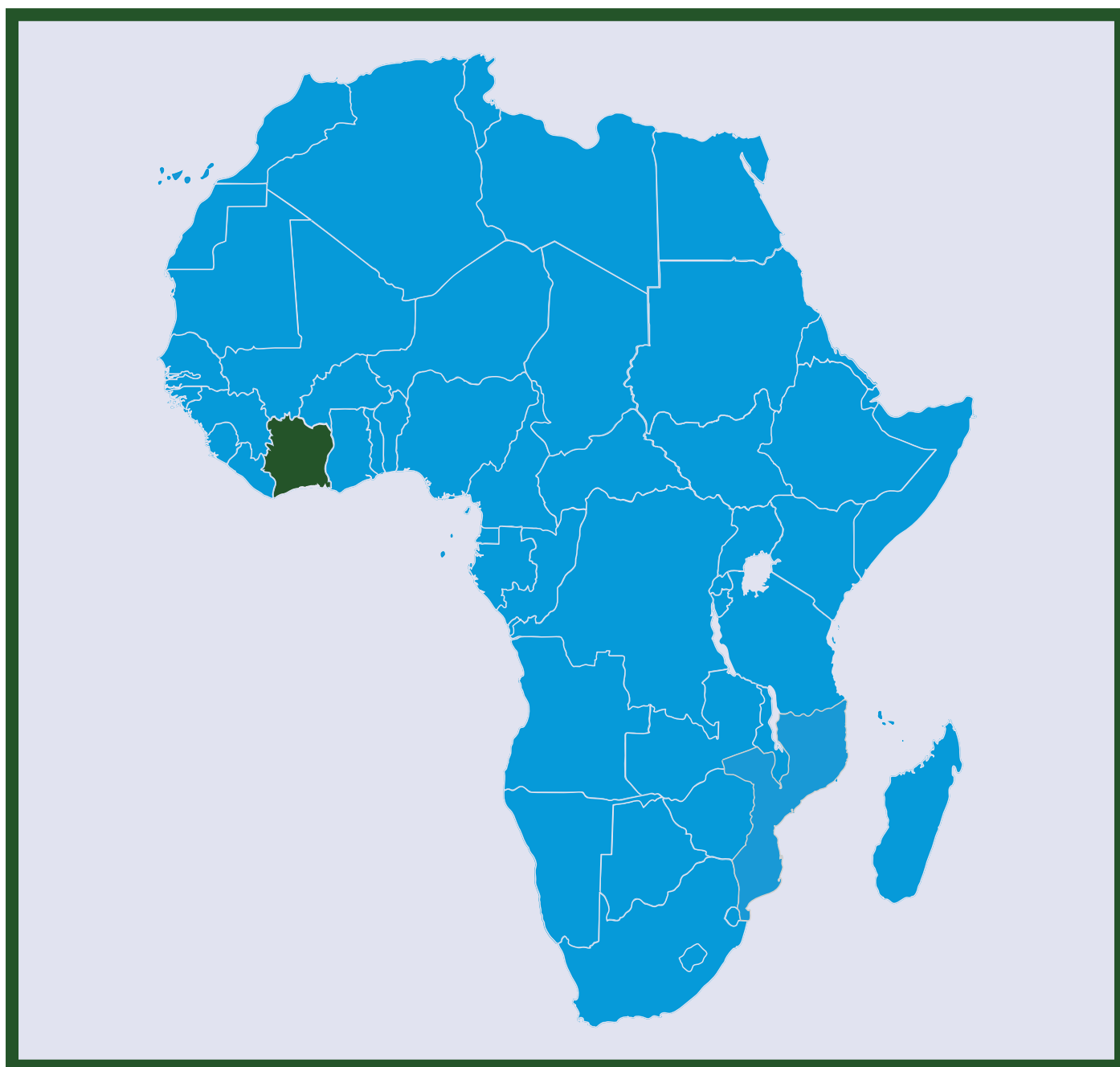


Mini-Grid Market Opportunity Assessment: Côte d'Ivoire

Green Mini-Grid Market Development Programme:
Sustainable Energy Fund For Africa & African Development Bank

February 2019





The Sustainable Energy Fund for Africa (SEFA) is a multi-donor trust fund administered by the African Development Bank to support small - and medium-scale Renewable Energy (RE) and Energy Efficiency (EE) projects in Africa. SEFA supports private-sector led economic growth initiatives under three financing windows: project preparation, equity investments and enabling environment support.



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



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



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



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

The Carbon Trust would like to thank the Côte d'Ivoire Ministry of Petroleum, Energy and Renewable Energy Development, in particular the Directorate General of Electricity, as well as members of the following institutions for further input and support: Compagnie Ivoirienne d'Electricité, CI-Energies, Association Ivoirienne des Energies Renouvelables, Autorité Nationale de Regulation du secteur de l'Electricité de Côte d'Ivoire, United Nations Industrial Development Organisation, BERTRAD, African Development Bank, World Bank, Bank of Africa, USAID, Agence Française de Développement, European Union and Expertise France.

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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 Côte d'Ivoire. 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, who may be required to sell power at prices significantly below the cost of production and delivery. Moreover, it leaves the most remote towns and villages without electricity. The latest Sustainable Energy for All (SEforALL) Global Tracking Framework estimates that the urban-to-rural divide in access to electricity in Africa is as high as 450 percent, with 69 percent of the population in urban areas electrified compared to only 15 percent in rural areas.

There are three principal options for providing new connections to currently unserved populations in Africa: (1) extension of the national grid; (2) installation of separate “mini” grids to operate independently from the main grid; (3) stand-alone generating systems that supply individual consumers (typically Solar Home Systems or SHS). 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 unfavourable policy and regulatory frameworks, barriers to growth of the private mini-grids sector in Africa include the lack of proven business models, market data and linkages, key stakeholder capacity, and access to finance.

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

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

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

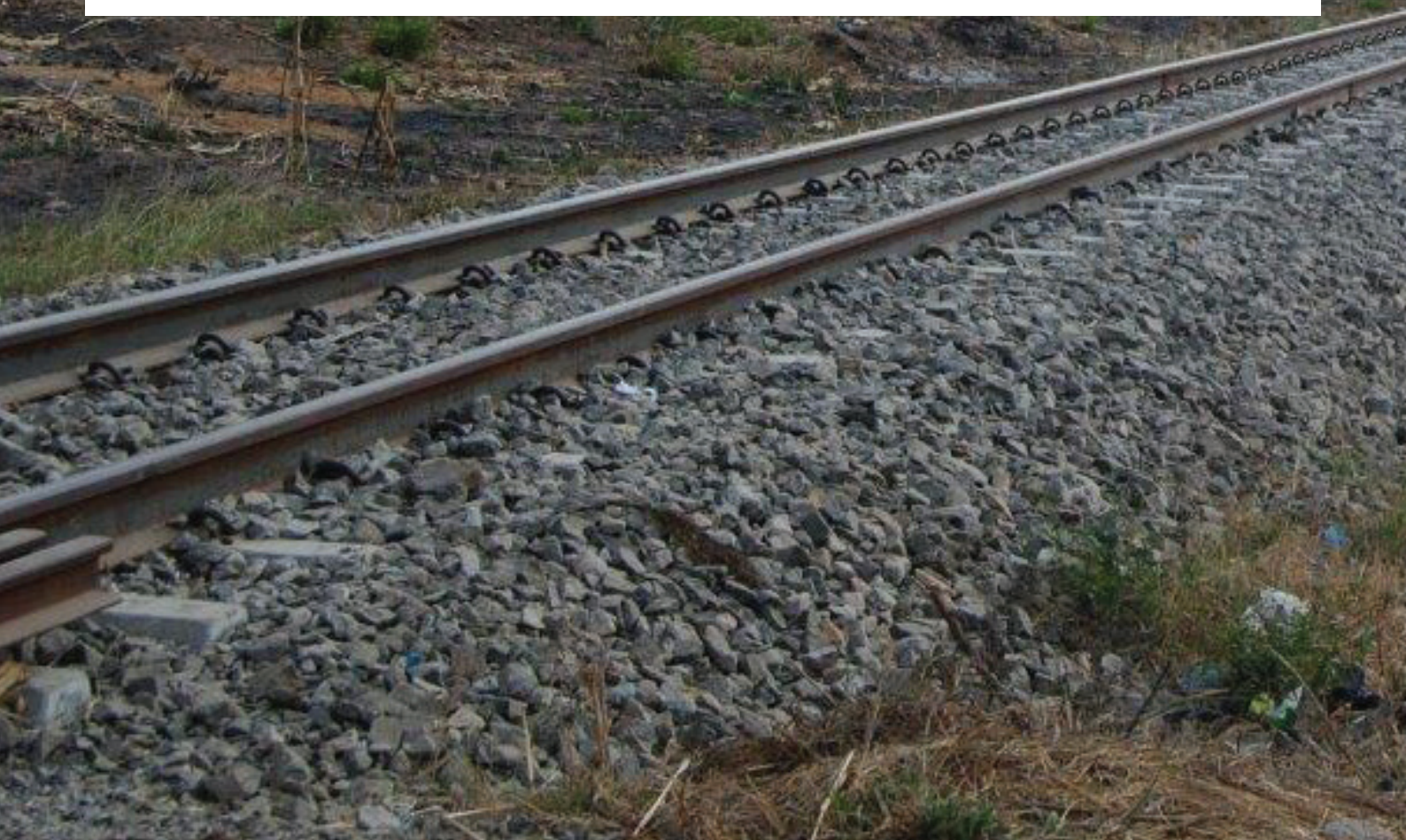
This report was prepared by the Carbon Trust and the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) at the request of the AfDB. It was written by Benjamin Curnier, William Hudson, and Sophie Bordat of Carbon Trust and Yuri Lima Handem from ECREEE. Carbon Trust is a mission-driven organization helping businesses, governments and the public sector accelerate the move to a low carbon economy. ECREEE is a specialised agency of the Economic Community for West African States.

The content of this report was reviewed by Jeff Felten of the AfDB's GMG team and cleared by Dr. Daniel-Alexander Schroth, SEforALL Africa Hub Coordinator at the AfDB. It was edited by Kimberlee Brown.

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

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LIST OF ACRONYMS

| | |
|----------|--|
| AFD | Agence Française de Développement / French Development Agency |
| AfDB | African Development Bank |
| AIENR | Association Ivoirienne des Energies Renouvelables/Ivorian Association for Renewable Energy |
| ANAER-CI | Autorité Nationale de Regulation du secteur de l'Electricité de Côte d'Ivoire/ Côte d'Ivoire's National Electricity Regulation Authority |
| CAPEX | Capital expenditure |
| DEG | Direction Générale de l'Energie/ General Directorate for Energy (DGE) |
| CIE | Compagnie Ivoirienne d'Electricité |
| ECOWAS | Economic Community of West African States |
| ECOWREX | ECOWAS Observatory for Renewable Energy and Energy Efficiency |
| ECREEE | ECOWAS Centre for Renewable Energy and Energy Efficiency |
| ESMAP | Energy Sector Management Assistance Program |
| GIS | Geographic Information System |
| HV | High Voltage |
| INDCs | Intended Nationally Determined Contributions |
| LV | Low Voltage |
| MDP | Market Development Programme |
| MPEDER | Ministère du Pétrole, de l'Energie et du Développement des Energies Renouvelables / Ministry of Oil, Energy and Renewable Energies Development |
| MT | Metric tons |
| MV | Medium Voltage |
| NAMA | Nationally Appropriate Mitigation Action |
| OPEX | Operational expenditure |
| PANER | Plan d'Action National des Energies Renouvelables/ National Action Plan for Renewables |
| PAT | Plan Directeur Automatisation et Téléconduite/ Distribution Automated and Remote Control Master Plan |
| PDD | Plan Directeur de Distribution / Distribution Master Plan |
| PDER | Plan Directeur d'Electrification Rurale / Rural Electrification Master Plan |
| PDPT | Plan Directeur Production et Transport / Production and Transmission Master Plan |
| PEPT | Programme d'Electricité Pour Tous (Electricity for All Programme) |
| PPA | Power Purchase Agreement |
| PPP | Private Public Partnership |

| | |
|---------|---|
| PRODERE | Programme de Développement des Energies Renouvelables et d'Efficacité Energétique/ Programme of Renewables and Energy Efficiency Development |
| PRONER | Programme d'Electrification Rurale / National Rural Electrification Programme |
| PV | Photovoltaic |
| SE4ALL | Sustainable Energy for All |
| SIDEES | Société d'Ingénierie et de Distribution d'équipements électriques et solaires / Engineer and distribution of solar and electric equipment company |
| UEMOA | Union Economique et Monétaire Ouest Africaine / West African Economic and Monetary Union |
| UNDP | United Nations Development Program |
| UNEP | United Nations Environmental Program |
| UNIDO | United Nations Industrial Development Organisation |
| WAPP | West African Power Pool |

EXECUTIVE SUMMARY

This country report is one of a series of country reports under the Market Intelligence business line of the African Development Bank's Green Mini-Grid Market Development Programme (GMG MDP). The MDP has the ultimate objective of fostering access to electricity across Africa by promoting the development of green mini-grids where they represent a technically and economically better option than the extension of the main grid. The Market Intelligence business line aims to provide comparable, actionable data on the potential for GMGs across countries in Sub-Saharan Africa (SSA). This report provides an analysis for Senegal. 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. A thorough assessment must include several criteria that are driven by the particular business model and approach of the implementing agency for each case. This report 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.

In 2017, Côte d'Ivoire had an estimated population of over 24.3 million people and a landmass of 322,462 km². Côte d'Ivoire's urban population represents up to 50.8% of the total population (CIA, 2018), with high annual population growth of approximately 2.6%. The country is divided into 31 regions and is considered politically stable since its politico-military crisis in 2011. It is located on the south coast of West Africa. It borders Guinea and Liberia to the west, Burkina Faso and Mali to the north, Ghana to the east, and the Gulf of Guinea (Atlantic Ocean) to the south.

Côte d'Ivoire is one of the fastest growing economies in the region with a growth rate of 8% in 2016, 7.6% in 2017 and 7.5% in 2018. GDP was estimated at US\$ 40.3 billion in 2017 and the country is the second largest economy in West Africa after Nigeria, (World Bank, 2018). Services are the biggest contributor to Côte d'Ivoire's GDP representing 53.3%, followed by industry 26.6% and agriculture 20% (CIA, 2018).

Agriculture related activity has been the biggest contributor to the country's growth. Côte d'Ivoire is the world's largest producer and exporter of cocoa beans, as well as a significant exporter of coffee beans and palm oil amongst other commodities. As a consequence, Côte d'Ivoire's economy is highly vulnerable to fluctuating commodities prices and, more seriously, impacts relating from long term climate change: changing rainfall patterns and rising temperatures are both affecting agricultural outputs.

Côte d'Ivoire's total annual primary energy consumption is c.12.7 Mtoe, with 9.4 Mtoe from biomass and waste (75%). Electricity contributes around 4.5% to the national energy balance. The country's per capita electricity consumption in 2013 was at 252kWh. Despite recent economic growth, these figures remain below the regional average (Sub-Saharan Africa's average: 552kWh per capita, global average: 2,975kWh per capita).

Despite low domestic electricity consumption, Côte d'Ivoire is the biggest electricity producer in the region, and a net exporter of power production. In 2015, Côte d'Ivoire exported 10% or 849GWh of its power production to neighbouring countries: Mali, Ghana, Benin, Burkina Faso, Liberia and Togo (RECP, n.d.). These exports are also expected to increase as Côte d'Ivoire is part of the West African Power Pool (WAPP); in 2019, a new transmission line is planned to be commissioned to connect Côte d'Ivoire, Liberia, Sierra Leone and Guinea. Electricity production is dominated by hydropower and natural gas which is sourced from national offshore gas fields.

Despite the introduction of the new Code D'électricité in 2014 which liberalised the energy market in Côte d'Ivoire, electricity generation, transmission and distribution remain a de-facto monopoly under a single contractor. Electricity infrastructure is developed and run by CI-Energies, the government energy agency, working under instruction from the Ministry of Petroleum, Energy and Renewables. The running of the infrastructure (generation, transmission and distribution) is presently undertaken by a single monopoly contractor, Compagnie Ivoirienne d'Electricité (CIE), whose present concession will expire in 2020. In addition to CIE running some of the generation assets, energy is also purchased

by CI-Energies from a small number of private IPPs. In order to fully liberalise the market, several Decrets d'Application for the 2014 law must still be developed and published, to detail how the liberalised market will be run. These are presently under development, and are expected during the course of 2019. In any case, these will need to be in place before the end of CIE's operation concession.

Today, Côte d'Ivoire has one of the most dense electricity networks in West Africa, with an overall national electrification ratio of 64% (92% in urban areas and 38% in rural areas). This is one of the highest rates in Sub-Saharan Africa. Despite relatively high electricity access rates, the share of household connections remain low, with as few as 30% of people connected to the grid. This is because connection to a household and installation of a meter is a paid-for service, the cost of which has remained prohibitive for many rural households. The recently introduced Energie Pour Tous (Energy for All) has dramatically reduced the cost for connection, and has prompted 400,000 connections between 2014 and 2018.

Côte d'Ivoire has sixty diesel mini-grids which are run by the CIE, the private monopoly concessionaire tasked with generation, transmission and distribution on behalf of the state. A further seven GMGs, developed with funding from the EU and UNIDO are presently operating under a community-owned model. Technically, these sites are in 'legal limbo', and should have been given to the CIE for operation, however this pilot is being permitted as all stakeholders are interested to explore alternative ownership models. Further GMGs are presently under development, but these are expected to be transferred to the CIE for operation once they have been constructed.

The government's main instrument for rural electrification, the Plan Directeur d'Electrification Rural (PDER - Electrification Master Plan) continues to promote rural electrification through grid extension, predominantly due to the network density across the country. However, GMGs have been identified as the favoured approach in approximately 100 localities which are situated further than 20 km away from the grid, or where further grid connections would result in poor quality of service from the main grid.

To date, rural electrification plans have only focused on 'formal' localities, neglecting c.5million inhabitants who live in 80,000 informal settlements across the country recognised as 'campements'. Technical assistance from Power Africa has identified the potential for a further 100 or so mini-grids in these locations, and has drafted an updated electrification strategy to be approved and published in 2019. As at January 2019, there is therefore no regulatory and concessionary framework for mini-grids. Looking forward, concessions regimes for mini-grid developers will have to be defined and the sector is awaiting for an application decree expected in 2020 to clarify this issue.

Our analysis estimates that 462,000 people (2% of the non-electrified population) will be best served by mini-grid solutions in Côte d'Ivoire; a relatively small market given existing grid coverage. A further 556,000 people (2.5% of the non-electrified population) will be best served by solar home systems (SHS) and 19.7 million people (95.5% of the non-electrified population) will be best served by grid extension, based on proximity to the existing grid. This calculation is based on current grid coverage² only; any planned grid extensions will reduce the estimated market size. Over 65% of the Ivorian mini-grid market is in the Montagnes, Sassandra-Marahoue and Vallée du Bandama West and Central districts, due to limited grid coverage and population densities high enough to support mini-grids. 127,000 and 128,700 people will be most economically served through mini-grids in Montagnes and Sassandra-Marahoue respectively, corresponding to around 5% of the population in each district. The districts with the largest percentage of the population best served by SHS technologies are Zanzan and Woroba, at 15% and 8% respectively.

This report estimates an annual mini-grid market size of USD \$5.9 million in Côte d'Ivoire, based on an average mini-grid tariff of USD \$0.09/kWh, and average household demand per day of 2.2kWh. This implies per capita annual electricity expenditure of \$12.8 within the population best served by mini-grids. Based on an estimated cost-reflective tariff of \$0.4/kWh across SSA, it is therefore estimated that **75% of project costs would need to be covered by subsidy (approximately \$57m annually)** to open up the mini-grid market to developers (lifetime project costs – with subsidy covering both CAPEX and OPEX).

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-GRIDS MARKET DEVELOPMENT PROGRAMME

The African Development Bank's (AfDB) Green Mini-Grids Market Development Programme (GMG MDP) aims to foster access to electricity across Africa. The MDP 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 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

Côte d'Ivoire is a coastal country in West Africa, with a total area of 322,462 km², and a population of 24.3 million people (World Bank, 2017). Côte d'Ivoire is bordered by Liberia and Guinea to the west, Mali and Burkina Faso to the north, and Ghana to the east. It also has a 550 km southern coastline, facing the Atlantic Ocean.

Most of the population is concentrated in the forested southern half of the country. The country is divided into 14 districts and 31 regions; Yamoussoukro is the legislative capital of the country with 230,000 inhabitants and Abidjan is the administrative and economic capital with 4.9 million inhabitants. Abidjan is additionally the main port and largest city in the country. Côte d'Ivoire is a young country with around 60% of the population under 25 years old (CIA, 2018); like most West African countries, it has a high urbanisation rate of around 3.4% annually. Today's urban population represents up to 50.8% of total (CIA, 2018). Annual population growth is approximately 2.6%. Côte d'Ivoire's population density, districts and regions are illustrated in figure 1 and 2 respectively.

Figure 1: Côte D'Ivoire's population density (CIA, 2018)

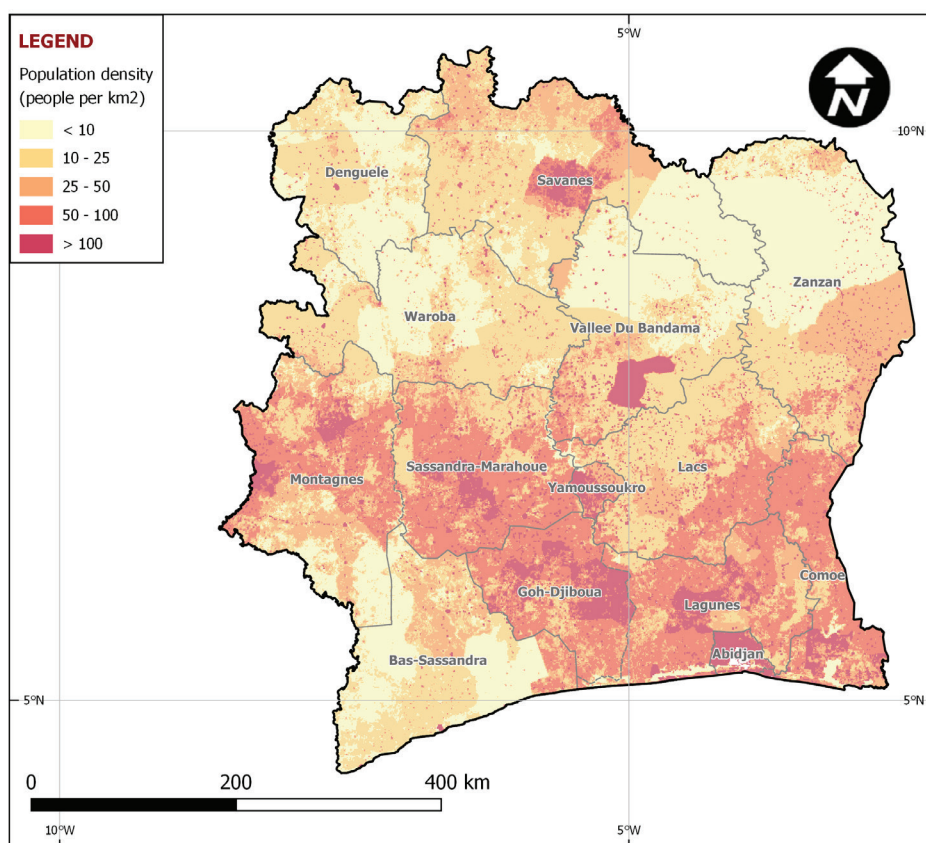
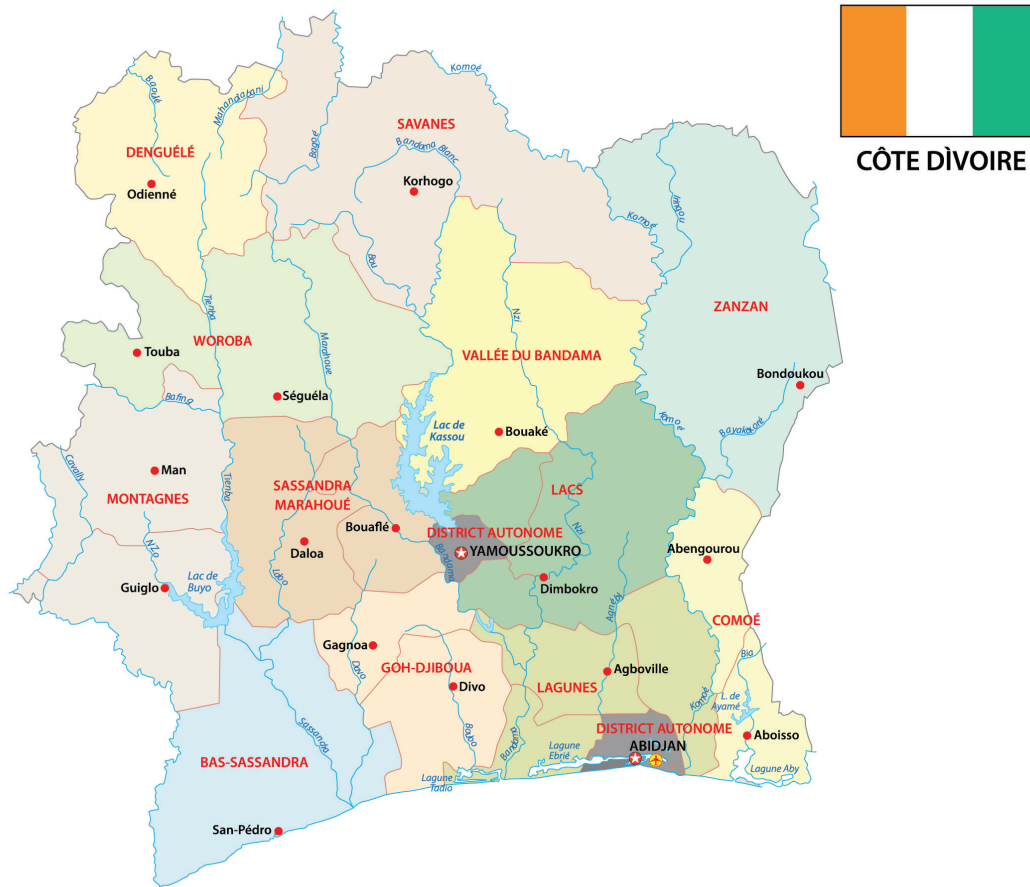
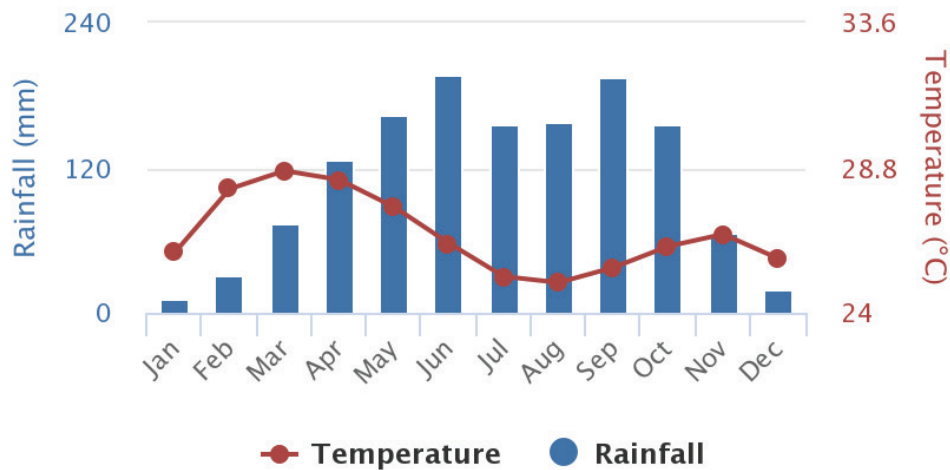


Figure 2: Côte D'Ivoire's administrative map (regions and districts)



Côte d'Ivoire is mostly flat with semi-arid and tropical climates in the northern and southern areas of the country respectively. Côte d'Ivoire's mean elevation is 250m, with its highest peak being the 1,752m Mont Nimba in the North Western region. Annual temperatures vary between 20 and 30 degrees Celsius, with the climate characterised by three seasons: warm and dry from November to February, hot and dry from March to April, and wet from June to October (UNEP, 2015). Côte d'Ivoire's landscape is characterised by tropical forests occupying 4.2 million hectares (37.5% of overall land area in 2011) (UNEP, 2015).

Figure 3: Average monthly temperature and rainfall for Côte d'Ivoire, 1991-2015 (World Bank, n.d)



Climate change impacts mean that environmental degradation and deforestation are major challenges that the country is facing today. The tropical South is being impacted by intensifying flooding affecting both people's health and agriculture. Conversely, droughts are increasing in the northern savannah, stressing water resources.

While Côte d'Ivoire has an extensive national road network of over 82,000 km, only 6,520 km of roads are paved (with just 136km of motorways). Over 5,000 km of the tarred roads are deemed to be in extremely poor condition; this is a significant constraint for industries and exports (Republique de Côte d'Ivoire, 2016).

In terms of other infrastructure, the Abidjan Autonomous Port is the major industrial hub of the country and is also a major economic growth driver as it constitutes 90% of Côte d'Ivoire's customs revenue and hosts 65% of the country's industrial activities (World Bank, 2018). Again, the port needs rehabilitation to improve passage and access.

Côte d'Ivoire has one of the most developed telecommunication sectors in West Africa: in 2015, mobile penetration rate was estimated at 99.5% (US Export.gov, 2017). Mobile network providers provide coverage for all urban and most rural areas, although signal quality varies significantly. The country counts approximately 33.3 million subscribers served by three mobile phone operators; Orange, MTN and MOOV (ARTCI, 2018).

Côte d'Ivoire is ranked as having the fastest growing economy on the African continent, with a growth rate of 7.6% in 2017 (World Bank, 2018). Côte d'Ivoire's GDP was estimated at US\$ 40.3 billion in 2017; the second largest economy in West Africa after Nigeria, and the largest economy in the West African Economic and Monetary Union (World Bank, 2018). Services are the biggest contributor to Côte d'Ivoire's GDP (53.3%), followed by industry (26.6%) and agriculture (20%) (CIA, 2018).

Despite the relatively low agricultural economic share (compared to other countries in SSA), agricultural activity is the largest recent contributor to the country's economic growth. Côte d'Ivoire is the world's largest producer and exporter of cocoa beans, and a significant exporter of coffee beans and palm oil among other commodities. Nearly half of Côte d'Ivoire's GDP relies on exports with cocoa being the leading export. Much of 2017's GDP growth was thanks to international price increases for most Ivorian exported products, as well as higher than usual rainfall resulting in a strong agricultural output.

The Ivorian economy is vulnerable to external price volatility, political risks and climate. Côte d'Ivoire is vulnerable to international prices of agricultural and mining products. For example, in 2016 cocoa prices decreased by 33.6% which heavily impacted the Ivorian economy: cocoa bean exports represent around 1/3 of the country's total exports and contribute 10% to GDP (World Bank, 2018). Similarly to other neighbouring countries, Côte d'Ivoire is also vulnerable to terrorism: in 2016, the country was hit by a jihadist attack in the southern part of the country. Finally, the economy is vulnerable to changing climatic conditions, given significant reliance on agriculture.

In 2018, Côte d'Ivoire was ranked 170th among 189 countries on the United Nations Human Development Index. Between 1998 and 2011 the proportion of the population living in poverty rose significantly, from 10% to over 50%, due to the impact of five years of civil war between 2002 and 2007, followed by a further military and political crisis in 2010. Since 2011, the country has remained stable politically and economically; however, high rates of poverty have remained. Poverty is more pronounced in rural areas than in urban areas, where 56.8% of the rural population is considered poor against 35.9% of the urban population. (AfDB, 2018).

Côte d'Ivoire is a Presidential Republic. President Alassane Ouattara and his party Rassemblement des Républicains (Republicans Union) have ruled Côte d'Ivoire since 2010 (most recently winning an election in 2015). Presidential elections occur every five years through a popular vote system, with the next election due in 2020. Political engagement, however, appears to be low and there is high vote abstention in the country, potentially exacerbated by occasional calls for boycotts by some opposition activists. Overall, the Ouattara government has been internationally recognised as effectively governing the country (BTI, 2018). However, former rebel commanders and militia members who played a major role in the military victory over Gbagbo in 2011 have maintained strong influence in the country. In particular with security forces, former rebels have a level of power over ex-rebels within the army and local police either through informal networks that deploy informal check points on roads or official connections.

In 2015, Côte d'Ivoire's Plan National de Développement 2016-2020 (PND- National Development Plan) was launched. Approximately ~US \$51.7bn were allocated to transform Côte d'Ivoire into a middle-income economy by increasing agricultural output and promoting the manufacturing sector. The plan also seeks to increase private & public investment and further attract FDI to reinforce current transport, ICT and energy infrastructure. The World Bank has supported the national development plan with US\$ 125 million International Development Association credit to focus on fiscal policy, education and energy. For the fiscal component of this technical support, operations have shown positive progress by removing several VAT exemptions to bring a gain of FCFA 18 billion (or US\$ 31 billion), increasing the number of taxpayers and reducing the average delays in public procurement.

Côte d'Ivoire is a challenging country in which to do business, ranked 122nd in the world according to the World Bank in 2019. Obstacles to doing business include difficulty acquiring permits, limited electricity access, protection of minor investors, property rights, amongst others. However, since 2012 the country has improved regulatory and institutional frameworks for Public Private Partnerships (PPPs) via a new investment code, as well as launching other sector-specific codes (oil, electricity, TIC, and mining). The government has also taken steps to improving relations with the private sector through introduction of a Private Sector Consultative Committee (de Concertation Etat-Secteur Privé (CCESP)), as well as launching a new infrastructure fund (Fonds de Développement des infrastructures Industrielles (FODI)).

2.2 OVERVIEW OF THE ENERGY SECTOR

2.2.1 ENERGY MIX, EMISSIONS AND TRENDS

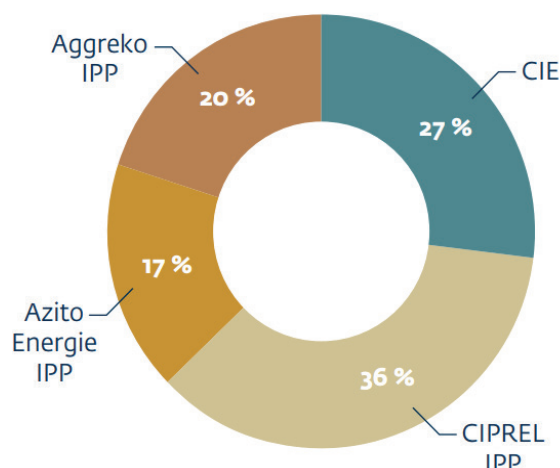
Côte d'Ivoire's total annual primary energy consumption is c.12.7 Mtoe, with 9.4 Mtoe from biomass and waste (75%), 1.9 Mtoe from natural gas (14.9%), 1.3 Mtoe from oil (10%), and 0.13 Mtoe from hydropower (0.1%) (IEA, 2018). Electricity contributes ~4.5% to the national energy balance. Per capita electricity consumption is amongst the lowest in the world at 252kWh per capita per year (Sub-Saharan Africa's average: 552kWh per capita, global average: 2,975kWh per capita). The residential sector has the highest share of electricity consumption in the country (34.5%), followed by commercial and public services (33.1%) (RECP, n.d.).

Table 1: Electricity Consumption in 2014 per Economic Sector (RECP, n.d.)

| Economic Sector | GWh | Percentage (%) |
|--------------------------------------|--------------|----------------|
| Industry | 1,738 | 30.0 |
| Transport | - | - |
| Residential | 2,003 | 34.5 |
| Commercial and Public Services | 1,923 | 33.0 |
| Agricultural /Forestry | 144 | 2.5 |
| Fishing | - | - |
| Other non-specified | - | - |
| Final Electricity consumption | 5,808 | 100 |

Today's electricity generation mix is dominated by gas-fired power. Despite significant hydropower capacity, the generation mix is dominated by gas. Natural gas independent power production represents over 60% of total Ivorian production while hydro production is 40% (with around 27% capacity factor) (IFC, 2018). The gas fuel is sourced from government owned offshore gas fields, typically at discounted or zero cost. In this way independent power producers (IPPs) do not have to pay for gas used for electricity production and ultimately, the subsidy passes through the market and consumers.

Figure 4: Generation actors' share of power production (IFC, 2018)



The power demand in Côte d'Ivoire has grown at an average of 11 percent per year since 2011, outpacing average annual GDP growth of 9% (IFC, 2018). This trend is expected to increase at an annual rate of 10% per year to 2020, with growth in electricity consumption largely driven by an increase of energy exports and intensification of industrial activity. Côte d'Ivoire is a net electricity exporter, with 10% or 849GWh of power being sold to neighbouring countries: Mali, Ghana, Benin, Burkina Faso, Liberia and Togo (RECP, n.d.). Exports are expected to increase as Côte d'Ivoire is part of the West African Power Pool (WAPP) and, in 2019, a new transmission line is planned to be commissioned to connect Côte d'Ivoire Liberia-Sierra Leone-Guinea.

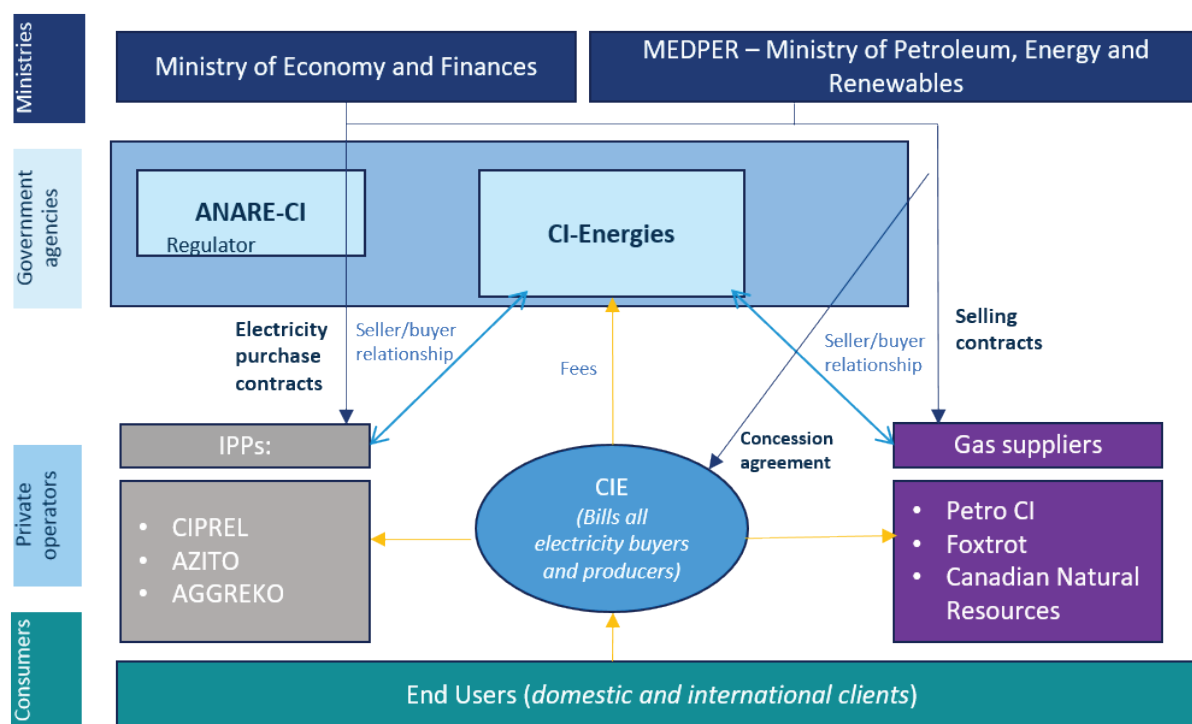
Categorised as a Least Developed Country (LDC) by the United Nations (UN), Côte d'Ivoire's contribution to global greenhouse gas (GHG) emissions and GHG emissions per capita are both very low when compared to global averages, estimated as 0.1% and 0.81tCO₂e respectively. Nonetheless, in its Intended Nationally Determined Contribution (INDC) document, submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2015, Côte d'Ivoire has committed to a low emission development trajectory with the objective of cutting greenhouse gas (GHG) emissions by 28% below the business as usual (BAU) scenario by 2030. Priority sectors for emissions cuts are the energy sector (-8%), agricultural sector (-7%), and transport sector (-6%). To support this objective, the National Development Programme 2016-2020 aims at attracting \$32 million in private investment into renewable energy (RE), delivering a 42% RE in the national energy mix by 2030. The country's NDC calls for 400 MW of solar development by 2030, but supportive policies for this target are limited (IFC, 2018).

2.2.2 KEY ENERGY AND ELECTRICITY SECTOR STAKEHOLDERS

Despite liberalisation being provided for in the new law of 2014, the sector remains dominated by a small number of governmental and private sector actors:

- **The Ministry of Oil, Energy & Renewable Energies Development (MPEDER) has overall responsibility for the energy sector in Côte d'Ivoire.** MPEDER is responsible for developing policies, initiating legislation and inspecting the energy sector overall.
- **Sitting under MPEDER, CI-Energies is the government's implementation agency** which owns all the public assets of electricity production, transport and distribution. CI-Energies is responsible for tracking the financial situation of the sector, planning and implementing all grid extension or rural electrification projects. CI-Energies is also responsible for contracting IPPs to buy energy for the national grid.
- **CIE is the private monopoly concessionaire** that operates the grid on behalf of CI-Energies. Under its 15-year licence, it manages and operates some generation assets, manages the transportation network (grid), and conducts all the distribution and billing to end users.
- **ANARE-CI is the independent regulatory agency** of the electricity sector in Côte d'Ivoire that sets tariffs and supervises compliance with all energy laws and regulations

Table 2: Key energy and electricity stakeholders in Côte d'Ivoire



Côte d'Ivoire's liberalisation of the electricity sector was initiated by the 1985 Electricity Law, allowing the transmission and distribution of electricity to be conceded to a private sector operator. In 1990, management and operation of the grid network was conceded to CIE, a private sector operator that has been responsible for managing the network through two consecutive 15-year concession agreements (with the present concession ending in January 2020).

CIE is responsible for operating and maintaining power plants owned by the government, including national transmission grid and distribution networks. It also provides commercial services related to electricity supply and customer service, and project delivery for expanding and replacing network infrastructure. Since 1990, CIE has received a management fee per unit of electricity sold and collected, provided from government funds.

After handing the monopoly of transmission and distribution networks to CIE, the government first signed concessions with IPPs in 1994. Subsequently, the proportion of IPPs sourced electricity has grown over time and increasingly Côte d'Ivoire has been able to respond to domestic demand and exporting energy to neighbouring countries.

In the late 1990s, the first national electricity regulatory authority was created, named the **Autorité National de Régulation du Secteur de l'Electricité (ANARE)**. ANARE was replaced by the **Autorité National de Régulation du Secteur de l'Electricité de Côte d'Ivoire (ANARE-CI)** in 2016 (via Application Decree N° 2016-785 as a fully independent body in terms of management and decision making. Responsibilities include:

- Control and enforcement of laws and regulations, as well as obligations and engagements of actors within the electricity sector;
- Protection of the interests and rights of users of the public electricity service;
- Proposal of tariffs for the electricity sector including tariffs for off-grid electricity access;
- Advising the Government regarding regulation of the electricity sector.

In 2014, the n°2014-132 Electricity Law was passed with the aim of increasing private sector participation in electricity production, including in off-grid electrification. The Electricity Code (within the n°2014-132 Electricity Law) was brought into effect, replacing the outdated Electricity Law of 1985 by liberalising transmission and distribution networks for private sector participation. This law also made allowances for progressive electricity tariff adjustments, in order to gradually implement cost-reflective tariffs.

Much of the detail as to how ongoing electricity market liberalisation will take place, and how private sector actors can participate, is yet to be delivered. Only a limited number of Decrets D'Application have been proposed. Specifically ownership, governance and technical structures permitting private sector ownership of assets remain to be determined and defined. It is widely anticipated that much of the detail must be developed during 2019, as in 2020, CIE's second 15-year concession will come to an end.

In 2016, Application Decree n°2016-787 made provision for private sector ownership and operation of mini-grids. This decree stipulates that all companies wishing to distribute or commercialise mini-grids and standalone systems have to obtain a concession under specific terms and conditions provided by CI-Energies. However, the nature of these terms and conditions (e.g. permitting structures, permitted tariff regimes etc.) are unknown.

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

Energy sector activities in Côte d'Ivoire are governed by the 2013 National Energy Policy and 2014 Electricity Code. The National Policy objective for Côte d'Ivoire was to become an energy hub in West Africa through three interventions:

1. Restoring financial viability of the energy sector through tariff adjustments and loss reduction;
2. Securing sufficient electricity generation and improve demand side management;
3. Improving the sector institutional framework.

Following release of the National Energy Policy, the 2014 Electricity Code liberalised generation, transmission and distribution dispatching activity under state monopoly as explained in the section 2.2.2 above.

Following the National Energy Policy, in 2016 Côte d'Ivoire developed four master plans designed to overcome the sector's challenges, focusing on improving transmission and distribution networks, and expanding electricity access and generation capacity. CI-Energies was responsible for the four master plans:

1. Plan Directeur Production Transport (The Electricity Production and Transport Master Plan, PDPT);
2. Plan Directeur Electrification Rurale (The Rural Electrification Master Plan, PDER);
3. Plan Directeur Distribution (The Distribution Master Plan, PDD);
4. Plan Directeur Automatisme et Teleconduite (The Distribution and Automated Systems / Remote Control Master Plan, PAT).

Unfortunately these master plans are not yet public; current understanding of them is based on stakeholder engagement.

The four master plans together have identified 66 potential energy sector projects with total estimated investment need of c.US\$3 billion (World Bank, 2018). Of this, around US\$2 billion has been estimated for transmission expansion, US\$680 million to upgrade urban distribution, and a further US\$675 million for rural electrification (World Bank, 2018). Upgrades are largely based on forecasts of growing demand from rural electrification, industrial growth and increasing regional demand. Several development finance institutions including the AfDB, Agence Française de Développement (AFD – French Development Bank), the European Union, the West African Development Bank and the World Bank have committed over US\$1 billion to support implementation of the four master plans by investing in transmission lines, substation expansion and rural electrification.

The Rural Electrification Master Plan (PDER) has ambitious objectives to electrify all ‘Lotie’³ villages by 2020, which is unlikely to be achieved. The PDER’s main objectives include:

1. All villages of 500 or more households in 2,112 localities be electrified by the end of 2017;
2. All households living in the vicinity of a MV line should be electrified;
3. All Ivorian villages or communities should be electrified by 2020.

In 2018 it was estimated that 849 villages of over 500 households still needed to be electrified, against the initial target of 2,112 by the end of 2017 (World Bank, 2018).

Historically, the government’s main electrification programme has been the Programme National d’Electrification Rurale (PRONER – National Rural Electrification Programme), launched in 2014. PRONER represents an initial government commitment of \$675 million of five years, with the aim to electrify all localities with over 500 inhabitants for an electricity penetration rate of electricity of 80% by 2020 (World Bank, 2018). The original target of the programme was to electrify 500 new localities per year to 2020. So far, in part thanks to donor support, 1,249 villages have been electrified over a four-year period (2011-2015) (World Bank, 2018); a further 800 communities are still to be electrified.

Alongside PRONER, the president also launched the presidential Electricite Pour Tous programme (Electricity For All) in 2014, designed to increase numbers of household connections. Although electricity availability across Côte d’Ivoire is high, individual household access to electricity remains low due to high connection and meter installation costs (150,000 CFA or \$250). The programme used donor money to create a revolving fund, subsidising the connection cost for low-income Ivorians, and reclaiming the subsidy through fixed charges on the bill over a 10-year period. The objective was to connect 200,000 households every year between 2014 and 2020. By 2018, 400,000 new connections had been made. The government plans on connecting a total of 1 million households through the programme by 2020 (USAID, 2018).

Both the PDER and the PRONER before it heavily favour rural electrification through on-grid extension. Nevertheless, the PDR acknowledges that some other systems (mini-grids and SHS) may need to be used in certain circumstances. The plan has identified 96 sites which could be electrified through mini-grids specifically. These were selected on the basis of being over 20kms from the grid, or being in locations where connecting to the grid would cause unacceptable voltage drops in the grid (over 10%).

In August 2019, the government held public consultation workshops to validate and finalise new strategic documents for the development of renewable energy and off-grid electrification, including the PDER, and the application decrees for off-grid electficiation (see further details later in this document). Documents that were reviewed and validated included:

- A new sector policy document for the development of Renewable Energies and Energy Efficiency
- PDER
- The application decree № 2016-787 fixing the typology of installations, terms of subscription, exploitation, invoicing, payment and cancellation
- The decree fixing penalties for non-compliance to performance indicators by concessionaires distributing electricity from solar stand alone, micro and mini-grid systems production
- The application decree N°2016-783 that authorises auto-production of electricity and sets conditions for auto-producers to sell excess production back to the national grid

3 Lotie villages are recognised villages characterised as having brick constructions, solid roofs, a school and a health centre with a population of 500 inhabitants, as opposed to informal settlements denominated as ‘campements’, further detail on the administrative definition for these two denominations is provided in section 2.4.

2.3 OVERVIEW OF THE POWER SECTOR

2.3.1 CONTEXT

There is a gap between wide electricity coverage and connections in Côte d'Ivoire. Electricity coverage⁴ in Côte d'Ivoire was high 78% as opposed to an electricity access rate⁵ of 29% in 2017 (World Bank, 2017). This gap indicates that a significant part of the population in electrified areas do not have a grid connection despite proximity to the grid. This is particularly the case in rural areas due to the fact that individual household connection (and meter installation) remains a paid for service, and is estimated to cost FCFA 150,000 (US\$ 250). Most urban populations have grid coverage at a rate of 92%, compared to rural areas at 38%; nearly half of the population lives in urban areas.

Table 4: Evolution of the urban, rural and national electricity access, 2012-2016 (Se4All, 2017)

| | 2012 | 2014 | 2016 |
|-------------------------------|-------|-------|-------|
| Urban electrification rate | 88.1% | 84.0% | 92.0% |
| Rural electrification rate | 29.0% | 36.5% | 38.0% |
| National electrification rate | 55.8% | 61.9% | 64.3% |

To achieve 100% electrification, Côte d'Ivoire is focussing on supporting those who cannot afford the connection fee. As mentioned earlier, the presidency launched its *Programme d'Electricite pour Tous* (PEPT- Electricity for All Programme) in 2014 with funding from World Bank, Government of Côte d'Ivoire and EU for an amount of US\$ 4.7 million. This involved setting up a revolving fund, to reduce the connection cost from FCFA 150,000 (US\$ 250) to only FCFA 1,000 (US\$ 1.75), with the remainder of the connection cost paid as additional charges to the electricity bill over 10 years (World Bank, 2017). The government claims 400,000 new connections were achieved by 2018 and the programme aims to connect 1 million people to the grid by 2020.

2.3.2 GENERATION

Côte d'Ivoire has the third largest electricity generation capacity in West Africa, following Nigeria and Ghana. Total installed capacity is 2,199MW. This is mostly run on natural gas, predominantly sourced from national off-shore reserves, with the remainder sourced from hydropower. However, the country has high potential to further develop renewables, according to projections, and the government has identified over 30 hydropower projects for an additional installed capacity of 1,684 MW (IFC, 2018) over the next 10 years. The Ministère du Pétrol, de L'Energie et du Développement des Energies Renouvelables (Ministry of Oil, Energy and Renewable Energies Development (MPEDER)) also plans on developing at least 81 MW of mini-hydro projects (projects with an installed capacity varying between 100 kW and 100 MW) (IFC, 2017). The latest hydropower plant in Soubré was commissioned in 2017 and is the largest in the country (275 MW), followed by the Taabo (210 MW) and Kossou plants (174 MW), as shown in Table 5 below.

4 Electricity coverage = number of people living in villages electrified / total number of people

5 Electricity access rate = number of households connected/total number of households

Table 5: Installed electricity generation capacity in Côte d'Ivoire, 2017 (IFC, 2018)

| Plant | Type | Installed Capacity (MW) | % of total |
|---------------------------------|-------|-------------------------|-------------|
| Soubré | Hydro | 275 | 13% |
| Taabo | Hydro | 210 | 10% |
| Kossou | Hydro | 174 | 10% |
| Buyo | Hydro | 165 | 8% |
| Ayame 1 | Hydro | 20 | 2% |
| Ayame 2 | Hydro | 30 | 2% |
| Faye/Grah | Hydro | 5 | 0% |
| Total Hydro | | 879 | 42% |
| CIPREL | Gas | 569 | 26% |
| Azito Energie IPP | Gas | 441 | 20% |
| Aggreko IPP | Gas | 210 | 10% |
| Vrdi Tag 5000 | Gas | 100 | 5% |
| Total gas | | 1,320 | 60% |
| Total installed capacity | | 2,199 | 100% |

In addition, Côte d'Ivoire has c.55-60 operating diesel mini-grids. All of these diesel mini-grids are operated by CIE and have a capacity varying from 20kW to 110kW. All sites are operational but only provide electricity at certain times of the day, often at night from 6pm to 6am. Recurrent fuel provision and delays in maintenance intervention are the main operating problems of the sites. Plans made to overcome these challenges are to connect all of sites to the main grid by 2020.

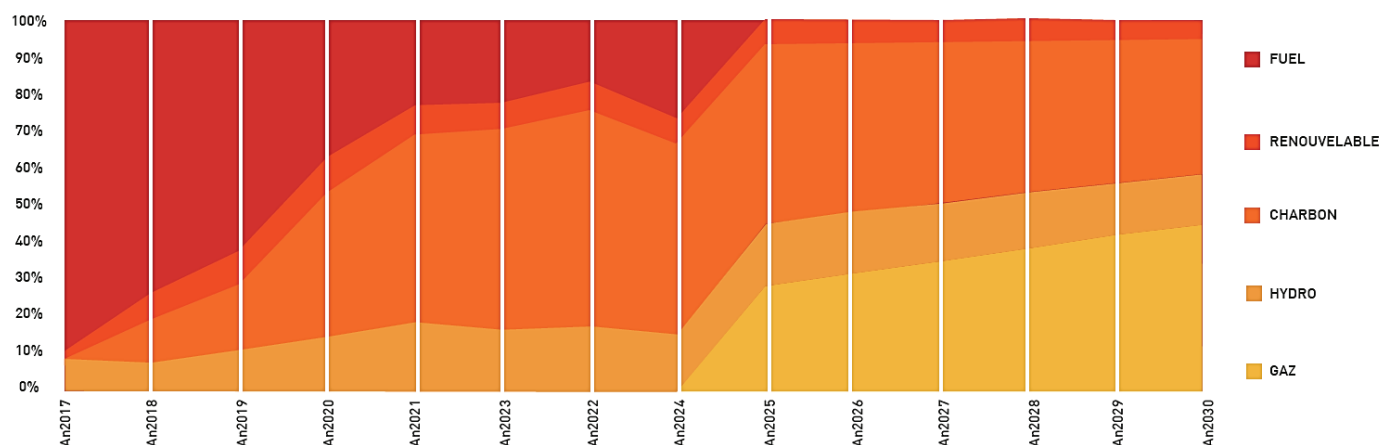
Côte d'Ivoire plans to double its generation capacity by 2020. This ambitious target plans to reach 4,000 MW by 2020 and 6,000 MW by 2030 with an estimated US \$22 billion to open new hydro and thermal plants (IFC, 2017). As the country's economic growth has remained around 7% since 2011 and has a target to reach universal access by 2025 and make Côte d'Ivoire the West African electricity trading hub with interconnection lines to Ghana, Burkina Faso, Mali, Liberia, Sierra Leone and Guinea.

Côte d'Ivoire intends to significantly scale up renewable energy (RE) technology deployment, taking advantage of solar, hydro and biomass sources. Côte d'Ivoire's Plan National des Energies Renouvelables (PANER – National Plan for Renewable Energies) projects a renewable energy generation capacity scale-up to around 3,600 MW to 2030, up from around 900 MW today. This contribution will be dominated by large scale hydropower generation. Further, the government intends to ensure that no more than 60% of generation capacity is made up of a single technology and is targeting 30% contribution from hydropower (IFC, 2018). Over the next 10 years, 4 hydropower projects are in the government's pipeline and concession agreements have been signed.

Table 6: Contribution of RE projects to Côte d'Ivoire's installed capacity and estimated electricity generation 2030 (MPE, 2016)

| | RE technology type | Intended installed capacity by 2030 (MW) | Estimated electricity generation annually (GWh) |
|--------------|---------------------------------|--|---|
| On-grid | Large hydroelectric power | 1,550 | 6,380 |
| | Small hydroelectric power | 130 | 685 |
| | Other RE power plants (<=30 MW) | 1,050 | 5,350 |
| | Solar PV (grid-connected) | 400 | 670 |
| Off-grid | Biomass cogeneration | 470 | 3,500 |
| | Solar PV and hybrid (mini-grid) | 5 | - |
| | Solar PV (solar home systems) | - | - |
| Total | | 3,605 | 16,750 |

Figure 5: Electricity generation mix 2017-2030 (CI-Energies, 2018)



Despite the government's ambitions to increase renewables contribution to the generation mix, thermal generation is also expected to grow. The development of a 1,340 MW of combined cycle gas turbine capacity is ongoing and a 700 MW coal plant is in the pipeline in San Pedro (IFC, 2017).

2.3.3 TRANSMISSION AND DISTRIBUTION

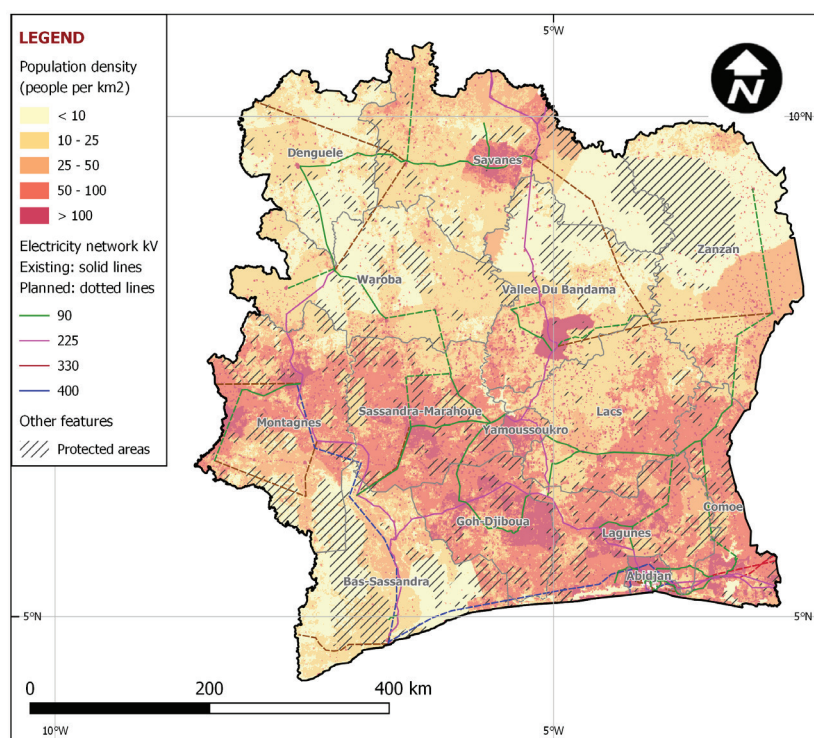
Transmission and distribution networks are state-owned. Since 1990, CIE has been responsible for the operation of all transmission and distribution assets, and the utility operates Côte d'Ivoire's low, medium and high voltage transmission infrastructures.

Côte d'Ivoire has one of the densest electricity grids in West Africa. The country's grid is comprised of transmission and distribution lines ranging from 220 V and 90 kV. The transmission grid is based on two high voltage levels: 90 kV (2,645 km) and 225 kV (2,088 km). The distribution grid consists of 30 kV and 15 kV (22,336 km) as well as 220 V and 380 V (19,599 km) lines. Power lines are spread across the whole country serving all regions and districts. As the map below indicates, most of the population lives within 20km of the network and the grid is extremely dense in the Southern part of the country and around regional capital cities.

However, the grid suffers from losses and in 2017 total electric power transmission and distribution losses, were estimated at 20% according to ANARE, due to a lack of historical investment. The majority of losses are in the distribution lines and are estimated to reach up to c.1,200GWh.

Côte d'Ivoire has one of the lowest electricity tariffs in the ECOWAS region. Its domestic energy price is between 0.063 and 0.11 US\$/kWh, far from being cost-reflective. By comparison, neighbouring countries such as Senegal in 2015 had national tariffs at 0.2 US\$/kWh, or at 0.16 US\$/kWh in Morocco, 0.06 US\$/kWh in Nigeria and 0.06 US\$/kWh in Algeria.

Figure 6: The existing transmission and distribution grid in Côte d'Ivoire, mapped to population density (Carbon Trust analysis)



Electricity prices remain politically sensitive. National tariffs are proposed by ANARE-CI to the Ministry of Energy, based on modelling. In the event, these are then approved by the Ministry of Energy, and also Ministry of Finance. However, as in several countries in West Africa, tariffs are an extremely emotive issue. In 2016 the Government attempted to incrementally increase tariffs by a 10% capped tariff and a subsequent five percent increase in 2017 and 2018, followed by a three per cent increase in 2019 and 2020. This prompted street demonstrations to such an extent that the president rolled back the increases.

2.4 OVERVIEW OF THE OFF-GRID SECTOR

2.4.1 ENERGY ACCESS POLICY AND PLANNING

Rural electrification in Côte d'Ivoire is covered by several institutions, including DGE, CI-Energies, ANARE-CI, and to some degree CIE. Note that unlike neighbouring countries, Côte d'Ivoire does not have a single government agency responsible for off-grid and rural electrification.

As a department of government, DGE has the responsibility for defining and setting electrification targets. To date this has resulted in the electrification of approximately 250 communities per year (despite the ambitions noted earlier of 500 p.a.) since Côte d'Ivoire's independence in 1960, almost exclusively through grid extension.

CI-Energies, as the government's implementation agency, is tasked with implementation of the electrification programmes. Once again, to date this has been predominantly through grid-extension. That said, diesel-powered mini-grids have been used in the past to electrify several sites, which would have been executed by CI-Energies before being handed over to CIE for operation. **CIE, as the nation's monopoly operator, today operates 56 diesel powered mini-grids, although this number is falling as the grid overtakes these sites.**

ANARE-CI's role as regulator is the setting of market rules, and the determination of tariffs. Given that rural electrification has to date occurred almost exclusively through 'on-grid' approaches, its main intervention to date has been through regulation of state tariffs. However, more recently it has adopted an exploratory strategy as new forms of rural electrification take place, notably through standalone systems and mini-grids. In the case of standalone or solar home systems, ANARE-CI has elected not to regulate these yet, having categorized operators as providing a service rather than selling electricity. Instead, it is presently conducting studies to understand how SHSs are being commercially priced, and how these compare to state pricing. It may at a later stage elect to introduce legislation if it feels that the service is taking advantage, or not sufficiently 'pro-poor' in its pricing. Likewise, in the case of GMGs it has elected to monitor and offer opinions, rather than regulate directly. This is notable in the case of the Akwaba mini-grids (see below), where ANARE-CI has allowed the project to operate outside of the CIE concession on the basis of it being a pilot study.

The Plan Directeur d'Electrification Rurale 2015-2030 (PDER - Master Plan for Rural Electrification) aims to electrify Côte d'Ivoire's 8,582 localities by 2025. In order to achieve this target, PDER initially had a target of supplying electricity to 2,112 localities with over 500 inhabitants by 2017, continuing to electrify 500 localities per year thereafter. Given that the PDER is publically unavailable, it is unclear whether this target is over-ambitious.

The PDER proposes two approaches for rural electrification, including (i) grid extension and (ii) decentralised solutions, including mini-grids and SHS. However, as previously noted Côte d'Ivoire has one of the most densely interconnected grids in francophone Africa, referred to as '*réseau araignée*' (spider grid), with the majority of its population living within 20 km of the grid. As a result, grid extension and connection 'in-fill' will continue to be prioritised.

The PDER identifies some 96 localities that could be electrified with mini-grids, including localities where existing diesel-powered installations can be hybridised with solar PV. 70 of these sites were selected based on a loss of voltage criterion, where grid-connected localities with losses of over 10% were selected. The remaining 26 sites were selected based on distance from the grid, with minimum grid proximity of 20km.

A significant limitation of the PDER is that it focuses only on villages called '*Lotie*', characterised as having brick constructions, solid roofs, a school and a health centre with a population of 500 inhabitants. By definition, the PDER therefore excludes smaller 'informal villages' referred to as '*campements*', numbering over 80,000 across the country, and representing a population of nearly 5 million. To date, these people have only been served by commercially available SHS.

To overcome this shortcoming, Power Africa has been working on the development of an off-grid electrification strategy to include the electrification of campements⁶ throughout the 31 regions. This strategy is under government review and is due for approval and publication in 2019. As part of its work, Power Africa has compiled statistics on the campements, to understand population size, density and whereabouts. A large number of these campements have over 500 inhabitants, with locations therefore offering a significant opportunity to develop the off-grid sector, especially given estimated population growth rate in campements of ~6% per year. Power Africa suggests that there could be over 100 suitable mini-grid locations in Côte d'Ivoire based on this analysis.

In addition to Power Africa's technical support in developing a rural electrification strategy, Expertise France is working on designing the regulatory framework for mini-grids. Under the €10.7 million Energos II programme, the European Union with Expertise France have designed one of the project's components around supporting the country's rural electrification process. To back up the PDER, activities include supporting the ministry in operationalizing a new regulatory framework that will promote both renewable energy and energy access, as well as developing the application decrees for mini-grid operation. The decrees are intended to provide clearer guidance on the sector's fair competition and operators' rights, and are due for publication in 2020.

6 The Administrative definition: « Campement » is a Temporary/seasonal settlement for productive use activities. However, in this case campements includes all the settlements that are not considered under the PDER.

Today, outside of CIE's diesel powered mini-grids, the only operational GMGs are the 7 'Akwaba' projects. Financed by UNIDO (GEF) and the EU, these are solar powered, community owned and operated mini-grids widely seen as a pilot project for the future of mini-grids in the country. Technically the mini-grids should have been handed over to the CIE for operation, but ANARE-CI has permitted them to operate under their own management as a one-off as described in table 7.

Table 7: Akwaba project description

| | |
|---|--|
| <p>Akwaba project</p> <p><i>Commissioned in 2016 in financed by UNIDO, GEF and EU Energy Facility Fund</i></p> | <ul style="list-style-type: none"> • This project created the first seven renewable energy mini-grids in Côte d'Ivoire, developed by Delegation Fondation Akwaba (an non-government organisation) and installed in Bondoukou, in the north-east region of the country • The project installed 200kW of generation capacity (30kW AC per site) with 600 connections for households and SMEs, bringing electricity to about 4,000 beneficiaries in off-grid isolated communities (note that these are the only renewable energy mini-grids currently installed in the country) • Sites were selected based on solar potential and communities' capacity to pay • The mini-grids are run through community management with a particular payment system based on household consumption contributions: tariffs for the system are more expensive than the national on-grid tariff, with a UNIDO report suggesting willingness to pay of up to \$0.27/kWh (compared to around \$0.09/kWh on-grid) • Sites were selected by UNIDO and approved by CI-Energies and ANARE-CI • The mini-grids were designed to be connectable to the main-grid • Total project financing and donors: US\$ 4.2 million (US\$ 3,000,000 from EU, US\$ 864,000 by GEF, US\$ 325,000 from UNIDO) |
|---|--|

In addition to mini-grid development, there is some SHS activity with an estimated 10,000 systems present in the country. Presently SHS are unregulated and tariffs undetermined. ANARE-CI has been engaging with SHS developers to understand and set the best tariffs for these products. Zola, EDF, and Lumos are today the main players in the market. Although a purely commercial offer, CI-Energies has issued a recent call to ask for providers to electrify c.30 households through solar home systems with a capacity of 200W-1KW, which is a first example of the state using SHSs as a route to electrify communities.

2.4.2 LICENCING

As previously explored, the electricity sector is governed by Law N° 2014-132 Electricity Code, which dictates that the main entity responsible for providing licences is the Ministry of Energy, following advice from the regulator ANARE-CI. However, the licencing regime for off-grid electrification is as yet unknown, with decrees for liberalisation of the sector not having been published.

Application decree N° 2016-787 is the only existing regulation addressing the off-grid sector directly. The decree states that all companies interested in distributing and commercialising mini-grid and/or standalone systems are required to obtain a concession, specific technical conditions of which are yet to be developed. Nonetheless, the text provides details on the following:

- Geographic area of the concessions: one can have a concession for one or more areas;
- Possibility to have one or more concessionaries in the same geographic area;
- All mini grid and standalone systems operators need to have a concession to operate; in the case of standalone systems, a client can acquire a system from any operator (with or without a concession); and
- The government and donors can also create mini grids and standalone systems.

Despite these decrees, as of January 2019, there is still no agreed concession system, nor have thresholds been set for different types of concessions and permits. Further clarification decrees are expected during 2019, which are expected to define different types of authorisation and procedure. Technical assistance to develop these is being provided

by both Power Africa, and the EnerGos 2 technical assistance package from the EU. It is interesting to note, however, that all conversations with stakeholders agreed that ultimately the aim was for the private sector to be able to develop and operate mini-grids, but that these would need to adhere to standardised tariffs.

Note: the seven Akwaba green mini-grid projects were considered pilot projects and thus given a special ‘non-objection’ authorisation by ANARE-CI. However, in the absence of any other regime, it must be assumed that following development of other mini-grid projects and programmes, mini-grid operation will have to be undertaken by the private monopoly CIE. This may change in 2020, once the CIE’s concession expires and application decrees related to the law of 2014 are issued.

Table 8: Côte d’Ivoire GMG development programmes

| Project Name | Project description |
|---|---|
| Éclair-ci (Energos 2) <i>Commissioned in 2017 financed by EU</i> | <ul style="list-style-type: none"> This programme is divided into two parts: the first is looking at energy efficiency in buildings, and the second is providing electrification to several sites through mini-grids and SHS Expertise France is the main implementer of the project: an EU funded project with EUR 8.5 million directed towards electrification (EUR 5.5 million in CAPEX) Pre-feasibility studies have been conducted for 11 sites, with TORs to be developed for project development at each site 11 sites have been identified for the deployment of solar mini-grids, and 19 sites covered by SHS; all are expected to be constructed between 2019 and 2020 to connect ~10,000 users (note: all sites selected under this project were previously identified under the PDER by CI-energies) The mini-grids will be constructed by third party developers and then handed over to CI-Energies that will provide the operation to CIE Tariffs applied will be the national standard tariff, which is subsidised to keep a level of profitability: traditional meters will be used, as CIE is the distributor and has mainly used traditional technology so far |
| Programme de Développement des Energies Renouvelables et d’Efficacité Energétique (PRODERE – Programme of Renewables and Energy Efficiency Development) in the UEMOA area (UEMOA- Economic and Monetary Union of West Africa) <i>Commissioned in 2016</i> | <ul style="list-style-type: none"> Regional programme aiming at increasing electrification rates and reducing the medium cost of electricity to FCFA 30 (0.046 euros/kWh), as well as increasing deployment of renewables’ contribution to energy production by 82% by 2030. During the first phase of the programme UEMOA financed feasibility studies conducted in 12 locations of Côte d’Ivoire resulting in: <ul style="list-style-type: none"> Six 60kW mini-grid projects in Côte d’Ivoire, all of which are currently being built by two private companies (4 by SAGECOM and 2 by BETRAD) to provide electricity to about 500 inhabitants (24hr service and street lighting) – once the installation is finalised, the operation will be transferred to CI-Energies and CIE The second phase of the programme has also been initiated, with feasibility studies on going in 14 villages indicated by the DGE under the PDER, 8 mini-grid projects are expected to be selected with 20-500 kW capacity |

It is interesting to note that CIE is preparing itself to re-bid for an operation concession in 2020 by getting more familiar with renewable energy assets, including off-grid. CIE is currently developing plans to hybridise two of its remote diesel mini-grids: Papara (north Tingrela) and Bedipo (San Pedro). The objective of this pilot project is to deepen CIEs knowledge, learning from experience to prepare for the post-concession phase and better understand the differences between the North and the South. The feasibility study is being conducted in-house with the objective to look for external capex financing for the development of the projects.

2.4.3 MINI-GRID TARIFFS

There are no agreed tariffs for mini-grids at present. In future, stakeholders have agreed that the government strategy is likely to be to maintain a uniform tariff throughout the country. Therefore, future mini-grids would likely need to apply standardised tariffs, with some sort of subsidy mechanism to cover unmet costs and profit margins for operators (as is the case with the main grid and CIE). The state presently subsidises electricity and in the future this is likely to remain the case, and private providers will be subsidised to support commercially viable projects.

The seven clean mini-grids from the Akwaba project are the only mini-grids with tariffs not in line with the uniformed tariff. Their systems are considered as 'service based' contributions from the households to cover the costs of running and maintaining the mini-grid. A report from UNIDO suggests that households are willing to pay up to \$0.27/kWh for up to 8kWh and US\$0.15/kWh for up to 17 kWh per month. This compares to existing on-grid tariffs of around \$0.09/kWh.

2.4.4 SUBSIDIES AND INCENTIVES

Côte d'Ivoire presently offers tax relief on solar products (9% Value Added Tax as opposed to 18%). *The Loi des Finances No 2011- 480* aims to promote solar energy uptake by reducing VAT on all solar energy products codified by Article 359 of the *Code general des impôts* (General Code of Taxes). All renewables' operators also benefit from a reduction of 50% on customs duties on all equipment and materials.

There are no subsidies or incentives specific to the mini-grid sector yet. In the future, it is expected that the government will provide support to identify the sites it seeks to electrify, conduct feasibility studies including evaluating communities' willingness and ability to pay for electricity, as well as running auctions to get the best tariff from private operators.

2.4.5 POWER PURCHASE AGREEMENTS

Côte d'Ivoire has no standardised Power Purchase Agreement (PPA) in place for renewable energy generation projects. PV projects are treated like conventional generation projects and power purchase agreements must be negotiated with the Ministry. All existing and future mini-grids have to be designed to fit into the grid.

2.4.6 ARRIVAL OF THE GRID

There are no real clear rules on arrival of the main grid and the impact this can have on existing mini-grids in the sector. Current diesel mini-grids are all operated by CIE, with the arrival of the main grid not representing an issue to the utility company: projects are simply connected to the grid, without any change in tariff. Current regulations require all mini-grid technologies to be designed with the possibility of being connected to the main grid.

2.4.7 TECHNICAL RULES

Mini-grids are expected to support and reinforce the grid in the case of arrival. Off-grid solutions must be designed to be grid compliant in case of grid arrival.

Mini-grids are subject to standard electrical codes. There are no other specific rules to be applied to mini-grids other than adherence to standard electrical codes, as regulated by the Electricity Law and applied to all generation technologies.

2.4.8 MOBILE SERVICES

Mobile penetration in Côte d'Ivoire is high, with mobile connection penetration in 2016 at 122%. A further 76% of the population is estimated to have access to 3G (GSMA, 2017). The Côte d'Ivoire mobile market comprises Orange (48% market share), MTN (30%) and Moov (22%). Côte d'Ivoire is mainly a prepaid market and has one of the highest multi-SIM usage rates in the world, with subscribers having an average of two or more SIM cards. Further, use of mobile internet has grown strongly, with the number of subscribers growing at an annual rate of 54% between 2012 and 2016. Since 2016, 4G networks have entered the market but today only cover 8% of the mobile population. Nevertheless, growth trends are expected to continue, and penetration is predicted to reach 53% as soon as 2020 (GSMA, 2017).

There are 9.8 million mobile money accounts in Côte d'Ivoire in 2015, ranking Côte d'Ivoire as having the fifth highest penetration rate in the world and the highest in West Africa (GSMA, 2017). Government and mobile operators have collaborated to digitalise school registration fees using mobile money in 2015, meaning that some 99% of secondary school fee payments are made digitally, with 94% via mobile money (GSMA, 2017). Mobile money is increasingly used for domestic remittances, with some 50% of recipients receiving money via mobile phone and 42% of senders using mobile phones to send domestic remittances. Additionally, Orange, MTN and Moov offer international remittance services between Mali, Côte d'Ivoire and Senegal which concentrates the largest flow of mobile money transfers in Sub-Saharan Africa.

Orange has developed the Orange Rural Electrification Programme as the first domestic solar-energy trial for consumers to generate electricity in rural Côte d'Ivoire. Orange provides solar kits to rural communities to generate electricity; payments for electricity consumption can then be made with Orange mobile money through the Pay-As-You Go business model.

In the same line of business model, FENIX International is entering the Côte d'Ivoire RE market introducing in the country the ReadyPay Solar Power systems using the MTN mobile phone platform.

2.4.9 BARRIERS AND POTENTIAL INTERVENTIONS FOR MINI-GRID DEPLOYMENT

The most pressing need to opening the mini-grid market in Côte d'Ivoire is to finalise the legal and regulatory framework in which mini-grids will be able to operate. Whilst private sector development and operation of mini-grids is nominally permitted, in practice the absence of the required application decrees for the law of 2014 prevents their development. This includes procurement, licensing, permitted tariffs, and clarity on grid interconnection.

Today, as a consequence, the only mini-grids in Côte d'Ivoire are either operated by CIE or, in the case of the seven green mini-grids funded by UNIDO and EU and implemented by Akwaba, are in legal "limbo", so to speak. In the absence of any legal framework permitting concessionary contracts between the government and operators, any future mini-grids will have to be transferred to the national utility for operation.

The deadline for clarity is fast approaching with the cessation of the CIE concession. CIE's concession for operation will end in 2020, meaning that this is the date that many stakeholders expect full market liberalisation to take place. Nevertheless, there remains much work to be done to finalise the proposed market structure. Support from Power Africa and the EU (through Energos 2) should assist with this.

Access to cheap finance for renewables projects is a main challenge in Côte d'Ivoire. The PV sector in general faces challenges relating to regulatory support, electricity prices, client base and awareness, qualified PV companies and available financing. For small-scale rural electrification projects, transactions costs are and the risk for investors are very high because national financial institutions have little experience and incentives with rural electrification (IFC, 2018).

Grid extension remains the firm priority of the government. Given the density and location of the grid, and the population, government is still very focuses on grid extension as the preferred route to rural electrification. The recent analysis by Power Africa which identifies greater need than the governments PDER (by considering campements) may encourage focus on off-grid electrification, but this remains to be seen. In any case clarity on the vision for off-grid technologies as either provisional measures or long-term energy solutions for the country need would be welcome.

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 Côte d'Ivoire. 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.

3.1 DATA AVAILABILITY

In Côte d'Ivoire, population density data can be sourced from WorldPop. WorldPop data estimates numbers of people per grid square, with national totals adjusted to match UN population division estimates.

The electricity transmission network map of Côte d'Ivoire was sourced from the West African Power Pool (WAPP) GIS database. This dataset is distributed by ECREEE providing details on the existing and planned transmission grid network (medium and high voltage lines) in the whole ECOWAS region and some countries in West Africa. Grid extension populations within the 15km buffer of the current grid were inferred based on a combination of high voltage (HV) line data (obtained from IFC GIS data: [electricity transmission and distribution grid maps](#)) and satellite mapping of night-lights. Off-grid populations are those outside of these areas.

In addition to the current and planned network, existing clean mini-grids were mapped by using ECOWAS data. ECOWAS observatory for Renewables Energy and Energy Efficiency (ECOWEX) database⁷ provides the location data for the seven existing mini-grids developed under the Akwaba project.

Existing electricity expenditure was taken from data on national grid tariffs. Current mini-grid tariffs are the standardised with the main grid tariffs varying between 0.063 and 0.11 US\$/kWh with per *capita annual consumption of 243 kWh, based on figures from 2013.*

3.2 MINI-GRID POTENTIAL: AN ASSESSMENT

3.2.1 ASSESSING MINI-GRID POTENTIAL: METHODOLOGY

The first step in understanding mini-grid potential in Côte d'Ivoire 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.

7 <http://www.ecowex.org/mapView/index.php?lang=eng&mclayers=layerCEMG&lat=883283.95500585&lon=-548279.0718926&zoom=8>

- Grid extension areas: defined as areas within 15km of the grid
- Mini-grid areas: defined as areas further than 15km from the grid⁸, with household density greater than 50 households per km²
- Standalone system (SHS) areas: defined as areas further than 15km from the grid, with household density less than 50 households per km²

To understand where these different areas lie, the national grid is inferred using a combination of high voltage (HV) line GIS data and satellite mapping of night-lights, buffered by 15km to produce the grid-extension area⁹. Potential off-grid populations are outside of this grid extension area, with mini-grid populations identified based on population density greater than 50 households per km².

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

1. **Existing rural household expenditure on electricity based on the World Bank Global Consumption Database** (World Bank, n.d.). This approach assumes that 60% of rural household energy expenditure is on electricity, and that household revenue comprises 60% of the total revenue of a mini-grid (when including revenue from businesses, public sector buildings and industrial users).
2. **Existing rural household expenditure on electricity based on other literature and sources.** This may be based on international or local studies, or local stakeholder interviews.
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.

3.2.2 ASSESSING MINI-GRID POTENTIAL: RESULTS

While Côte d'Ivoire has a transmission system that is relatively well spread geographically, there remain some areas with no grid coverage mainly in the north-eastern part of the country. The backbone of the grid network runs through the centre of the country from Denguele to Abidjan, with transmission lines extending to the east

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- 8** While we have assumed GMG populations are those beyond 15km of the grid, some developers may also wish to consider regions already serviced by the grid. In some areas currently reached by the grid, mini-grid market potential exists due to both high main grid connection costs, as well as its lack of reliability due to the aging grid network. The possibility of mini-grids in proximity to the main grid is not considered in our analysis due to its high dependence on the business model used and local demographics.
- 9** Using this combination of night-lights and HV line datasets provides a more comprehensive picture of current electrification than using HV lines alone. Although HV grid line data is commonly available for countries in Sub-Saharan Africa, these lines provide a limited view of electrified areas, since medium voltage (MV) lines are often used to reach towns at distances exceeding 15km. This analysis therefore infers the position of the MV lines from satellite data of night-time light emissions, pre-processed to provide yearly-average datasets from which noise and cloud cover have been removed.

of the country). Transmission lines above 220kV are illustrated in Figure 7. 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: Côte d'Ivoire grid network

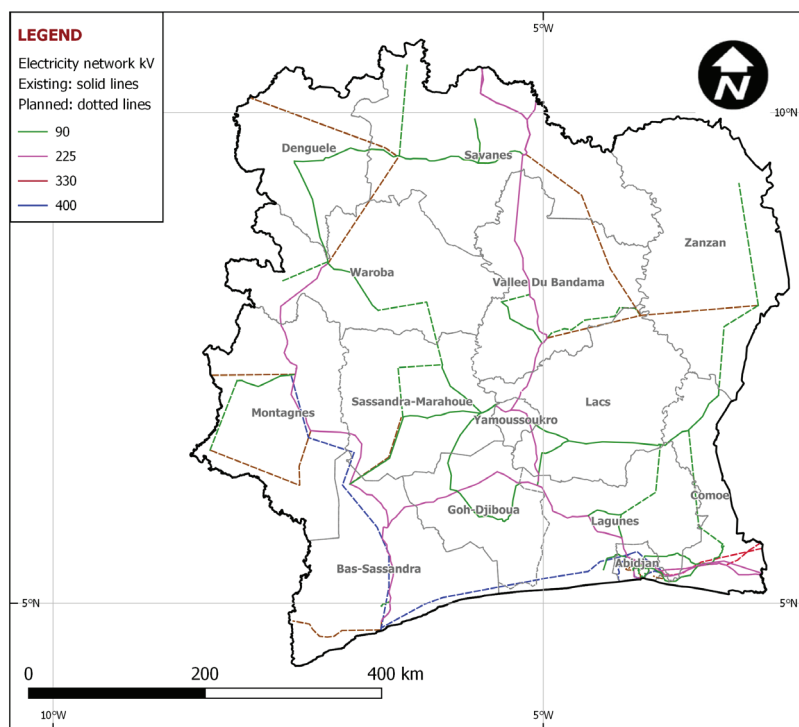


Figure 8: Population density in Côte d'Ivoire

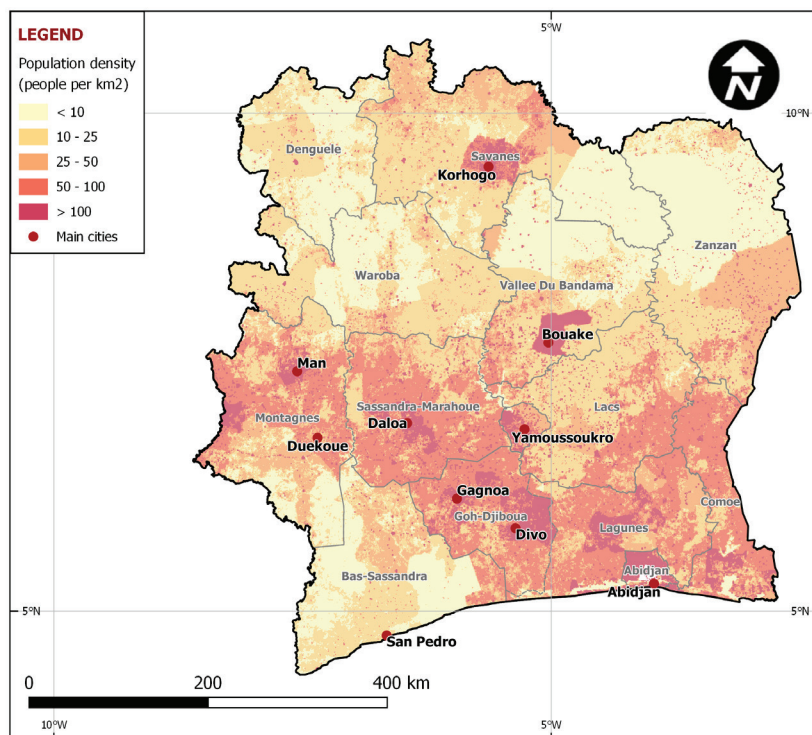
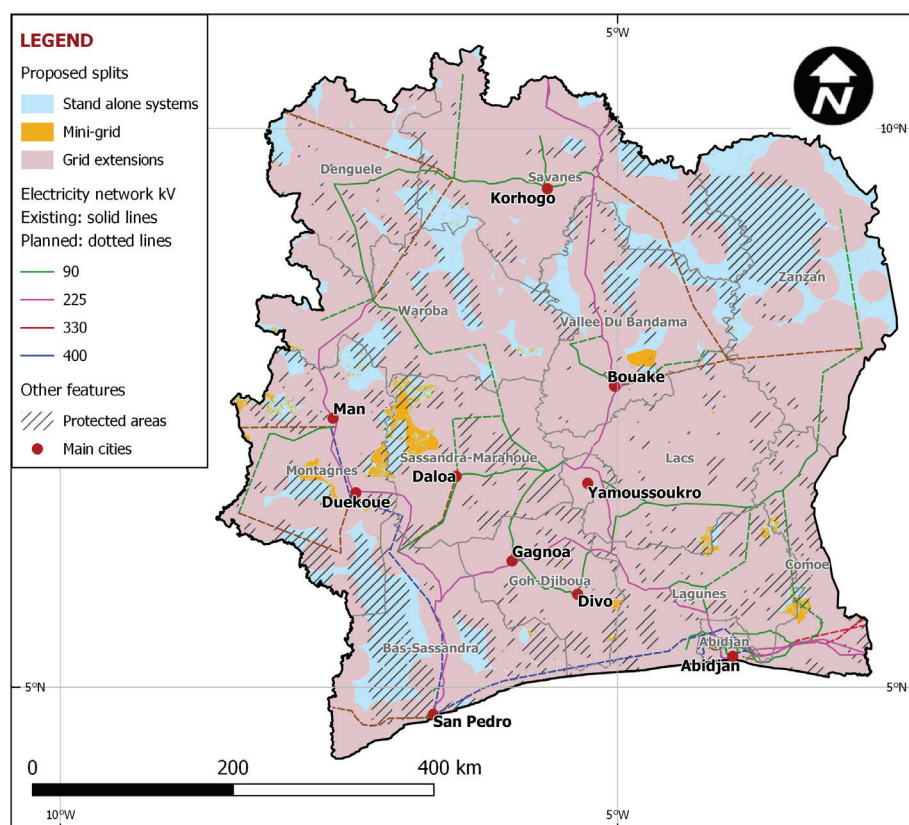


Figure 9: Regions best served by grid extension, mini-grid and standalone systems in Côte d'Ivoire, shown with major and minor population center (Carbon Trust analysis)



Our analysis estimates that ~462,000 people (2% of the non-electrified population) will be best served by mini-grid solutions in Côte d'Ivoire. A further ~556,000 people (2.5% of the non-electrified population) will be best served by solar home systems (SHS) and another 19.7 million people (95.5% of the non-electrified population) will be best served by grid extension. This calculation is based on the current grid coverage¹⁰ only; any planned grid extensions will reduce the estimated market size.

Over 65% of the Ivorian mini-grid market is in the Montagnes, Sassandra-Marahoue and Vallée du Bandama West and Central districts, due to limited grid coverage and population densities high enough to support mini-grids 127,000 and 128,700 people will be most economically served through mini-grids in Montagnes and Sassandra-Marahoue respectively, corresponding to around 5% of the population in each district. The districts with the largest percentage of the population best served by SHS technologies are Zanzan in the extreme east of the country and central-west district Woroba at 15% and 8% respectively. Populations best served by either grid extension, mini-grid or SHS are shown by district in Table 9.

¹⁰ 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 9: Suitable electrification solutions by district in Côte d'Ivoire (Carbon Trust analysis)

| District | Current grid network | | | | | Planned grid network to 2025 | | | |
|--------------------|----------------------|----------------------------|----------------|----------------|------------------------|------------------------------|----------------|----------------|------------------------|
| | Electrification rate | Non-electrified population | | | Mini-Grid Market (\$m) | Non-electrified population | | | Mini-Grid Market (\$m) |
| | | < 15km of grid | Mini-Grid | SHS | | < 15km of grid | Mini-Grid | SHS | |
| Abidjan | NA | 4,667,869 | - | - | - | 4,667,860 | - | - | - |
| Sassandra | NA | 558,507 | 4,422 | 69,234 | 189,002 | 573,345 | 3,178 | 55,640 | 189,002 |
| Comoe | NA | 1,308,412 | 30,594 | 3,175 | 169,283 | 1,338,871 | 2,846 | 463 | 169,282 |
| Denguele | NA | 290,335 | 1,523 | 23,789 | 84,402 | 297,403 | 1,419 | 16,825 | 84,402 |
| Goh-Djiboua | NA | 1,661,627 | 17,330 | 389 | 1,030,788 | 1,661,627 | 17,330 | 389 | 1,030,788 |
| Lacs | NA | 1,389,888 | 11,252 | 2,897 | 669,264 | 1,391,415 | 11,252 | 1,370 | 669,264 |
| Lagunes | NA | 1,663,549 | 25,575 | 10,246 | 646,681 | 1,681,065 | 10,872 | 7,432 | 646,681 |
| Montagnes | NA | 1,625,865 | 127,452 | 97,667 | 6,979,122 | 1,648,296 | 117,333 | 85,356 | 6,979,122 |
| Sassandra-Marahoue | NA | 2,006,935 | 128,786 | 23,655 | 7,643,760 | 2,007,327 | 128,507 | 23,542 | 7,643,760 |
| Savanes | NA | 1,334,062 | 9,457 | 77,058 | 266,986 | 1,354,954 | 4,489 | 61,136 | 266,986 |
| Valle du Bandama | NA | 1,518,417 | 53,205 | 51,244 | 2,024,730 | 1,547,332 | 34,040 | 41,493 | 2,024,730 |
| Waroba | NA | 602,514 | 13,131 | 58,782 | 717,254 | 609,973 | 12,058 | 52,397 | 717,254 |
| Yamoussoukro | NA | 382,103 | - | - | - | 382,103 | - | - | - |
| Zanzan | NA | 787,191 | 39,160 | 138,043 | 2,329,286 | 821,576 | 29,166 | 113,652 | 1,734,844 |
| Total | 65% | 19,797,273 | 461,885 | 556,179 | 27,473,607 | 19,983,155 | 372,488 | 459,695 | 22,156,116 |

In terms of potential revenue, the size of the market based on 462,000 potential customers varies according to the four electricity expenditure scenarios described in section 3.1.2:

1. **Existing rural household expenditure on electricity from the World Bank Global Consumption Database:** According to this database, average rural household spend on energy consumption in Côte d'Ivoire is US\$ 431.58 annually. To convert this to expenditure on electricity, we use two assumptions: (1) that around 60% of household energy spend is on electricity, and (2) that household spending comprises 60% of the total revenue of a mini-grid (when including revenue from businesses and community buildings). Electricity spend translates to \$258.94 per annum. Given that the average number of persons per household in Côte d'Ivoire is 5.4, this translates to per capita electricity expenditure of approximately \$47.95 annually, or an overall market size of \$22.1m annually (assuming 462,000 customers). Based on grid expansion projections to 2025, this market size will drop to \$17.8m (assuming 372,000 customers).
2. **Existing rural household expenditure on electricity based on other reports / literature in Côte d'Ivoire** was unavailable.
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, represents annual per capita electricity demand of 148.70 kWh (5.4 persons per household). Based on annual electricity demand of 148.70 kWh per capita, a tariff of \$0.09 / kWh gives an average annual electricity expenditure of USD \$13.38 per person: an overall annual mini-grid market size of \$6.2m given a mini-grid population of 462,000.

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 148.70 kWh per capita, a tariff of \$0.4 / kWh gives an average annual electricity expenditure of USD \$59.48 per capita: an overall annual mini-grid market size of \$27.5m given a mini-grid population of 462,000.

A summary of these four market size estimates is shown in Table 10.

Table 10: market size estimates for the four scenarios

| Scenario | Estimated per capita annual costs for GMG (\$) | Market size given current GMG population (\$m) | Market size of GMG population given planned grid extension (\$m) |
|------------------------------------|--|--|--|
| 1 World Bank Database | \$48.0 | \$17.8 | \$14.4 |
| 2 Other Donor Reports | Not available | Not available | Not available |
| 3 'Bottom-up' + existing tariff | \$12.8 | \$5.9 | \$4.8 |
| 4 'Bottom-up' + theoretical tariff | \$59.48 | \$27.5 | \$22.2 |

In summary, under the present grid, this report estimates an annual mini-grid market size of USD \$5.9 million in Côte d'Ivoire, based on an average mini-grid tariff of USD \$0.09/kWh, and average household demand per day of 2.2kWh. This implies per capita annual electricity expenditure of \$12.8 within the population best served by mini-grids. Based on an estimated cost-reflective tariff of \$0.4/kWh across SSA, it is therefore estimated that **75% of project costs would need to be covered by subsidy (approximately \$57m annually)** to open up the mini-grid market to developers (lifetime project costs – with subsidy covering both CAPEX and OPEX). The actual market size may be greater than the estimates given here considering decentralised solutions could also be feasible in areas in grid proximity.

3.3 RENEWABLE ENERGY POTENTIAL FOR MINI-GRIDS

3.3.1 HYDRO

Studies conducted in 1979 estimated a potential hydro capacity of more than 1,900 MW which could generate about 10,000 GWh per year. Four large hydro projects are in the pipeline for the next ten years totalling in installed capacity of 592MW, including Singrobo (44 MW), Gribo Popoli (112MW), Boutoubre (156 MW), and Louaga (283 MW). In addition to these sites, the Ministry of Energy is planning to develop 81MW of small hydro projects before 2030 and 20 potential sites with individual capacities between 1 MW and 12.5 MW have also been identified.

3.3.2 BIOMASS

Biomass can be considered as the second most abundant renewable energy source in Côte d'Ivoire. The country's agricultural sector produces more than 12 million tons of residues (byproducts) per year from growing and processing crops on farms; IFC has estimated that approximately 9 million tons or 70% of the total generated amount could be available for fuel. Biomass resources, such as agricultural waste, and agribusiness by-products, also potential uses in on-grid and off-grid electricity generation. Estimated generating potential is 2,900 GWh (RECP, 2015).

In December 2017, the government signed for the first biomass plant of 46MW. The plant is projected to use 400,000 tons of waste from palm oil production to generate up to 288 GWh of electricity per year. Several other plants are under development in the country, small-to-medium power plants, including 20 MW facility in Gagnoa and 25 MW in Boudili. Municipal waste-to-energy projects of more than 15 MW capacity are also in the pipeline which will use biomass waste and landfill gas in Abidjan area.

3.3.4 SOLAR

With an estimated daily irradiation energy of 5.8 kWh/m²/day at horizontal, and an average of six hours of sunshine a day, Côte d'Ivoire has a good potential for solar deployment. Solar potential ranges from 2-6 kWh/m²/ day, with a potential for PV installations of about 10,325 terawatt hours is being considered as one of the most economically viable solution for decentralized electrification (IFC,2018). The potential is especially higher in the northern part of the country where the demand is the lower.

3.3.5 WIND

Wind regime in Côte d'Ivoire is quite moderate-to-low with speeds in the range of 5-6.5 meters per second in several inland regions. However to date there is little information and knowledge on the wind potential of the country. No wind projects have been built as of January 2019, although a number of private sector developments are under way in Touba and Ehania. As part of Energos 1 programme EU is preparing to support the identification of wind energy potential.

Figure 10: Yearly Global Horizontal Irradiation (kWh/sq.m) 1994-2005 ave

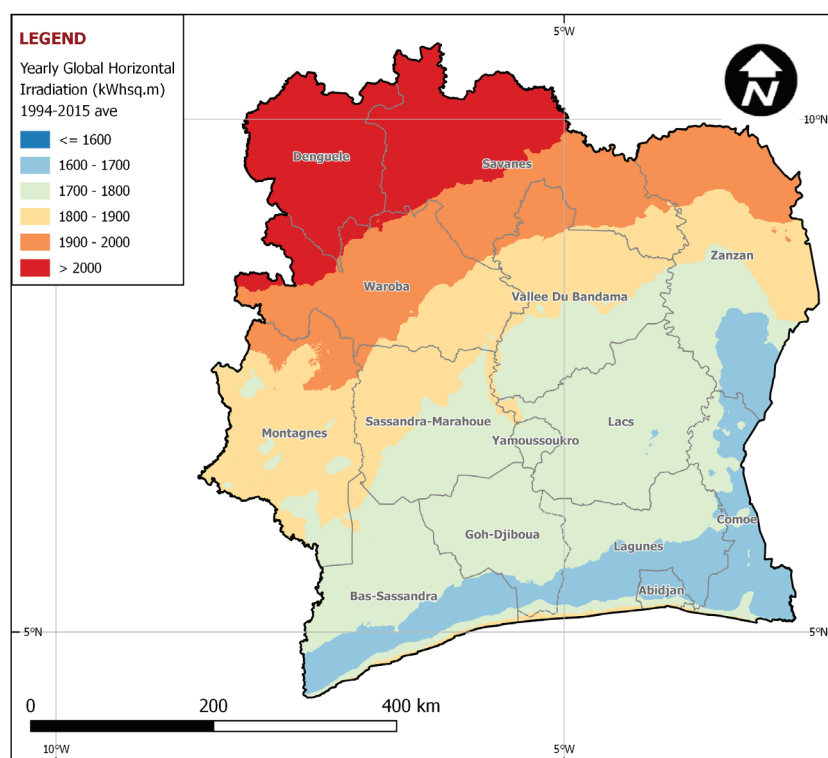
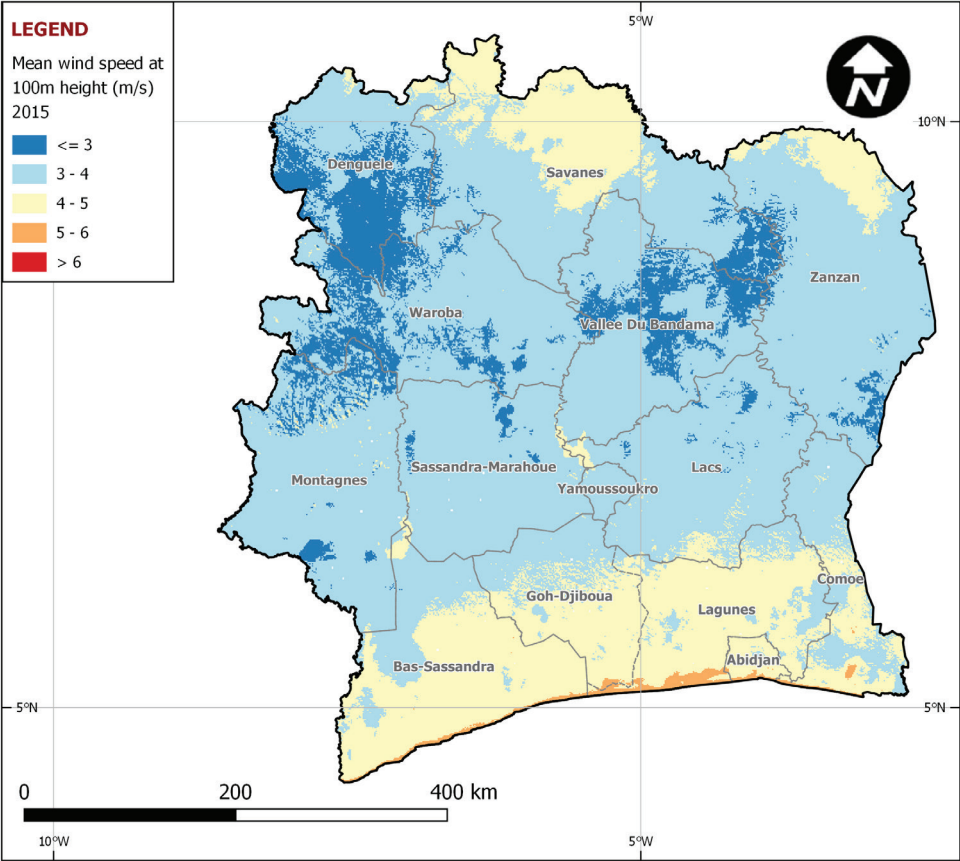


Figure 11: Mean wind speed at 100m height (m/s). 2015



4. DIRECTORY

4.1 ENERGY SECTOR POLICIES AND REGULATORY FRAMEWORKS DIRECTORY

Law on Electricity Code N° 2014-132: is the main law covering all electricity matter including, regulations to all activities related to the electricity sector activities: Production, transport, dispatching, importation, exportation and transit of electrical energy, the distribution and commercialization and control of energy. It also provides conditions for authorisations and conventions.

Application Decree N°2016-783: authorises auto-production of electricity and sets conditions for auto-producers to sell excess production back to the national grid.

Application Decree N°2016-784: dissolved the agency in charge of the Regulation of the Electricity sector ANARE (Autorité National de regulation du Secteur de l'Electricité) that was created BY Décret N°98-725 of 16 December 1998.

Application Decree N° 2016-785 : established the new regulation agency for the electricity sector. The New agency denominated: Autorité National de Régulation du Secteur de l'Electricité de Côte d'Ivoire (ANARE-CI) its mission is to:

- Control and enforce the laws and regulations in place as well as the obligations and engagements of the authorizations and conventions of the Electricity sector.
- Protect the interest and droits of the users of the public electricity service.
- Propose Tariffs for the electricity sector including tariffs for electricity access.
- Advise the Government with regards to the regulation of the electricity sector.
- Identify and propose sanctions for the no respect of the Electricity laws and regulations.

Application decree N° 2016-787 : Is the only Law that addresses the off-grid sector directly. The decree states that all companies interested in distributing and commercializing mini-grid and or Standalone systems are required to obtain a Concession with specific technical conditions to be provided:

- Geographic area of the concessions. One can have a concession for one or more areas
- Possibility to have one or more concessionaries in the same geographic area.
- All mini grid and standalone systems operators need to have a concession to operate. In the case of standalone systems a client can acquire a system from any operator (with or without a concession)
- The government and donors can also create mini grids and standalone systems

Application Decree N° 2016-862 November 2016 established Energy Efficiency regulations such as:

- The sales of incandescent lamps will be forbidden starting January 1st 2019.
- Obligation of periodic energy audits to better control consumption in industry, textile and residential.

The Plan National de Développement 2016-2020 (National Development Plan: PND) was adopted by the government in 2016 and is the main social and economic development short-medium term policy of Côte d'Ivoire.

Plan d'Action National des Energies Renouvelables (PANER – National Plan for Renewable Energies) Côte d'Ivoire was adopted in 2016. This plan was designed under the support of ECOWAS with the intention to scale up renewable energy generation capacity to 3,600 MW in 2030 from 900MW today.

Plan d'Action National d'Efficacité Energétique (PANEE – National Plan for Energy Efficiency) also adopted in 2014. With the support of ECOWAS commission that elaborated this policy to define objectives and measures to be implemented to improve the country's energy efficiency. Overall policy ambitions include the introduction of norms in energy efficiency, finance activities in energy efficiency, conduct user's awareness and provide technical training among other activities.

The Programme National d'Électrification Rurale (National Rural Electrification Programme: PRONER) represents the government's commitment to electrify all localities with over 500 inhabitants and maintain an annual electrification of 500 new localities until 2020 with \$675 million investments over a five-year period.

The Plan Directeur d'Électrification Rurale 2015-2030 (PDER- Master Plan for rural electrification) is the only rural electrification plan to date aiming at electrifying all 8582 localities by 2025, to achieve this target PDER has planned to supply electricity to 2,112 localities with over 500 inhabitants in 2017 and continue electrifying 500 localities each year. The programme focuses on villages called 'Lotie', characterised as being formal with brick constructions, solid roofs, a school and a health centre with a population of at least 500 inhabitants. Two approaches have been designed to realise this objective (i) grid extension and (ii) decentralised solutions, including mini-grids and SHS.

Programme d'Électrification pour Tous (PEPT- Electricity for All Programme): PEPT is the government's programme aiming at supporting low-income communities with financial support for grid connection fee. The programme was established to spread the cost of grid connection throughout a few months. This allowed low-income category to pay FCFA 1,000 (US\$ 1.75) and reimburse connection fees over 10 years (World Bank, 2017).

4.2 INVESTMENT INCENTIVES DIRECTORY

4.3 DATA SOURCES DIRECTORY

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

This analysis, the results of which are provided in Section 3, considers the potential for mini-grids by segmenting the countries into two areas: **grid and off-grid areas**. This split is based on the distance of 15km from the power network. We have used the planned power network for up to 2025. The GIS sources used in this analysis are detailed below.

Electricity transmission network (medium and high voltage)

Source: Western African Power Pool (WAPP) GIS database, distributed by ECREEE

Link: <https://energydata.info/dataset/transmission-grid-ecowas-region>

Clean Energy Mini-grids

Source: ECOWAS observatory for Renewable Energy and Energy Efficiency (ECOWREX) database

Link: <http://www.ecowrex.org/mapView/index.php?lang=eng&mclayers=layerCEMG#>

Worldpop Population Density

Data Source: World Pop data portal

Link: http://www.worldpop.org.uk/data/data_sources/

Administrative Layers (National and Region Boundaries; Main cities)

Source: Humanitarian Data Exchange

Link: <https://data.humdata.org/dataset/cote-d-ivoire-settlements> and <https://data.humdata.org/dataset/cote-d-ivoire-administrative-boundaries>

Wind

Source: DTU, IRENA

Link: <https://irena.masdar.ac.ae/gallery/#gallery>

Source: DTU, IRENA

Link: <http://globalsolaratlas.info/downloads/cote-d-ivoire>

4.4 STAKEHOLDER DIRECTORY

4.4.1 GOVERNMENT AND AGENCIES

Ministre du Pétrole l'Energie et du Développement des Energies Renouvelables/ Ministry of Petroleum Energy and Development of Renewable Energies

Contact: Email: info@energie.gouv.ci

Telephone: (+225) 20 21 50 03

Link: <http://mpeder.ci/>

Brief description: The ministry prepares and implements the policy of State in terms of energy production and distribution, promotion of renewable energies. It develops, in particular, plans and programs of energy saving and development of alternative energies likely to provide the national economy with a substantial reduction in the weight of conventional energies such as natural gas.

Autorité Nationale de Régulation du secteur de l'Electricité de Côte d'Ivoire/ Côte d'Ivoire National Electricity Regulation Authority (ANARE-CI)

Contact: Email: nfo@anare.ci / recours@anare.c

Telephone: (+225) 20 206 010

Link: <http://www.anare.ci/>

Brief description: ANARCI was created in 2016 as a substitute of ANARE. It is in charge of reviewing license or concession applications and ensuring compliance with ToRs; determining the structure and composition of the tariffs; and ensuring compliance with technical standards. ANARE-CO is also responsible for reviewing and suggesting tariffs to the Ministry.

CI-Energies

Contact: Email: secretariatdg@cienergies.ci

Telephone: (+225) 20 62 01

Link: <http://www.cinergies.ci/>

Brief description: CI-Energies is a state-owned company that responds to MPEER priorities and manages the whole energy sector this involves energy planning, project management and development as well as financial management and rural electrification planning. CI-Energies has developed all four Côte d'Ivoire's master plans.

4.4.2 MINI-GRID PRACTITIONERS AND PRODUCT DEVELOPERS

Société d'ingénierie et de distribution des équipement électriques et solaires (SIDEES- electric and solar distribution and engineering company)

Contact: -

Telephone: (+225) 22 50 90 97

Brief description: SIDEES was created in 1998. The company focuses on solar PV, solar thermal, and biomass and also provides training in solar energy activity. The company has been working on ongoing projects on the PRODERE programme in Côte d'Ivoire by doing feasibility studies.

4.4.3 BILATERAL AND MULTILATERAL DONOR ORGANISATIONS

World Bank

Contact: Email: endri@worldbank.org

Telephone: +225 22 400 400

Link: <https://www.worldbank.org/en/country/cotedivoire>

Brief description: WB has been supporting the National Development Plan of **Côte d'Ivoire** by pledging \$US 15.4 billion in grants and loans to support the plan. The WB is actively supporting the national utility CIE to improve its operation and energy network. As of the end of January 2018, the active portfolio for **Côte d'Ivoire** comprised 23 investment projects, totalling \$2.48 billion.

African Development Bank (AfDB)

Contact:

Telephone: +225 2026 3900

Link: <https://www.afdb.org/fr/contact-us/>

Brief description: AfDB headquarters are located in Abidjan. AfDB's support in Côte d'Ivoire has mainly been around development aid and emergency programme support in post conflict period after 2011. Within the power sector, the AfDB has invested over \$1 billion in power plant expansion projects and network rehabilitation.

Agence Francaise de Developpement (AFD- French Development Bank)

Contact: Email: afdabidjan@afd.fr

Telephone: +225 22 40 70 40

Link: <https://www.afd.fr/fr/notre-agence-en-cote-divoire>

Brief description: AFD's activity in Côte d'Ivoire is around youth employment, social wellbeing and infrastructure development. AFD has been supporting with the World Bank the Electricity for All Programme in providing additional funding to the programme and increase the number of connections to the grid.

UNIDO (United Nations Industrial Development Organisation)

Contact: Email: office.cotedivoire@unido.org

Telephone: +225 22482748

Link: <https://open.unido.org/projects/CI/projects/>

Brief description: UNIDO's activity in Côte d'Ivoire focuses on Creating Shared Prosperity by supporting Educational programmes for improved access to career development. UNIDO has ~ US\$ 30 million directed in different projects. Within the mini-grid sector, UNIDO funded the Akwaba project to implement the only 7 green mini-grids operating in the country.

APPENDICES

Table 11. Low voltage power supply post payment regime (CIE, 2019)

| Tariff categories | FCFA/kWh | FCFA |
|---|-----------------|----------------|
| Social Domestic tariff low voltage power supply | | |
| <i>Fixed bi-semester prime</i> | | 559 |
| <i><= 80 KWh/bimonthly</i> | 36.0 5 | |
| <i>>80 kWh/bimonthly</i> | 73.99 | |
| General Domestic low voltage power supply tariff | | |
| <i>Fixed bimonthly kVA prime</i> | | 140.94 |
| <i><= 180h x power contracted bimonthly</i> | 79.01 | |
| <i>>180h x power contracted bimonthly</i> | 68.48 | |
| Professional general low voltage supply tariff | | |
| <i>Fixed bimonthly kVA prime</i> | | 1831.48 |
| <i><= 180h x power contracted bimonthly</i> | 101.84 | |
| <i>>180h x power contracted bimonthly</i> | 86.62 | |
| Conventional domestic low voltage supply tariff | | |
| <i>Bimonthly price</i> | 21.03 | |
| Public lightning low voltage supply tariff | | |
| <i>Bimonthly price</i> | 86.62 | |

Table 12. Low voltage power supply pre-payment regime (CIE,2019)

| Tariff categories | FCFA/kWh | FCFA |
|--|-----------------|-------------|
| Social Domestic low voltage supply tariff | | |
| <i>Energy share</i> | 24.30 | |
| <i>Fixed kVA prime</i> | | 5.91 |
| General domestic low voltage power tariff | | |
| <i>Energy share</i> | 98.67 | |
| Professional General tariff | | |
| <i>Energy share</i> | 98.67 | |

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