transmission network of Mali
Projected coordinate system: WGS_1984 (EPSG: 4326)
Source: Western African Power Pool (WAPP) GIS database, distributed by ECREEE
Link: https://energydata.info/dataset/transmission-grid-ecowas-region

2. **Clean Energy Mini-grids**

File Name: cemgs_30072018
Source Age: 2018
File type: ESRI Shapefile, points; GEOJSON
Description: A shapefile of off-grid power plants in Mali
Projected coordinate system: WGS_1984 (EPSG: 4326)
Source: ECOWAS observatory for Renewable Energy and Energy Efficiency (ECOWREX) database
Link: http://www.ecowrex.org/mapView/index.php?lang=eng&mclayers=layerCEMG#

3. **Population Density**

File Name: MLI_pph_v2b_2015_UNadj.tif
Source Age: 2015
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 coordinate system: WGS_1984 (EPSG: 4326)
Data Source: World Pop data portal
Spatial Resolution: 100m
Link: http://www.worldpop.org.uk/data/data_sources/

4. **Administrative Layers (National and Region Boundaries)**

File Name: mli_admbnda_adm1_gov_ocha_itos
Source Age: 2017
File type: ESRI Shapefile, polygons and points
Description: Shapefiles of State and Local Government Area boundaries
Projected coordinate system: WGS_1984 (EPSG: 4326)
Source: Humanitarian Data Exchange
Link: https://data.humdata.org/dataset/administrative-boundaries-cod-mli

5. **Main cities**
File Name: ML_Cities_84.shp
Source Age: 2018
File type: CSV-based list
Description: List of main cities
Projected coordinate system: WGS_1984 (EPSG: 4326)
Source: Geonames
Link: http://www.geonames.org/ML/largest-cities-in-mali.html

6. **Wind - Mean Wind Speed at 100m Height**
File Name: gwa__gwa_ws_100m_mean.tif
Source Age: 2015
File type: Raster
Description: Mean wind speed at 100m height
Coordinate system: WGS_1984 (EPSG: 4326)
Source: DTU, IRENA
Link: https://irena.masdar.ac.ae/gallery/#gallery

7. **Solar - Annual Total Global Horizontal Irradiation (GHI)**
File Name: GHI.tif
Source Age: 2015
File type: Raster
Description: Annual total Global Horizontal Irradiation (GHI) (kWh/sqm) averaged over 1994-2015
Coordinate system: WGS_1984 (EPSG: 4326)
Source: DTU, IRENA
Link: http://globalsolaratlas.info/downloads/mali

4.3 STAKEHOLDER DIRECTORY

GOVERNMENT AND AGENCIES

Direction Nationale de l'Energie (DNE)

Brief description: According to Ordinance No. 99-013 / P-RM of 01 April 1999 establishing the National Directorate of Energy, the DNE is a central department whose mission is the elaboration of the elements of the national energy policy, as well as the coordination and technical control of regional, sub-regional and related services which contribute to the implementation of this policy.

Agence des Energies Renouvelables du Mali - AER Mali (Mali Renewable Energy Agency)

Brief description: The Agence des Energies Renouvelables du Mali (AER-Mali), previously called the National Centre for Solar and Renewable Energy (CNESOLER), is a research entity focusing on technical certifications to promote the use of renewable energies, particularly solar, across the country. AER - Mali is a Public Scientific and Technical Establishment (EPST) which was created in October 2014 with a mission to promote renewable energies for their large-scale use. The mission includes contributing to the definition of national energy strategies and monitoring the implementation of renewable energy projects for the benefit of stakeholders. AER-Mali is also responsible for doing an inventory and evaluating the country's potential for renewables, informing and educating promoters and users of renewable energy equipment and developing and strengthening their capacities, testing, quality controlling and labelling of renewable energy equipment, and conducting studies

Société Energie du Mali (EDM-SA)

Brief description: Société Energie du Mali (EDM-SA) is the state-owned Malian company responsible for the production, transmission and distribution of energy in urban and peri-urban areas, as well as for the distribution of water. It owns an agency more specifically dedicated to the production of electricity, named Electricity of Mali. Through its concession contract, the company EDM-SA has accepted the development responsibility and the operation of electricity generation, transmission and distribution services in a geographical perimeter composed of 98 localities. Within the perimeter of its concession, EDM has monopoly over power transmission and distribution, while generation is open to the private sector.

Agence Malienne pour le Développement de l'Energie Domestique et de l'Electrification Rurale – AMADER (Malian Agency for the Development of Domestic Energy and Rural Electrification)

Brief description: The Agence Malienne pour le Développement de l'Energie Domestique et l'Électrification Rurale (AMADER/ Malian Rural Electrification Agency), created in 2003, supplies electricity to rural areas through PPPs, whereby rural electrification concessions are granted to private operators. AMADER is the regulatory authority outside the urban centers for energy. AMADER works alongside EDM-SA (state-owned utility), and is in charge of the domestic energy sub-sector and thus operates in rural electrification.

Commission de Régulation de l'Electricité et de l'Eau - CREE/ Electricity and Water Regulator

Brief description: The Regulatory Agency for Electricity and Water (Commission de Régulation de l'Electricité et de l'Eau, CREE), reporting to the Prime Minister's Office, was established in 2000 to regulate the water and electricity sectors. CREE's mandate is to protect customers, promote competition when possible, arbitrate disputes between the GoM and operators, and approve adjustments to ensure fully cost reflective tariffs. CREE's mandate is limited to EDM's concession perimeter.

BILATERAL AND MULTILATERAL DONOR ORGANISATIONS WITH ENERGY ACCESS PROGRAMMES

World Bank

Brief description: The World Bank's approach in Mali is to first and foremost diversity the energy mix of the country, in particular boosting solar plants, as well as developing interconnectors with neighbouring countries, such as the Ivory Coast, that are developing new renewable sources. The Word Bank has also financed key projects to restructure the energy market in Mali and promote the deployment of mini-grids across the country.

Agence Française de Développement

Brief description: AFD has an ambition of driving the renewable energy agenda in Mali, especially in light of the Paris agreement. ADF is currently chairing the Technical and Financial Partners Working Group (Groupe des Parternaires Techniques et Financiers – PTF) until the end of 2019. The PTF groups donors and international organisations that meet on a monthly basis to try to push the renewable agenda. One of the key AFD's funded projects in the mini-grid market is the PHARE project that will finance the hybridisation of, it is hoped, a 60 sites.

African Development Bank

Brief description: The AfDB provides financial and technical support to key actors in the Malian energy sector to help promote renewable energy in Mali and increase the access to electricity. The AfDB commissioned Tractebel to review and update a number of key energy policies and legislative and regulatory texts on behalf of the national Ministry of Energy and Water, under the PAPERM (Projet d'appui à la promotion des énergies renouvelables au Mali/ Project for Scaling up Renewable Energy in Mali).

Swedish Aid

Brief description: Swedish Aid provides technical assistance in Mali across the following areas: environment and climate, democracy and human rights, and security. Swedish Aid support exclusively comes under grant form and technical assistance, they do not have credit lines in Mali. Swedish Aid have been active in the environmental sector for a number of years in Mali and are increasingly shifting from resilience towards renewable energy deployment, especially in rural environments and linkages with improved agriculture.

European Union

Brief description: The EU international development aid in Mali is being delivered through the FED (European Development Funds). The three sectors of intervention are: rural and environment; economic development and security; and infrastructure. The EU is for instance according financial assistance to reinforce grid connections as hydro sites are enlarged. Recently funded a small number of rural electrification projects which focused respectively on: solar pumps and solar thermal in rural environments; the development of solar kiosks, and solar products, including deployment of solar home systems in 1000 homes; and the deployment of small scale bio digesters (~100) deployed. The entirety of the support is through grant funding, though they do blend support with other development agencies as was the case with the interconnection reinforcement where the credit lines came from the AFD.

GERES

Brief description: GERES is a relatively small French NGO active throughout the world, with operations in South East Asia, Central Asia, Southern and Central Europe, and West Africa (Mali, Senegal and Burkina Faso notably). In Mali GERES employs ~30 people. GERES is working in three main areas in Mali, notably energy, including biomass, clean cook stoves, solar PV and energy efficiency, as well as climate and economic development. GERES' primary interest is in interventions that lead to economic development, so typically they work to develop economic activities through their interventions, e.g. with regards to cook stoves it's about helping organisations to develop and market the stoves.

MAJOR MINI-GRID PRACTITIONERS PROJECT DEVELOPERS, AND PRIVATE SECTOR ACTORS

KAMA

Brief description: Established in 2003, The KAMA Group SA, headquartered in Bamako, Mali is a group operating in various sectors of activity in West Africa. Electricity is at the heart of their business. They distribute electrical equipment, install electrical networks, and promote rural electrification through the production and distribution of thermal and solar energy. KAMA's client base includes EDM and AMADER. The company currently runs 25 mini-grids on behalf of AMADER, of which eight are being hybridised under the SHER programme.

SONIKARA SOLAR ELECTRO SARL

Brief description: The areas of intervention of the company are: renewable energies, irrigation, drilling for drinking water supply, air conditioning (bio climate air) and air cooling. For over eight years, the company has been operating in the field of renewable energy in Mali. Recently, the company completed the installation of three solar power plants and won a hybridisation contract for five mini-grids in the Kayes region as part of the SHER project financed by the World Bank. SONIKARA's responsibility under this contract is limited to design and installation.

YANDALUX MALI SARL

Brief description: Founded in 2004, Yandalux GmbH is a Hamburg-based company specializing in autonomous solar energy applications and a large network of partners in West Africa. Yandalux main services are related to solar energy for off-grid users, PV projects for municipalities and investors, and solar power for trade and agriculture. Yandalux has experience in installing mini-girds in Mali on behalf of AMADER and has expressed interest in becoming an operator in the sector.

YELEEN KURA

Brief description: The Decentralized Services Company called SSD-EN Yeelen Kura is a limited company under Malian law created in 1997 by Electricité De France (EDF) and NUON from Netherlands. The purpose of the company is to provide energy services from power generation equipment, on a financially profitable basis to ensure the sustainability of services. Yéelen Kura's activities really started in May 2001. Since 2008, the Rural Energy Services Foundation (FRES) in the Netherlands is the main shareholder for the company. In 2006 with the creation of AMADER, Yeelen Kura launched into mini-grids. Yeelen Kura today has nine hybrid mini-grid projects (three hybridised sites funded by the company, and six financed by the World Bank via AMADER (prior to SHER). All nine also feature storage.

HORONYA SOLAR

Brief description: Horonya Solar is a local company specialised in the construction of renewable energy equipment. They are the first producer and distributer of solar panels in the Malian territory, ranging from 50 to 240W, available in 12 and 24V.

ACCESS

Brief description: ACCESS- SARL is a Malian solar and hybrid energy systems company with ten years of experience in urban and rural electrification. It also constructed mini-grids in partnership with the government and KfW, as well as solar hybrid systems. Its future growth ambitions are the densification of the mini-grid market, extending solar capacity and battery storage, and replicating its model with the government of Mali for further mini-gird projects.

ZED SA

Brief description: ZED SA is a Malian company specialised in electricity, hydraulics, design, construction and installation of equipment. The company offers a wide range of products and services, including: sale of solar, electric or hydraulic equipment sale of compound solutions, installation of equipment, maintenance and after sales services. It also carries out studies of energy consumption in order to propose solutions for optimising consumption. ZED also worked with ECREE on the installation of solar PV stations connected to the main grid, with battery storage options.

OMVS

Brief description: The Organisation pour la mise en valeur du fleuve Sénégal (OMVS; in English Senegal River Basin Development Authority) is an organisation grouping Guinea, Mali, Mauritania and Senegal for the purpose of jointly managing the Senegal River and its drainage basin. The OMVS aims to promote self-sufficiency in food security, to improve the income of the local populations, and to preserve the natural ecosystems.

Table 18. Number of electricity subscribers by location, 2016

Interconnected network			
	Low voltage	Medium voltage	Total
Bamako /Kalanban Coro/Moribabou-gou	314288	1310	315598
Kayes	14905	94	14999
Kita	4785	21	4806
Manantali	549	2	551
Mahina-Bafoulabé	1111	4	1115
Fana	2470	13	2483
Koulikoro	3955	79	4034
Kati	10620	51	10671
Dioila	987	12	999
Tienfala	321	0	321
Selingue	1820	14	1834
Kalana	698	1	699
Yanfolila	1342	4	1346
Ségou	17733	77	17810
Markala	2217	13	2230
Sikasso	13678	91	13769
Koutiala	8867	55	8922
Konobougou	669	0	669
Sanakoroba	740	0	740
Banakoroni	677	0	677
Baguineda	1382	0	1382
Sansanding	526	0	526
Kambila	284	0	284
Niono	4510	0	4522
Dio	93	0	93
Baraoueli	……	……	0
Total interconnected	409 227	1 841	411 080
Isolated centres			
Nioro	2776	11	2787
Gourel	395	0	395
Kangaba	730	3	733
Ouelessebougou	978	5	983
Bougouni	3998	19	4017
Kadiolo	1366	0	1366
Zegoua	1008	6	1014
Koro	1112	7	1119
Bankass	589	27	616
San	3109	4	3113
Tominian	348	0	348
Mopti	12071	20	12091
Djenne	1251	0	1251
Bandiagara	1376	1	1377
Douentza	1210	59	1269
Tombouctou	5937	1	5938

Dire	1334	4	1338
Goundam	852	3	855
Niafunke	808	27	835
Gao	6446	3	6449
Kidal	92	2	94
Ke Macina	879	4	883
Total isolated centres	48665	206	48871
Total EDM	457 892	2 047	459 951

Source: (INSTAT, Annuaire Statistique Mali, 2016)

Table 19. Details of the existing interconnected network, EDM SA

The interconnected network is composed of:

- a 63-kV line linking the towns of Ségou and Niono;
- a 150-kV line linking Bamako to the cities of Fana and Ségou in the East, powered principally by the Sélingué hydro power station;
- a 225kV line (operated by SOGEM) powered by the Manantali hydro plant which also connects Bamako with the towns of Kayes and Kita; and
- another 225kV line in the context of the interconnection with the Ivory Coast (Ferkessedougou), which has enabled the extension of the interconnected network to the cities of Koutiala and Sikasso via the 150kV Bamako-Fana- Ségou network.

The interconnected network is composed of the following power stations:

- Five EDM-SA power stations, two hydroelectric ones in Sélingué and Sotuba (47MW and 5.7MW respectively), and three thermal power stations in Darsalam (36.6MW), Balingué (24.3MW) and another in Balingué (71.6 MW);
- A SOGEM hydroelectric power station in Manatali (200MW of which 104MW is for Mali);
- The Felou hydropower plant (SOGEM, part of Mali under the OMVS) (63MW of which 27.0 MW is for Mali);
- The SOPAM thermal power plant operated by the independent producer of the same name with an installed capacity of 56 MW;
- Aggreko's thermal power plants in Darsalam, Kati and Balingué for 78 MW and SES in Sikasso and Koutiala for 10 MW each, representing an installed capacity of 98 MW in total; and
- The interconnection with the Ivory Coast network for a minimum guaranteed power of 30 MW has been increased to 50 MW by an interim amendment.

Table 20. Extension of the network by voltage, 2015-2025

Year	Voltage (kV)	Network	Size (km)
2017	225	Bamako North and South	166
2017	225	Sikasso – Syama	90
2018	225	Bamako - Sikasso	355
2018	225	Manantali – Bamako	285
2019	225	Kayes – Manantali	354
2019	225	Koutiala – Mopti	300
2022	225	Interconnection Guinea	150
2025	225	Dialakorobougou – Ségou	215
2025	225	Interconnection Guinea	110
2025	225	Interconnection Burkina Faso et Ghana	50
Total	-	-	2075
2019	90	Koumantou - Massigui	55
2020	90	Kayes – Nioro	270

2020	90	Extension network outside of Bamako	46
2025	90	Nioro – Bamako	400
2025	90	Kolokani – Banamba	75
Total	-	-	846
2016	33	Extension network outside of Bamako	254
2017	33		342
2018	33		585
2019	33		541
2020	33		1296
2021	33		47
2022	33		27
2024	33		65
2025	33		579
TOTAL	**-**	**-**	**6,657**

Source: (CREE, 2015)

Table 21. On-grid generation licenses, as proposed in AfDB's review

Declaration	
Hydro	P ≤ 500 kW
Wind	P ≤ 250 kW
Solar PV	P ≤ 150 kW
Authorisation	
Diesel	P ≤ 500 kW
Hydro	500 kW < P ≤ 5MW
Wind	250 kW < P ≤ 5MW
Solar thermal	P ≤ 5 MW
Solar PV	150 kW ≤ P ≤ 5 MW
Biomass	P ≤ 5 MW
Geothermal	P ≤ 10 MW
Waste	P ≤ 5 MW
Concession	
Diesel	P > 500 kW
Hydro	P > 5MW
Other	P > 5 MW

Source: (Tractebel, 2018)

Table 22. Population by locality ('000s), 2016 projection from 2009 census

Locality	Men	Women	Total
Kayes	1,256	1,261	2,517
Koulikoro	1,526	1,532	3,058
Sikasso	1,665	1,672	3,337
Segou	1,473	1,473	2,952
Mopti	1,283	1,288	2,571
Tombouctou	425	427	852
Gao	342	343	685
Kidal	43	43	86
Bamako	1,140	1,145	2,285
Total	**9,244**	**9,097**	**18,341**

Source: (INSTAT, Annuaire Statistique Mali, 2016)

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