Update of the ECOWAS revised master plan for the development of power generation and transmission of electrical energy

Final Report

Volume 2: State of play of the current situation of the electricity system and perspectives

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TRACTEBEL ENGINEERING S.A.
Boulevard Simón Bolívar 34-36
1000 - Brussels - BELGIUM
tel. +32 2 773 99 11 - fax +32 2 773 99 00
engineering@tractebel.engie.com
tractebel-engie.com

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ACRONYMS

ADB	*Asian Development Bank*
AFD	*Agence française de développement*
BIO	*Biomass Plant*
CAPEX	*Capital Expenditure*
CAPP	*Central Africa Power Pool*
CC	*Combined Cycle*
CEB	*Communauté Electrique du Bénin*
CEET	*Compagnie Energie Electrique du Togo*
CFB	*Circulating Fluidized Bed*
CIE	*Compagnie Ivoirienne d'Electricité*
CI-ENERGIES	*Côte d'Ivoire Energies*
CLSG	*Côte d'Ivoire – Liberia – Sierra Leone – Guinea loop*
COAL	*Coal*
COD	*Commercial operation Date*
CSP	*Concentrated Solar Plant*
CUE	*Cost of Unserved Energy*
DAM	*with Dam*
(D)DO	*Ordinary Diesel*
DFI	*Development finance institutions*
DI	*Diesel group*
DNI	*Direct Normal Irradiation*
DSO	*Société de distribution d'électricité (Distribution System Operator)*
EAGB	*Electricidade e Aguas da Guine-Bissau*
ECOWAS	*Economic Community of West African States*
EDG	*Electricité de Guinée*
EDM	*Electricité du Mali*
EDSA	*Electricity Distribution Supply Authority*

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(E)ENS	*(Expected) Energy Not Served*
EGTC	*Electricity Generation and Transmission Company*
EIB	*European Investment Bank*
ERERA	*Ecowas Regional Electricity Regulatory Authority*
EU	*European Union*
EUR (or €)	*Euro*
FCFA	*Francs CFA*
FSRU	*Floating Storage and Regasification Unit*
GDP	*Gross Domestic Product*
GENCO	*GENenration COrporation*
GHI	*Global Horizontal Irradiation*
GO	*Gasoil*
GRIDCo	*Electricity Transmission Company of Ghana*
GT	*Gas Turbine*
GWh	*Giga Watt heure*
HFO	*Heavy fuel oil*
HRSG	*Heat Recovery Steam Generator*
HYD	*Hydroelectric plant*
ICC	*Information and Coordination Center*
IEA	*International Energy Agency*
IFI	*International Funding Institution*
IMF	*International Monetary Fund*
IPP	*Independent Power Producer*
IPT	*Independant Power Transporter*
IRENA	*International Renewable Energy Agency*
JET	*Jet A1*
LCO	*Light Crude Oil*
LCOE	*Levelized Cost of Electricity*
LEC	*Liberia Electricity Corporation*
LFO	*Light Fuel Oil*

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LHV	*Low Heating Value*
LNG	*Liquefied Natural Gas*
LOLE	*Loss of Load Expectation*
LOLP	*Loss of Load Probability*
MMBTU	*Million British Thermal Unit*
MMCFD	*Million Cubic Feet per Day*
MRU	*Union de la Rivière Mano (Mano river Union)*
N/A	*Not Available*
NAWEC	*National Water and Electricity Company*
NBA	*Niger Basin Authority*
NDC	*National Determined Contribution*
NG	*Natural Gas*
NIGELEC	*Société nigérienne d'électricité*
NTP	*Notice to proceed*
O&M	*Operation & Maintenance*
OC	*Open Cycle*
OECD	*Organisation for Economic Co-operation and Development*
OLTC	*On Load Tap Changer*
OMVG	*Organisation de Mise en Valeur du fleuve Gambie*
OMVS	*Organisation de Mise en Valeur du fleuve Sénégal*
ONEE	*Office National de l'Electricité et l'Eau Potable (Morocco)*
OPEX	*Operating Expenditure*
PC	*Pulverized Coal*
PPA	*Power Purchase Agreement*
PPP	*Private Public Partnership*
PSS	*Power System Stabilizer*
pu	*per unit*
PV	*Photovoltaic plant*
RES	*Renewable Energy Sources*
ROR	*Run of river*

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SAIDI	*System Average Interruption Duration Index : Indicateur de la durée moyenne de coupures sur le système*
SAIFI	*System Average Interruption Frequency Index : Indicateur de la fréquence moyenne de coupures sur le système*
SBEE	*Société Béninoise d'Energie Electrique*
SENELEC	*Société nationale d'électricité du Sénégal*
SOGEM	*Société de Gestion de l'Energie de Manantali*
SONABEL	*Société nationale d'électricité du Burkina*
ST	*Steam Turbine*
SV (or VS)	*Standard Value*
SVC	*Static Var Compensation*
TCN	*Transmission Company of Nigeria*
TSO	*Transmission System Operator*
USD (or US$ or $)	*US Dollar*
VRA	*Volta River Authority*
WAGP(A)	*Western Africa Gas Pipeline (Association)*
WAPP	*West Africa Power Pool*
WT	*Wind Farm*

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1. INTRODUCTION

1.1. Context

The Economic Community of West African States (ECOWAS) is a regional community with a surface of 5.1 million of square km which represents about 17% of the African continent. With a population of more than 300 million inhabitants in 2017, ECOWAS Member States are home to about one-third of the population of sub-Saharan Africa.

ECOWAS has been created with a mandate of promoting economic integration in all fields of activity of the constituting countries. The fifteen-member countries making up ECOWAS are Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, The Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Sierra Leone, Senegal and Togo. The ECOWAS treaty (also known as treaty of Lagos) established the Community during its signature in Lagos (Nigeria) on May 28th, 1975.

One of the most important steps of economic integration in the field of energy was the creation, in 2006 of the Western African Power Pool (WAPP). The WAPP promotes the integration of the national power systems of the fourteen inland countries into a unified regional electricity market with the ultimate goal of providing, in the medium and long-term, a regular and reliable energy at competitive cost to the citizenry of the ECOWAS region

However, the region, which is characterized by a great diversity in terms of culture, language, demography and resources, faces enormous challenges in providing access to sustainable energy for its population. But the 15 ECOWAS Member States are driven by a common desire to offer "affordable, reliable, sustainable and modern energy for all", as per the three main goals of the Sustainable Energy for All (SE4All) initiative, launched by the United Nations Secretary-General.

West-African countries have a great opportunity to reach their objectives thanks to the vast untapped potential in renewable energy (including solar, wind, bioenergy and hydro-power). The Energy Transformation will happen both on-grid and off-grid. It involves the development of mini-grids with hybrid power generation, centralized and decentralized renewable projects potentially coupled with a more flexible demand side, enabled by storage and smart-metering technologies.

Several initiatives like the *African Renewable Energy Initiative* and the *ECOWAS policy on Renewable Energy* support this transformation. However, such a revolution requires financing, leadership and international cooperation. In this context the West African Power Pool is playing a significant role by supporting the development of major energy projects in the region.

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1.2. Objectives of the project

The West African Power Pool promotes cooperation and supports the development of regional projects. In 2012, the Authority of the ECOWAS Heads of State and Government approved, through Supplementary Act A/SA.12/02/12, a list of 59 Priority Projects for the subregion that emanated from the update of the ECOWAS Revised Master Plan for the Generation and Transmission of Electrical Energy prepared by Tractebel.

Considering the evolution of

- the energy landscape,
- the socio-economic context of West Africa over the last 5 years and
- the difficulty in mobilizing public and concessional financing in the sub-region,

  the development of the power system in West Africa deviated from what was foreseen in 2011. A lot of challenges affect the utilities efficiency on several aspects including financial, regulatory, technical and organizational points of view.

Another key parameter which should affect the energy development roadmap of WAPP region is the expected increase penetration of Renewable Energy Sources (RES). Thanks to the significant decrease of costs and increased willingness for the transition to sustainable energy, many WAPP countries have revised their RES targets and launched RES projects.

Consequently, while some flagship generation and transmission projects were developed in the region, some of them are still under development or were strongly delayed while, in parallel new non-anticipated projects emerged.

In this context, the study presents four different main objectives:

- Assessing the **implementation status** of the priority projects identified in 2011, understanding the main challenges and barriers to the development of these projects and identifying the lessons learned that will be taken into account when updating the Master Plan;
- Identifying the **main challenges and critical factors** affecting the performance of utilities in their activities as a public service and proposing a new action plan and mitigation measures to address these constraints in a long-term perspective;
- Assessing the opportunities and constraints for the deployment of **Renewable Energy Sources** in the sub-regional power system (potential, economics, grid constraints…);
- Presenting a clear, comprehensive and coherent view of the future development of power generation and transmission facilities with a list of **priority projects** for West Africa that takes into account the new drivers of electricity generation and consumption, while integrating the current development of the power system at national and regional level and while providing recommendations for facilitating the implementation of the projects.

This will lead to an **update of the ECOWAS Master Plan for Generation and Transmission of Electrical Energy**, a comprehensive study providing a rational basis for decision making and implementation in the power sector.

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1.3. Organisation of the report for the update of the ECOWAS revised master plan for the development of power generation and transmission of electrical energy

The report is divided into five main volumes corresponding to the five main deliverables of the study.

VOLUME 1: Executive Summary

Volume 1 is the synthesis of the Final Report of the update of the revised ECOWAS Master Plan. It contains the main recommendations of the study concerning the future development of the electricity generation and transmission infrastructures as well as a list of priority projects and the implementation strategy of these projects.

VOLUME 2: State of play of the current situation of the electricity system and perspectives

Volume 2 consists of a synthesis of data collected and assumptions used in the context of this project, and in particular for the update of the generation and transmission master plan.

VOLUME 3: Challenges and Action Plans for electricity Companies

Volume 3 aims at presenting the main challenges and critical factors affecting the performance and the sustainability of utilities members of WAPP and at recommending a new action plan and mitigation measures to address these critical factors from a transversal perspective...

VOLUME 4: Generation and Transmission Master Plan

Volume 4 is devoted to the results of the generation and transmission master plan: It presents a robust and economically optimal development plan while taking into account the current state of the energy sector in West Africa and opportunities for developing renewable energy sources in the region while ensuring the technical stability of the interconnected system

VOLUME 5: Priority Investment Program and Implementation Strategy

Volume 5 focuses first on carrying out a review of the implementation of the ECOWAS 2012-2025 Master Plan and assessing the causes of the gaps between what was initially planned and what was concretely achieved, allowing some effects to be taken into consideration for the development of the 2017-2033 updated master plan. Then, a new list of priority investment projects is drawn up on the basis of the generation-transmission master plan and a strategy is recommended for the progressive implementation of these projects.

1.4. Objectives of Volume 2

The State of play of the current situation of the electricity system and perspectives report is a very important deliverable. It consists of a collection of all the data and assumptions that have been used for the next stages of the project, and in particular for updating the generation and transmission master plan.

Based on the data collected and the review of the various studies available, this report summarizes the first analyses of demand, supply and transmission network. In particular, the document includes:

- The list of data collected (Chapter 2);
- A demand analysis including an analysis of current demand and a forecast by 2033 (Chapter 3);
- An analysis of the current generation fleet and the list of projects decided as well as a set of hypotheses for future projects (Chapter 4);
- An analysis of electricity transmission infrastructure (Chapter 0);
- The definition of planning and operational criteria (Chapter 6).

For each of these categories, the data are organized by country in order to facilitate the validation step by the member states.

Note that, given its insular character, Cape Verde is not an active member of the WAPP and is therefore not studied in detail in this study. The current state of the power system is, however, summarized in this report for the sake of completeness

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2. DATA COLLECTION

The data collection made it possible to meet the representatives of the actors of the electric sectors (national companies, ministries, regulators, ...) of all the member countries of the WAPP. Meetings were also held with the representatives of the *Organisation de Mise en Valeur du fleuve Senegal* (OMVS), the *Organisation de Mise en Valeur du fleuve Gambie* (OMVG) and TRANSCO-CLSG. This phase aimed to:

- To enable stakeholders in the countries concerned to present the current situation of the energy sector in their country, including the difficulties encountered in implementing projects and to convey their expectations regarding regional projects.
- To gather the necessary information for the modeling of the electrical systems: statistics, economic data, studies of local master plans, characteristics of the generation projects, inventory and diagnosis of the transmission network, static and dynamic data of the components of the network, etc.

It is important to highlight the excellent collaboration and assistance provided by the energy directorate of ECOWAS, the WAPP, the UEMOA, the utilities, departments and agencies in the various countries visited. These exchanges and the data collection process have also been greatly facilitated by the active and effective participation of the WAPP.

The data collected are described in a non-exhaustive way below. The detailed list of data collected is presented in Appendix A.

	Data	**Barriers/ Opportunities**
Load Demand	Historic profiles, Evolution of the demand	Brakes on the demand growth Load Shedding/ Unmet demand Technical and non-technical losses Energy Efficiency measures Strategy of rural electrification
Current Generation System	Installed Capacity Energy produced Fuel Consumption and Cost of fuel Hydrological conditions Geographic Coordinates	Obsolescence and Outages Fuel availability and Supply conditions Water shortages Dispatch rules
Future development of Generation	Local Resources National Generation Master Plans Investment Plan per technology (RES, Hydro, Thermal) Characteristics of future generation RES targets and planned projects	RES potential National energy policies (e.g. for RES development) Planning and Operational Criteria Barriers to the development of project Legal framework for the development of private investments Environmental constraints
Existing Transmission Network	Characteristics of the transmission network (PSS/E model, single-line diagram)	Rules for the operation of the network Grid Code

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	Data	Barriers/ Opportunities
		Obsolescence and Outages
Future Transmission Network	National Transmission Master Plans Investment Plan Characteristic of future transmission network Expected barriers for the integration of RES	Financing and authorization issues Environmental constraints
Power Exchanges	Existing Infrastructure and Transfer Capacity Import/Export Tariff Time Series of Exchanges Future expected development of interconnection	Role of the interconnection (commercial exchanges/ back-up/ contractual import-export) Contractual terms and deviations in the day-to-day operation Expected benefits from further interconnecting the system Delays occurred and issues faced in the development phase
Legal and institutional frameworks	Electricity sector laws Investment codes BOT / PPP laws if any Public procurement law Fiscal code	Reforms, either undertaken or planned Governance structure the role national power utilities shall be expected to play in the regional electricity market
Financial performance of power utilities	Tariff structure and adjustment system Audited financial statements of electricity sector utilities over a 5-year period Tariff studies	Tarification reforms Commercial performance of electric utility (in terms of non-technical losses, billing rate and recovery rate) Long and short-term liabilities of the electricity sector utilities Subsidies and policy regarding subsidies
National policies in the electricity sector	National development plans and strategies Policy notes regarding renewables, rural electrification and demand side management IMF country reports	

In most countries, a lot of data have been collected, allowing to establish a vision of the current electricity sector (demand, generation, transmission network). Nevertheless, the consultant had to deal with the lack or obsolescence of some data. In this case, assumptions were made based on the consultant's knowledge of the regional context and rules of international good practice.

The validation of the assumptions taken is therefore an important step for the future acceptance of the results of the study.

3. DEMAND ANALYSIS

3.1. Introduction

The objective of this section is to achieve the forecasts of electricity demand as well as peak load for each of the WAPP countries until 2033.

This analysis is carried out at the level of the injection in the distribution network, that is to say that we will consider the demand for net electricity of the transport losses, but gross of the distribution and commercial losses.

The demand for electricity here is to be understood in the broad sense, that is, it represents the potential of electricity consumption of a country, including therefore the isolated consumers, having their own generator, and likely to connect to the power grid when the latter develops.

In that regard, a special attention will be addressed to the mining sites, whose operations require an important electricity consumption.

Unserved energy is also included in the forecasts that are made in this report.

It should also be noted that the analysis developed here focuses on the electrical energy consumed each year. The peak load will then be deducted from the development of this energy consumption, involving a load factor.

3.2. Methodology

There are a number of methodologies to produce electricity demand forecasts. In the context of this study, we used two techniques, namely the global method and the analytical method, the choice of which depends on the available history, but also on the state of development of the power grid.

The first technique, called *global*, consists in the study of the historical correlation between electricity consumption and other macroeconomic variables such as GDP or population size. The demand forecast is then carried out assuming that the correlation between these different variables will remain constant in the future. This technique is used for the countries characterized by a controlled demand evolution and for which historical data could be collected, namely Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Sénégal and Togo. In order to harmonize the analysis, only one source is used for the past and future evolution of GDP and the population, namely the International Monetary Fund (IMF). For electricity consumption, on the other hand, we rely on the figures transmitted by each country.

The second, so-called *analytical* technique, decomposes demand according to the different sectors of activity (residential, services, industries and administrations) and different geographical areas (urban and rural areas). The demand forecast is then made for each of these segments and then reaggregated at the national level.

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Some factors used in the latter analytical method (such as the number of households, the rate of electrification, …) are taken from reports emanating from institutions of the country. Other factors, such as the specific consumption of households in urban or rural areas for instance, have been harmonized for all countries. This particular method has been applied to the countries for which the past evolution of the demand of electricity doesn't reflect the future evolution (high rate of load shedding for instance). This is the case for the Gambia, Guinea, Guinea-Bissau, Liberia, Niger and Sierra Leone.

For Nigeria, we considered the demand forecast from the last master plan, since too little information was available to be able to achieve a precise forecast.

These two methodologies are discussed in more details below.

Finally, regarding the electricity consumption of mining sites, the following treatment has been applied:

- The existing sites located close to existing transmission lines or decided future lines will be included in the base case scenario of the demand forecast
- The existing sites that are not close to existing transmission lines or decided future lines will be included in the high scenario of the demand forecast, at horizon 2020
- The future mining sites that are still in project will be integrated in the high scenario at horizon 2033

Finally, we should note that these forecasts have been discussed with each country and that some adjustments have sometimes been made in order to best stick with the reality (taking into account national estimates of GDP or population, introduction of mining projects, justification for taking into account other explanatory factors than GDP such as the population, …).

3.2.1. Global method

The global method is based on the technique of multiple linear regression. The latter consists in connecting the consumption of electricity (dependent variable) with other macroeconomic indicators, such as GDP or population size (independent or explanatory variables):

$$C_t = \alpha_0 + \alpha_1 PIB_t + \alpha_2 POP_t$$

where :

- C_t represents the electricity consumption of the country for year t
- PIB_t represents the country's GDP for the year T
- POP_t represents the country's population for the year T

This statistical model is calibrated on a history of electricity consumption data, amount of GDP and population size. The purpose of this calibration is to determine the parameters of the regression $(\alpha_0, \alpha_1, \alpha_2)$ That allow the model to best match the data observed in the past. This step will be done using the least squares method.

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Once the model is calibrated, it can then be used to be able to forecast electricity consumption in the future. However, this requires the provision of forecasts on the evolution of dependent variables such as GDP or population. As a reminder, we will use the IMF's GDP and population forecasts here. It is important to note, however, that this technique assumes that the relationship between the different variables of interest will remain unchanged in the future.

But before you can calibrate this model, you must first of all choose which explanatory variable(s) to include in the model. Should we use the GDP and the population, or only one of these two variables? Which one, if any? To answer this question, one possibility is to use the Akaïke information criterion, which is to find the best compromise between the information provided by a variable and the additional complexity of the resulting model. The table below lists the optimum variables for each country:

Countries	Optimal Explanatory Variable(s)	Multicolinearity?	Final Explanatory Variable(s)
Benin	GDP & POP	Yes	GDP
Burkina Faso	GDP & POP	Yes	GDP
Côte d'Ivoire	GDP & POP	No	GDP & POP
Ghana	GDP	No	GDP
Should	GDP	No	GDP
Senegal	GDP	No	GDP
Togo	GDP & POP	Yes	GDP

Table 1: Optimum variables for the global method

We have taken care here to verify that the use of the two variables GDP and population did not introduce multicollinearity[1] in the model. If this is the case, the final model involves only one of the two variables (also chosen according to the Akaïke criterion).

We see that in the end, only Côte d'Ivoire will use a model that involves both GDP and the population. For other countries, GDP will be chosen as the single explanatory variable.

The summary of the technical values of the models will be detailed in the section dedicated to each country below.

Note that a low and high scenario are also introduced, in order to give a sensitivity analysis. The low scenario is achieved by taking into account 75% of GDP growth rates and possibly of the expected population growth by the IMF. The high scenario considers 125% of these same growth rates.

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[1] The phenomenon of multicollinearity materializes when the correlation between several explanatory variables is too large, which results in a significant reduction in the accuracy of the estimators. The test of multicollinearity is based on the Variance Inflation Factor (VIF), which must be less than 10 to conclude that there is no multicollinearity.

3.2.2. Analytical method

For some countries, the current development of the electricity grid is such that it is difficult to apply the global method.

Firstly, because the history is often very short, or almost non-existent, given the recent nature of the development of electrical infrastructure, or simply the cessation of operations in some cases (due to civil war for example).

Secondly, because it is difficult to make future predictions on the assumption of a constant correlation between GDP, population and electricity consumption, given the low development of the grid. Growth rates will effectively be more important in the short term than in the longer term.

We have therefore developed an analytical technique for countries with these characteristics, namely Gambia, Guinea, Guinea-Bissau, Liberia, Niger and Sierra Leone.

This technique is based on a breakdown of electricity consumption between residential use and use by companies, industries and other administrations.

For residential consumption, we introduced the following elements in the analysis:

- The number of households: growing according to the growth forecast of the IMF population;
- The rate of electrification: defined as the ratio of the number of clients to the number of households:
  - The initial rate depends on the initial situation of each country
  - The final rate (in 2033) is assumed to be 90% for urban areas and 65% for rural areas
- Specific consumption : defined as the annual consumption of a household, we will make a distinction for urban and rural areas. In addition a growth of 1.5% per year will be considered reflecting the increase in the consumption of each household over time.
  - Urban areas:
    - Consumption Specific: 1000 kWh/y
  - Rural areas:
    - Consumption Specific: 500 kWh/y
- Load factors: they will also be assumed constant throughout the projection horizon;
  - Residential consumers: 50%

Concerning professional, industrial and administration clients, the main hypothesis in the analytical approach is to increase their consumption according to the expected evolution of the IMF's GDP, while taking into account an elasticity of 1.3. This means that if GDP rises by 1%, then electricity consumption for these customers will increase by 1.3%.

A constant 70% load factor will be considered for these customers.

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To perform a sensitivity analysis, we have also introduced low and high scenarios, defined as follows:

- Low scenario:
  - Specific consumption:
    - Urban areas: 750 kWh/Year
    - Rural areas: 350 kWh /Year
    - Annual growth rate: 1%
  - Electrification rate 2033:
    - Urban areas: 80%
    - Rural areas: 50%
  - Elasticity of electricity demand with respect to GDP for professional, industrial and business customers Administrations: 1
- High scenario:
  - Specific consumption:
    - Urban areas: 1 250 kwh/Year
    - Rural areas: 650 kwh/Year
    - Annual growth rate : 2%
  - Electrification rate 2033:
    - Urban areas: 95%
    - Rural areas: 75%
  - Elasticity of electricity demand with respect to GDP for professional, industrial and business customers Administrations: 1.5

3.3. Load Demand Forecast per Country

3.3.1. Benin

3.3.1.1. MACRO-ECONOMIC PARAMETERS

The GDP of Benin experienced an average growth of 4.3% in real terms over the period 2000-2017, according to the IMF figures. This growth is still quite volatile, due in particular to the large proportion of agriculture in GDP, the latter sector being strongly dependent on weather conditions, as well as international markets (concerning cotton especially in the case of Benin).

GDP per capita followed a lower growth rate of 1.3 per cent over the same period, with the result that the poverty rate increased from 36.2 per cent in 2011 to 40.1 per cent in 2015.

The population of Benin is estimated at 11.4 million inhabitants at the end of the year 2017. It grew at an average rate of 3% between 2000 and 2017, which partly explains the modest performance of the per capita GDP mentioned above. In the medium-term, the IMF expects a lower growth rate of 2.2%.

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3.3.1.2. HISTORICAL DEMAND ANALYSIS

The demand for electricity in Benin is mainly provided by:

- The CEB, which is the transport network manager, having its own means of production, but which imports the majority of the electricity;
- The SBEE, which is the manager of the distribution network, which has its own production facilities.

The history of electricity consumption at the point of injection is included in the table below. It is therefore made up of the CEB's electricity sales to the SBEE and SCB Lafarge to which the own production of the SBEE (called *internal source*) is still to be added.

	CEB sales to SBEE + SCB Lafarge [GWh]	SBEE Internal Source [GWh]	Total [GWh]
2008	663		663
2009	868		868
2010	937		937
2011	1065		1065
2012	1125		1125
2013	1156	30	1186
2014	1170	91	1261
2015	1146	121	1267
2016	1101	180	1281

Table 2: Historical demand for electricity in Benin

According to these figures, consumption growth in Benin has averaged 8.9% over the last 9 years.

The peak load of the SBEE network was 257.3 MW in 2016 with an estimated load factor of 57%.

Transport losses averaged 4.9% over the last 6 years.

The energy non served amounted to 22 GWh (or 0.8% of the total electricity demand) in 2016 for the whole CEB network (covering Togo and Benin).

3.3.1.3. ELECTRICITY DEMAND FORECAST

Statistically, Akaïke's information criterion indicates that GDP is the optimum variable for explaining electricity consumption. The summary of the statistical model used is included in the table below. In particular, the explanatory power of the model is very good, given the R^2 of 0.6. The significance of GDP is also very important (P-value less than 5%).

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	Coefficients	Standard deviation	t-stat	P-value
constant	- 75,10	360,30	- 0,21	0,84
PIB	0,32	0,10	3,07	0,02
R^2	0.6			

Table 3: Summary of the statistical model used for Benin

According to this model, the forecast of demand for electricity in 2033 is 3531 GWh for the baseline scenario (taking into the IMF GDP growth assumptions). This forecast corresponds to an average consumption growth rate of 6.4%, which is in line with the growth figures collected in the last data collection from the CEB (6%).

It should be noted, however, that this forecast is below a 2014 forecast carried out by the consultant IED, which provided 5829 GWh[2] consumed in 2033 (an average annual growth of 7.25%).

The low and high scenarios, obtained by considering respectively 75% or 125% of the expected growth rates of the IMF, foresee an energy consumption of respectively 2737 GWh and 4535 GWh.

The peak load forecast was calculated by keeping the 2016 load factor constant, or 57%, assuming the repartition between residential and industrial load will remain constant in the future. According to our calculations, this peak load will reach 704 MW in 2033 in the base scenario.

This value is also below the forecast made by IED, waiting for a peak load around 1282 MW in 2033.

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[2] In order to be able to compare the different forecasts, we had to integrate the sales and distribution losses to the Consultant forecast, the latter being achieved at the level of final consumption (final sales to the consumer). The commercial loss rate and distribution used is the one estimated in 2014, namely 21% (assumed constant over the entire projection time).

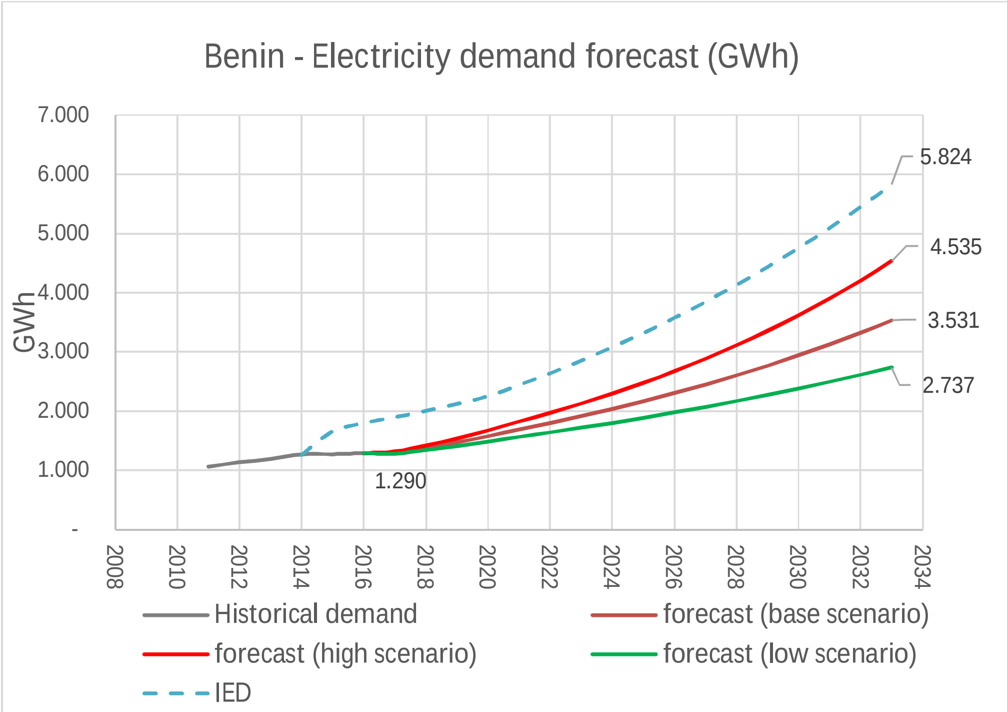

Figure 1: Electricity demand forecast for Benin

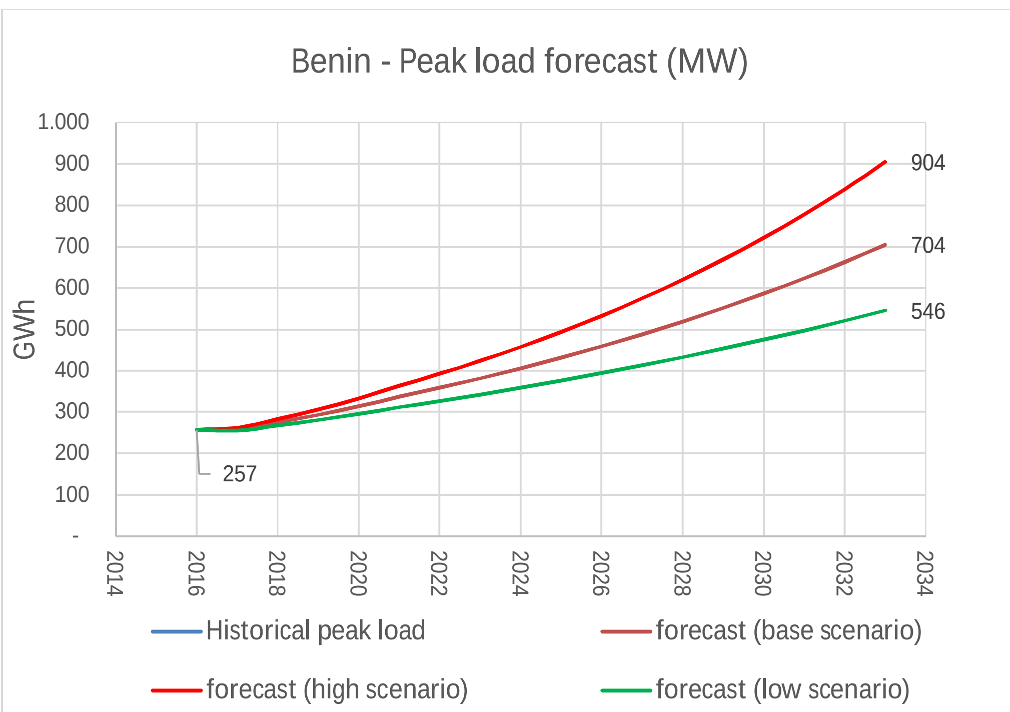

Figure 2: Peak load forecast for Benin

Final version

3.3.2. Burkina Faso

3.3.2.1. MACRO-ECONOMIC PARAMETERS

Until 2009, the population of Burkina Faso showed annual growth of around 3%. Currently, the population of Burkina Faso is 18,9 million according to IMF figures, and population growth revolves around 2.5%. The IMF expects that the growth rate will stabilize around 2% in the coming years.

GDP in Burkina Faso (at constant prices) has grown on average by 5% per annum over the last 10 years according to the International Monetary Fund. According to the same source, the growth rate is expected to remain similar in the next five years.

3.3.2.2. HISTORICAL DEMAND ANALYSIS

In 2016, the energy delivered to the distribution reached 1523 GWh, for an energy billed 1317 GWh. This energy comes from 40% of imports and 60% of domestic production.

Energy distributed to cru at an average rate of 9% between 2004 and 2016, with peaks of growth exceeding 11% in 2009, 2010 and 2012.

3.3.2.3. ELECTRICITY DEMAND FORECAST

In order to be consistent with the approach adopted for each country, the forecast of electricity demand will be realized at the level of net energy injected into the network, i.e. net of transport losses, but gross loss of distribution and Business losses.

The starting point of the forecast therefore corresponds to a net electricity injected from 1639 GWh in 2017.

Statistically, Akaïke's information criterion indicates that GDP is the optimal variables for explaining electricity consumption. The summary of the statistical model used is included in the table below. In particular, the explanatory power of the model is very good, given the R ² of 0.99. The significance of GDP is also very important (P-value much less than 1%).

	Coefficients	Standard error	t-stat	P-value
Constant	-539.79	42.42	-12.7	2.51E-08
GDP	0.44	0.01	37.3	8.75E-14
R^2	0.99			

Table 4: Summary of the statistical model used for Burkina Faso

According to this model, the forecast of demand for electricity in 2033 is 5026 GWh for the baseline scenario (taking into the GDP growth assumptions and the IMF population). This forecast corresponds to an average consumption growth rate of 7.3%.

Final version

This forecast is relatively aligned with the forecast achieved in 2015 during the study "reliability and optimization of means of production".

The peak load forecast was made considering that the load factor will stabilize at 0.55 in the coming years. The load peak will then reach 1043 MW in 2033.

The low and high scenarios, obtained by considering respectively 75% or 125% of the expected growth rates of the IMF, foresee an energy consumption of respectively 3872 GWh and 6458 GWh.

The high scenario, however, includes existing and future mining sites. According to the information collected from the SONABEL, existing mining sites currently represent a peak consumption of 110 MW, and sites in project 266 MW. Existing sites are progressively integrated until 2020 while the sites in project are introduced in the high scenario at horizon 2033.

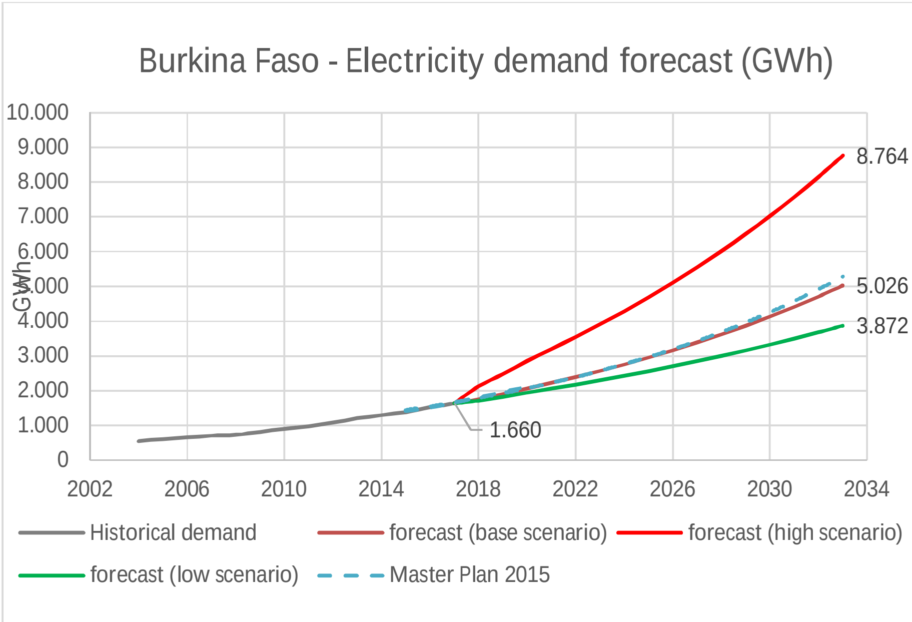

Figure 3: Electricity demand forecast for Burkina Faso

Final version

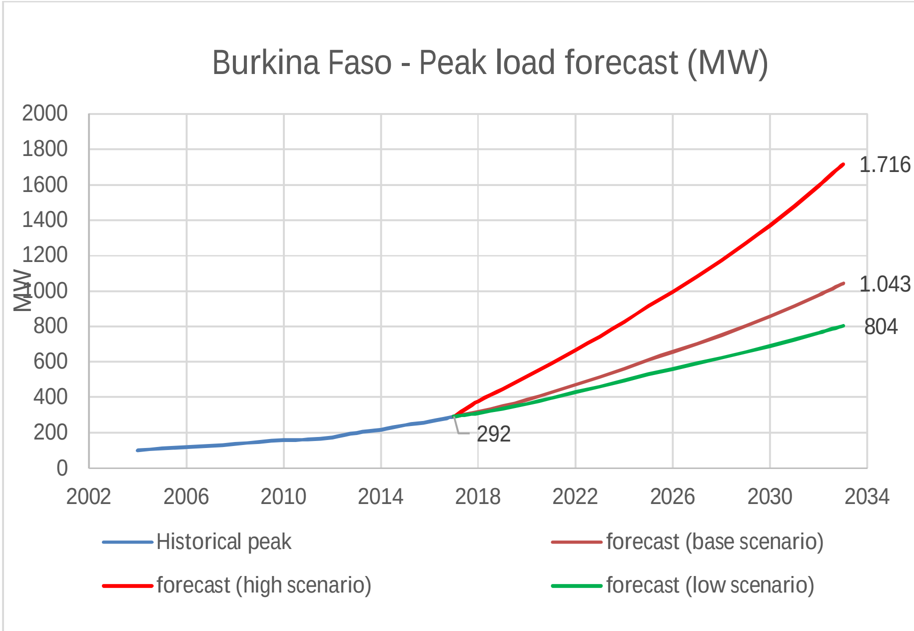

Figure 4: Peak load forecast for Burkina Faso

3.3.3. Côte d'Ivoire

3.3.3.1. MACRO-ECONOMIC PARAMETERS

Since 1997, the population of Côte d'Ivoire has risen with an annual growth rate of 2.6%. The International Monetary Fund expects that the growth of the population will continue at the same pace in the years to come. The population of Côte d'Ivoire was almost 25 million inhabitants in 2017.

Gross domestic product (at constant prices) remained almost constant between 1997 and 2012. Since 2012, it grows at an average rate of 8% per annum. The IMF expects that GDP growth will average 7% in the next 5 years.

At the national level, Côte d'Ivoire has set the goal of becoming an emerging country on the 2020 horizon. The 2016-2020 National Development Plan, which is the roadmap for achieving this objective, predicts growth rates of 8.5% at Horizon 2020.

3.3.3.2. HISTORICAL DEMAND ANALYSIS

By 2017, the energy delivered to the distribution reached 8716 GWh. The energy delivered to the distribution has increased at an average rate of 6.2% per annum since 2004, but in a very irregular manner. This irregularity is due to an irregular growth in the country's economy (politico-economic shocks) and fluctuating climatic conditions from one year to the next.

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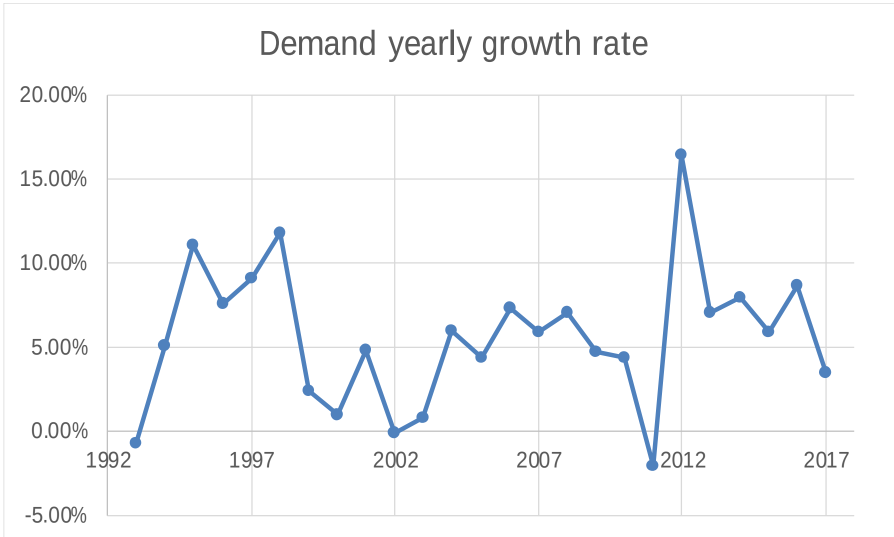

Figure 5: Yearly Growth Rate of Demand in Côte d'Ivoire

The energy consumed in Côte d'Ivoire is generated locally. In addition, Côte d'Ivoire exports part of its production to Burkina Faso and Mali.

3.3.3.3. ELECTRICITY DEMAND FORECAST

In order to be consistent with the approach adopted for each country, the forecast of electricity demand will be realized at the level of net energy injected into the network, i.e. net of transport losses, but gross loss of distribution and business losses.

The starting point for the forecast therefore corresponds to a net electricity injection of 8715 GWh in 2017.

Statistically, Akaïke's information criterion indicates that GDP and population are the optimal variables for explaining electricity consumption. The summary of the statistical model used is included in the table below. In particular, the explanatory power of the model is very good, given the R^2 of 0.98. The significance of both GDP and population is also very important (P-value much less than 1%).

	Coefficients	Standard deviation	t Stat	P-value
constant	-3672724.84	229072.52	-16.03	1.22 e-15
Population	203712.42	27943.55	7.29	6.16 e-08
PIB	409.24	46.17	8.86	1.29 E-09
R^2	0.98			

Table 5: Summary of the statistical model used for Côte d'Ivoire

According to this model, the forecast of demand for electricity in 2033 is 25 458 GWh for the baseline scenario (taking into the IMF GDP growth assumptions). This forecast corresponds to an average consumption growth rate of 6.9%.

Final version

This forecast is relatively aligned with the forecast made in 2014 in the production and transport Master plan.

The low and high scenarios, obtained by considering respectively 75% or 125% of the expected growth rates of the IMF, foresee an energy consumption of respectively 19 677 GWh and 31 767 GWh.

The forecast of the peak load was made considering that the load factor will stabilize at 0.73 in the coming years, this value corresponding to the average of the last 5 years. In this way, peak load is forecasted to reach 3981 MW in 2033.

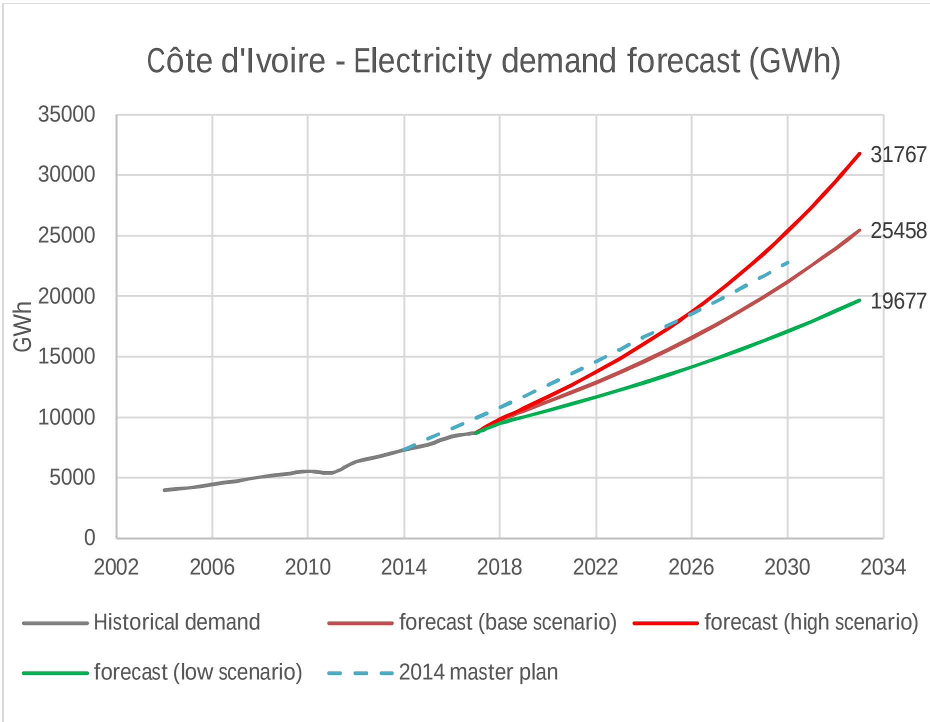

Figure 6: Electricity demand forecast for Côte d'Ivoire

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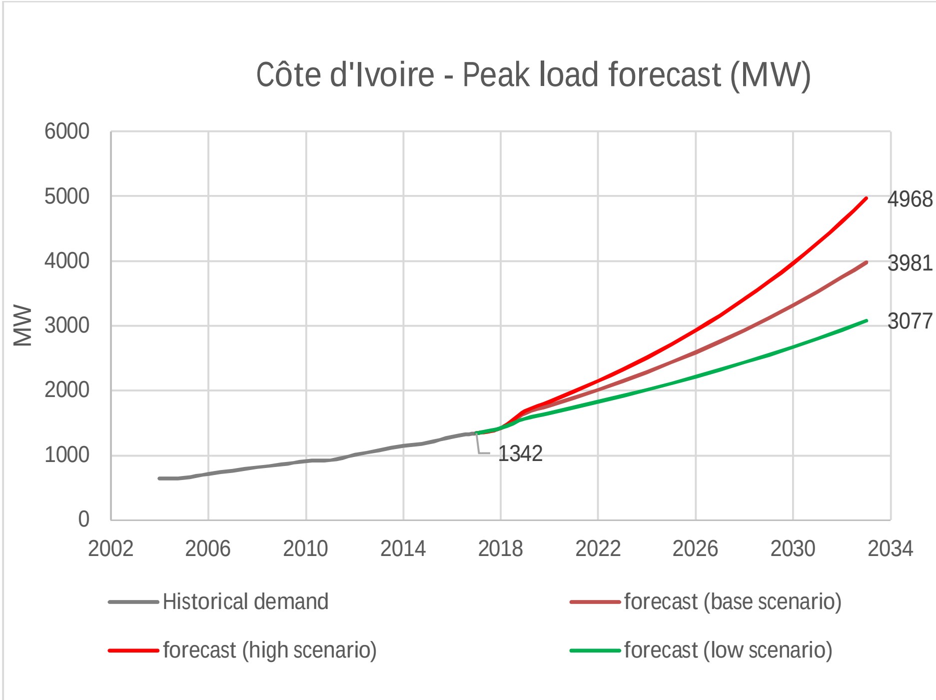

Figure 7: Peak load forecast for Côte d'Ivoire

3.3.4. Gambia

3.3.4.1. MACRO-ECONOMIC PARAMETERS

The GDP of the Republic of The Gambia has experienced a growth of 3.4% on average, in real terms, between 2000 and 2017, according to the IMF. Regarding the GDP per capita, the growth averaged less than 0.5% over the period ranging from 2004 until 2014. This moderate performance is mainly attributable to repeated weather-related shocks. Indeed, over the last 50 years, The Gambia experienced 11 periods of drought, with 4 in just the last 12 years. The outbreak of Ebola in 2014 has impacted also significantly the GDP recently.

The outlook regarding the development of the GDP on the medium-term for The Gambia is expected around a 4% growth rate, according to the analysis of the IMF.

The population of The Gambia, estimated to amount to 2,1 million in the end of 2017, experienced an important growth rate of 3.3% from 2000 to 2017, being one of the fastest growing population in the region over that period. The IMF foresees that the current pace of growth of the population will be maintained in the coming years.

3.3.4.2. ANALYSIS OF THE HISTORICAL ELECTRICITY DEMAND

According to the Electricity roadmap document transmitted, the sales of electricity grew from 175 GWh in 2012 to 240 GWh in 2016. The current peak demand is approximatively of 70 MW but the requirements are estimated around 100 MW, given the suppressed demand.

The electrification rate as of 2014 was of 47% according to SE4ALL Global Tracking Framework. The NAWEC reported 155 000 clients in 2016.

The average transmission and distribution losses was reported as 23% and the electricity bill collection rate as 88% according to 2016 figures.

3.3.4.3. LOAD DEMAND FORECAST

Given the limited information on the history of electricity demand, it was decided to adopt an analytical approach in order to make the demand forecast. This technique starts from the specific consumption of households and companies and then reconstitute the aggregate demand at the national level, as explained in the introduction.

To implement this methodology, we will use the following elements:

- Evolution of the number of households: taken from the "2015 Population and Housing Census" of Statistics Sierra Leone and to which the population growth rates foreseen by the IMF will be applied;
- Electrification rate: defined as the ratio between the number of customers and the number of households :
  - The Initial rate (2014) is of 47% (SE4ALL)
  - The Final rate (in 2033) is assumed to be 90%
- Specific consumption: defined as the annual consumption of a household, a growth of 1.5% per annum will be considered
  - Urban areas:
    - Specific consumption: 1000 kWh/y
  - Rural areas:
    - Specific consumption: 500 kWh/y
- Consumption of enterprises, industries and administrations: The starting point for these consumers is deducted from the residential consumption and the global sales figures; their consumption amounts to 111 GWh as of 2016 and it evolves according to the GDP, with an elasticity of 1.3 considered.
- Load factors: They will be assumed constant also throughout the projection horizon in question;
  - Residential consumers: 50%
  - Business consumers: 70%
- Network performance: transmission and distribution losses are assumed to stay constant at their 2014 value of 23.4%

According to this approach, the prediction of the energy injected into the network is of 1590 GWh by the year 2033, corresponding to an average growth rate of 6.9%.

To provide a sensitivity analysis, we will introduce a low scenario and a high scenario, varying the different factors as presented in section 3.2.

According to these two scenarios, the energy injected into the network at Horizon 2033 will be 1299 GWh in the low scenario, and 1809 GWh in the high scenario.

Regarding peak load, our forecast indicate that it will reach 297 MW in 2033, which corresponds to an average growth rate of 7.1%. This forecast is in line with the one realized by Fichtner, which was forecasting circa 200 MW in 2025.

The evolution of the peak load in the two scenarios defined above will be of 230 MW in 2033 in the low scenario and 344 MW in the high scenario.

As far as energy not served is concerned, it was estimated by 2017 at 211 GWh, or 38% of the total demand. It is however forecasted to be completely absorbed by 2023, following the effective implementation of the planned projects.

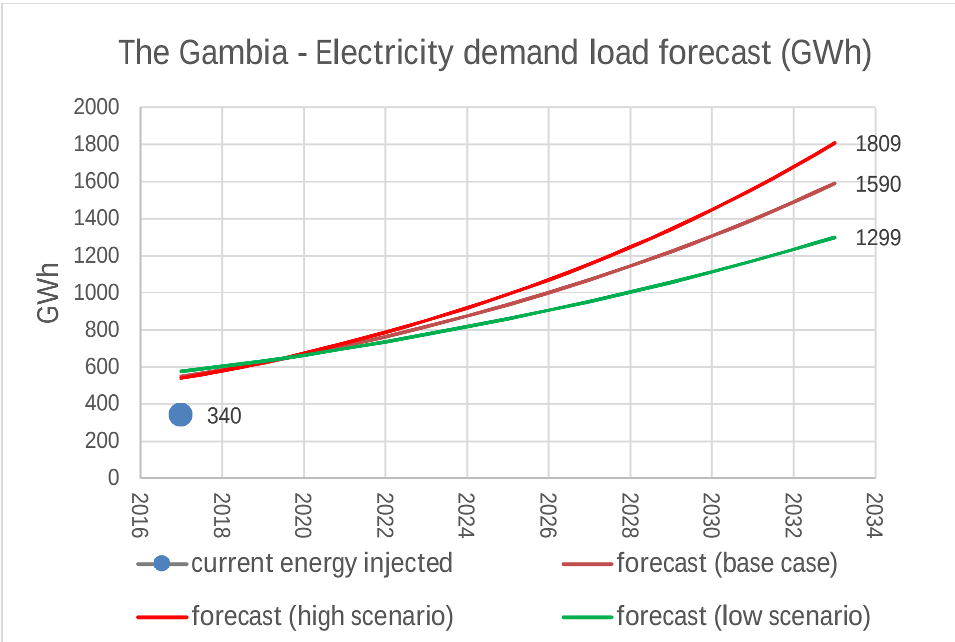

Figure 8: Electricity demand forecast for The Gambia

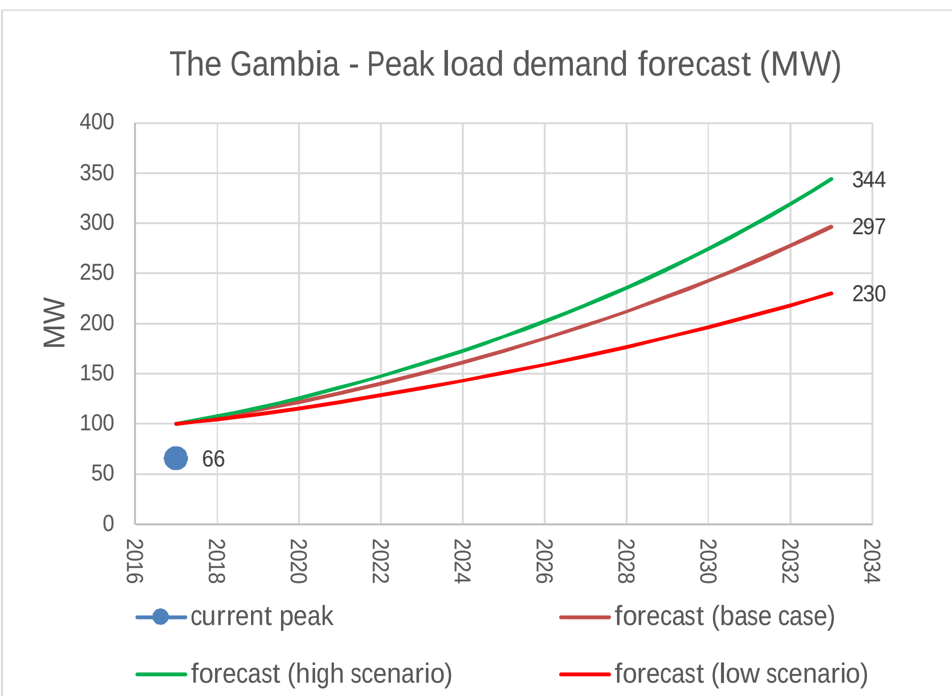

Figure 9: Peak load forecast for The Gambia

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3.3.5. Ghana

3.3.5.1. MACRO-ECONOMIC PARAMETERS

Over the past 20 years, Ghana's GDP has experienced a stable growth of 5.4% in real terms. This growth has even risen lately, with the discovery and exploitation of several oil fields, notably the *Jubilee*, averaging 7% over the 2010-2017 period. According to the IMF, the medium-term prospects are supported by a rising hydrocarbon production with an expected growth of 6.1% average.

As of end of 2017, the population of Ghana was of 28.3 million, according to the last figures from the IMF. With a current growth rate of 2.6%, the population is expected to double in 29 years, threatening hence somewhat the expected economic progress.

3.3.5.2. ANALYSIS OF THE HISTORICAL ELECTRICITY DEMAND

If we exclude the industrial client Volta Aluminium Company (VALCO), the electricity consumption in Ghana increased from 6414 GWh in 2005 to 12 705 GWh in 2017, which represents an average growth rate of 6.1%. The volatility of this growth rate was important though (7%), with some years experiencing even a decrease in electricity consumption[3].

VALCO, the biggest industrial customer in Ghana, accounted for 631 GWh as of 2016, or 5% of the total electricity consumption of the country.

GridCo, the Electricity Transmission Utility transmits the power to the electricity distribution companies (ECG and NEDCo) and to other bulk customers, such as mining and textile companies.

It imports electricity from Côte d'Ivoire and exports to Burkina Faso (SONABEL), Togo and Bénin (CEB) and Côte d'Ivoire (CIE).

As far as peak load is concerned, it increased from 1274 MW in 2007 to 2087 MW in 2016, corresponding to a growth rate of 5.7%. Over the same period, according to our computation, the load factor evolved from 62% to 70%.

The transmission losses averaged 4.1% from 2007 until 2016. The distribution losses are about 23% for ECG and NEDCo, the two distribution companies, but they aim to reduce it to 13-14% for 2021-2022.

Finally, the unserved energy is about 10%.

3.3.5.3. LOAD DEMAND FORECAST

To be consistent with the rest of the study, the load demand forecast is done at the level of the net energy injected in the distribution grid, i.e. net of transmission losses but gross of distribution and commercial losses.

Final version

[3] In particular, the year 2015 showed a decrease of circa -10 % of the electricity consumption, mainly caused by the numerous load shedding that occurred that year, due to insufficient generation.

Also, the regression has been performed without considering VALCO, given the size and the volatility of the consumption of this client. The expected demand of this particular client, transmitted by GRIDCo, will be added afterwards to the forecast.

The starting point of the forecast corresponds therefore to a net injected electricity of 12 705 GWh without VALCO and 13 336 GWh with VALCO.

Statistically speaking, the Akaïke Information Criterion indicates that the GDP is the optimal variable to derive the electricity consumption. The summary of the statistical model used is shown in the table below. In particular, we observe that the explanatory power of the model is very good, given the R^2 of 0.93. The significance of GDP is also very important (P-value well below 1%).

	Coefficients	Standard deviation	t Stat	P-value
constant	1108,35	929,22	1193,0	2,67E-01
PIB	315,84	32,36	9759,0	1,02E-05
R^2	0,93			

Table 6: Summary of the statistical model used for Ghana

According to this model, the electricity demand forecast in 2033 is of 32 361 GWh in the base case scenario (based on the growth hypothesis of the IMF). This forecast corresponds to an average growth rate of the electricity consumption of 5.8%.

This figure is below the last forecast found in the "2017 Electricity Supply Plan for Ghana" that is expecting 27 523 GWh in 2027 (corresponding to a growth rate of 7.5%). This last version is however aligned with the high scenario that we have built (see below).

The low and high scenarios, obtained by considering respectively 75% or 125% of the expected growth rates of the IMF, foresee an energy consumption of respectively 27 372 GWh and 38 443 GWh in 2033.

The forecast regarding the peak load has been computed by keeping constant the load factor as of 2016 (70%), considering that the share of consumption between residential and industrial consumers. According to our computation, the peak load will reach 4957 MW in 2033 in the base case scenario.

This forecast is again below the one developed in the "2017 Electricity Supply Plan for Ghana" that is expecting 4567 MW in 2027 (corresponding to a growth rate of 7.5%), aligned with our high scenario.

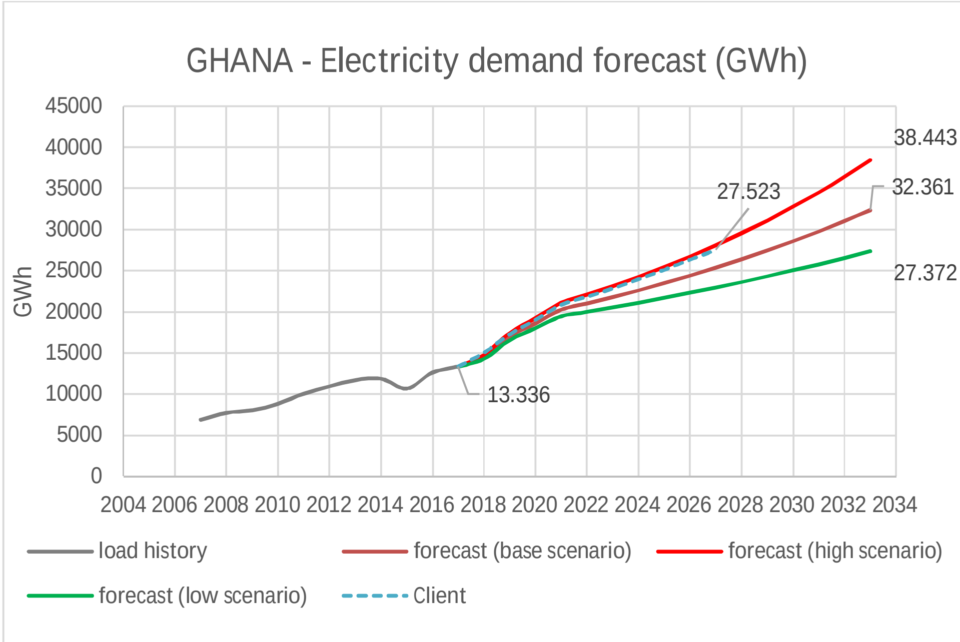

Figure 10: Electricity demand forecast for Ghana

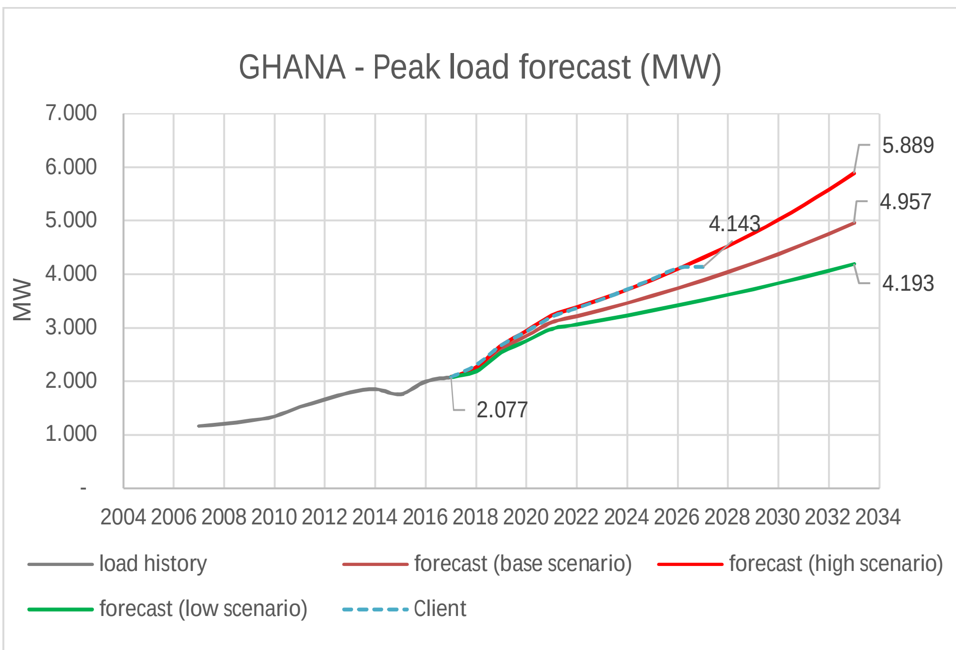

Figure 11: Peak load forecast for Ghana

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3.3.6. Guinea

3.3.6.1. MACRO-ECONOMIC PARAMETERS

Guinea's GDP experienced an average growth rate of 3.9% between 2000 and 2017 according to the IMF. This growth has steadily accelerated over the last few years to reach an average of 5% between 2010 and 2017, despite a contraction in 2014 and 2015 due to the Ebola crisis, rising commodity prices in international markets, and political instability.

The IMF's projections are based on a growth rate of 5.9% in the medium term, fuelled by a sharp increase in mining activity (especially in the operation of bauxite, of which Guinea has a third of the world's reserves) and a rise in public investment in infrastructure.

The population of Guinea is estimated at 13 million per capita at the end of 2017. Its growth rate has accelerated over the last few years, from 2.3% between 2000 and 2017 to 2.6% between 2010 and 2017. The IMF expects a growth rate of 2.5% in the medium term.

3.3.6.2. HISTORICAL DEMAND ANALYSIS

There was little information about the history of electricity demand. According to the report " Studies of the Electric interconnection line 225 kV Guinea-Mali" realized by the consultant Intec in 2015, the amount of electrical energy injected into the interconnected network oscillated around 600 GWh per year between 2000 and 2014.

This stagnation is mainly due to the weak production of the EDG Park as well as poor condition of the transmission network. The demand for electricity is actually more important and the weak quality of services has pushed many customers to install their own generators.

However, since 2015 and the commissioning of the Kaleta Dam (240 MW), electricity production and consumption have increased significantly, as attested in particular by the billed volumes rising from 582 GWh in 2014 to 758 GWh in 2015 and 1003 GWH in 2016, as can be read in EDG's annual report 2016.

As far as peak load is concerned, it reached 295 MW in 2016.

Given the injected energy of 1375 GWh in 2016, the performance of the network, defined as the ratio between the invoiced energy and the energy injected into the network, was then of 72.9% in 2016.

More recently (2018), a study on demand forecasting was carried out by Studi. The latter identified 74 MW of existing mining sites localized close to decided transmission lines (OMVG and OMVS). These will therefore be included in the base case scenario of electricity demand forecast. Considering a load factor of 70%, the energy required to cover these mining needs is 454 GWh.

Taking into account these mining sites, the potential demand for electricity in 2016 is therefore estimated at 1829 GWh, which is the starting point for the current study.

3.3.6.3. ELECTRICITY DEMAND FORECAST

Given the limited information on the history of electricity demand, it was decided to adopt an analytical approach in order to make the demand forecast. This technique starts from the specific consumption of households and enterprises and then reconstitutes the aggregate demand at national level, as explained in the introduction.

To implement this methodology, we will use the following elements:

- Evolution of the number of households: taken from the "Statistical yearbook" 2015 of the National Statistical Institute of Guinea and to which the population growth rates foreseen by the IMF will be applied;
- Electrification rate: defined as the ratio of the number of clients to the number of households, Different electrification rates between Conakry and the rest of the country will be distinguished:
  - Conakry:
    - The initial rate (in 2016) for Conakry is of 57% (calculated on the basis of the information in the EDG Annual report)
    - The final rate (in 2033) is assumed to be 90%
  - Rest of Country: hypotheses taken from the consultant Intec
    - The initial rate (in 2016) is assumed to be 25%
    - The final rate (in 2033) is assumed to be 65%;
- Specific consumption: defined as the annual consumption of a household, a growth of 1.5% per annum will be considered
  - Conakry:
    - Specific consumption: 1000 kWh/y
  - Rest of the country:
    - Specific consumption: 500 kWh/y
- Consumption of enterprises, industries and administrations BT and MT: These consumptions will be expected to grow along with Guinea's GDP to which an elasticity of 1.3 will be applied
- Load factors: They will be assumed constant also throughout the projection horizon in question;
  - LV Consumers: 50%
  - MV Consumers: 60%
- Network performance: assumed constant and equal to its 2016 value, i.e. 27.1%

For potential mine sites, more than 1000 MW (1078 MW) were identified in the Studi study with planned start dates by 2020. These will be gradually integrated into the high scenario, considering a complete connection to the network of these sites on the horizon 2033.

According to this approach, the prediction of the energy injected into the network is of 5294 GWh by the year 2033, i.e. an average growth rate of 7.5% without mining consumption. This forecast is below the one achieved by the consultant Studi, which foresees 8195 GWh in 2032.

It should be noted that the starting point of Studi is more important, namely 2684 GWh in 2016, which is mainly due to the fact that Studi considers the potential demand for an electrification rate of 100%, whereas we have considered the demand corresponding to current and expected future electrification rates.

To provide a sensitivity analysis, we will introduce a low scenario and a high scenario, varying the different factors as presented in section 3.2.

According to these two scenarios, the energy injected into the network at horizon 2033 will be 4314 GWh in the low scenario, and 12 568 GWh in the high scenario (including the consumption of mines).

On the side of the peak load, our forecasts indicate that it will reach 1104 MW in 2033, an average growth rate of 7.5% as well, without mines. Again, this forecast is under the forecast made by Studi, which provided for 1422 MW in 2032.

The evolution of the peak load according to the two scenarios defined above will be 898 MW in 2033 in the low scenario and 2320 in the high scenario (including 1152 MW for mining sites).

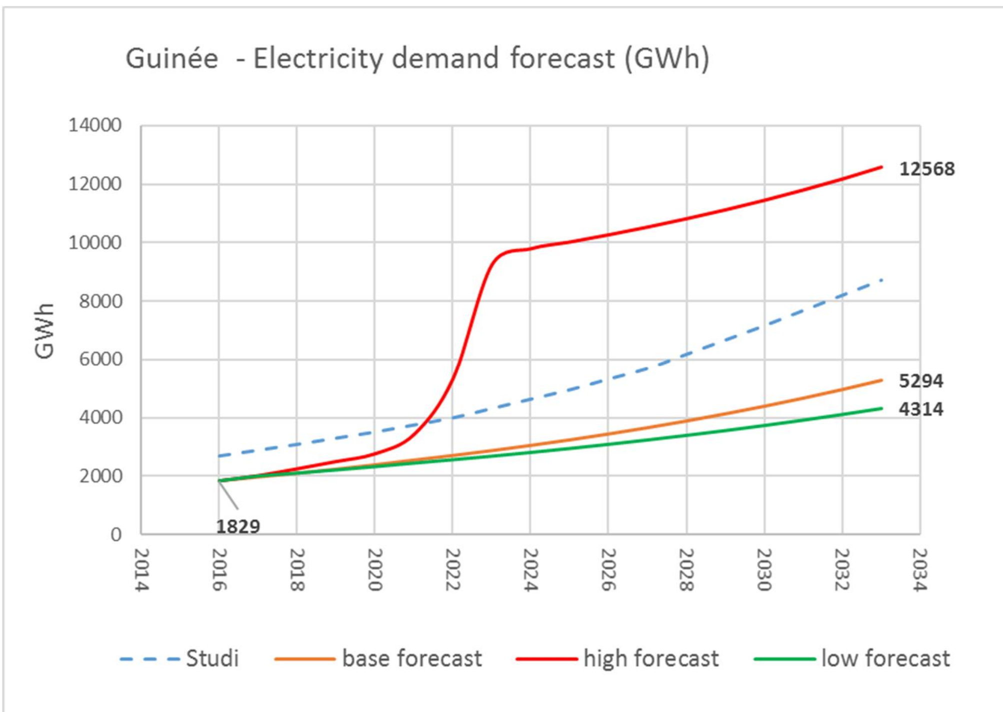

Figure 12: Electricity demand forecast for Guinea

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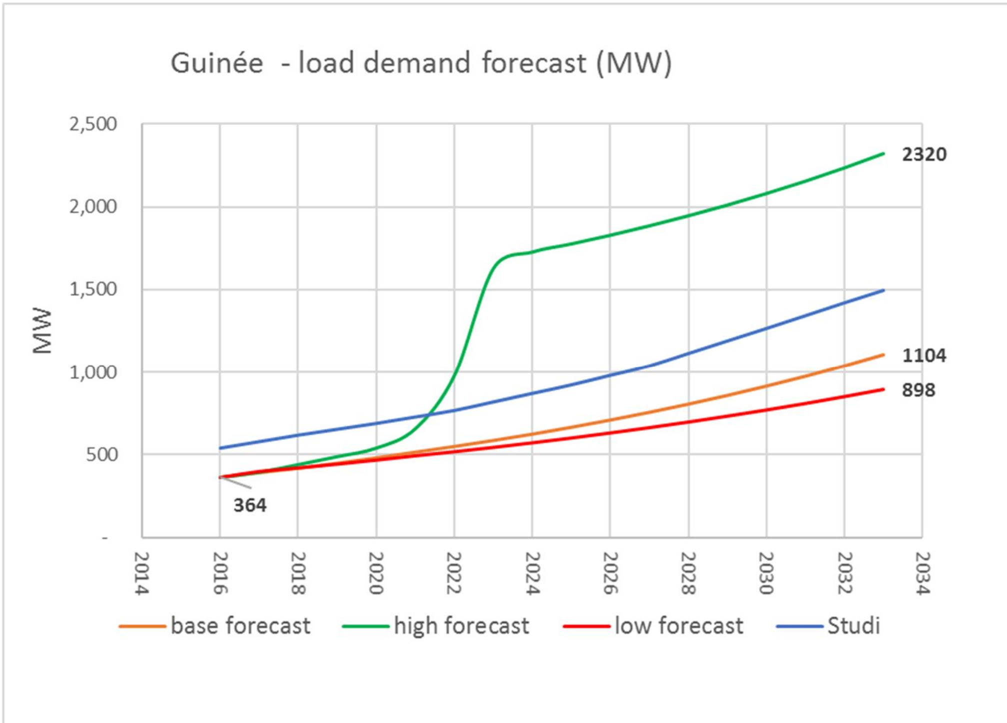

Figure 13: Peak load forecast for Guinea

3.3.7. Guinea Bissau

3.3.7.1. MACRO-ECONOMIC PARAMETERS

The economic activity of Guinea Bissau has experienced an unstable growth over the period 2000-2017, with an average growth rate of 2.8% in real terms. The agriculture constitutes an important part of the GDP (about 40%), exposing the country to weather and commodity price shocks. Political instability, including a civil war in 1998-1999 and military coups in 2003 and 2012, have also contributed to this moderate performance.

However, the economy rebounded since 2015 with an average growth over the recent years of about 6%, helped by higher cashew prices and lower prices for imported food and oil products. The IMF expects this trend to continue in the medium term, with an average rate of the GDP of 5%.

The population of Guinea Bissau is estimated around 1.7 million inhabitants. It grew at a pace of 2.1% and is likely to continue growing at the same rhythm in the coming years, according to the IMF.

3.3.7.2. ANALYSIS OF THE HISTORICAL ELECTRICITY DEMAND

Few information was transmitted regarding electricity consumption figures in Guinea-Bissau. The principal information is taken from the report « Etude du plan directeur énergie et d'un plan de développement des infrastructures pour la production et la distribution d'électricité » of 2012.

Final version

In this report, one can read that the low voltage (LV) sales reached 4139 MWh in 2010, representing 42% of the total sales, while the medium voltage (MV) sales amounted to 5716 GWh the same year.

Historically, the peak power oscillates between 4 and 5.5 MW.

The electrification rate was around 11% for the whole country in 2011.

The transmission and distribution network losses are very important and were estimated at 40% in 2018 according to the World Bank.

3.3.7.3. LOAD DEMAND FORECAST

Given the limited information on the history of electricity demand, it was decided to adopt an analytical approach in order to make the demand forecast. This technique starts from the specific consumption of households and companies and then reconstitute the aggregate demand at the national level, as explained in the introduction.

To implement this methodology, we will use the following elements:

- Evolution of the number of households: estimated using the assumption of 8 people per household. This number of households then evolve according to the population growth rate foreseen by the IMF;
- Electrification rate: defined as the ratio between the number of customers and the number of households:
  - The Initial rate (2014) is of 10%
  - The Final rate (in 2033) is assumed to be 90%
- Specific consumption: defined as the annual consumption of a household, a growth of 1.5% per annum will be considered
  - Specific consumption: 1000 kWh/y
- Consumption of enterprises, industries and administrations: the repartition of 2010 between residential and industrial consumption is kept constant here, and those consumptions are expected to follow the growth rate of GDP with an elasticity of 1.3;
- Auto-producers: 22.5 MW estimated in 2011 (Master Plan 2012);
- Load factors: They will be assumed constant also throughout the projection horizon in question;
  - Residential consumers: 55%
  - Business consumers: 70%
- Network performance: transmission and distribution losses evolve from 40% in 2018 to 25% in 2033 (World Bank Group).

According to this approach, the prediction of the energy injected into the network is of 1203 GWh by the year 2033, corresponding to an average growth rate of 6.8%. This prevision is relatively more optimistic than the one realized in 2012 in the Master Plan and corresponds actually to the high scenario envisaged in this plan, forecasting 728 GWh in 2025.

To provide a sensitivity analysis, we will introduce a low scenario and a high scenario, by varying the different factors as presented in section 3.2.

According to these two scenarios, the energy injected into the network at horizon 2033 will be 818 GWh in the low scenario, and 1604 GWh in the high scenario.

Final version

Regarding peak load, our forecast indicate that it will reach 215 MW in 2033, which corresponds to an average growth rate of 7%.

The evolution of the peak load in the two scenarios defined above will be of 145 MW in 2033 in the low scenario and 290 MW in the high scenario.

As far as energy not served is concerned, it was estimated by 2011 at 35 GWh, or 78% of the on-grid demand. It is however forecasted to be completely absorbed by 2023, following the effective implementation of the planned projects.

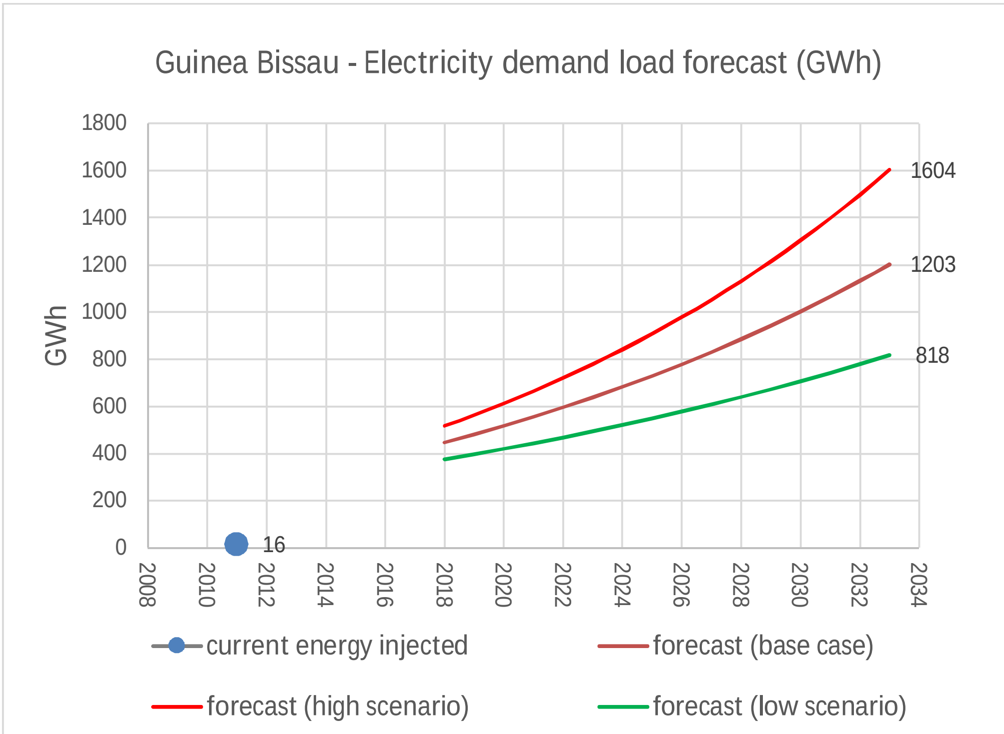

Figure 14: Electricity demand forecast for Guinea Bissau

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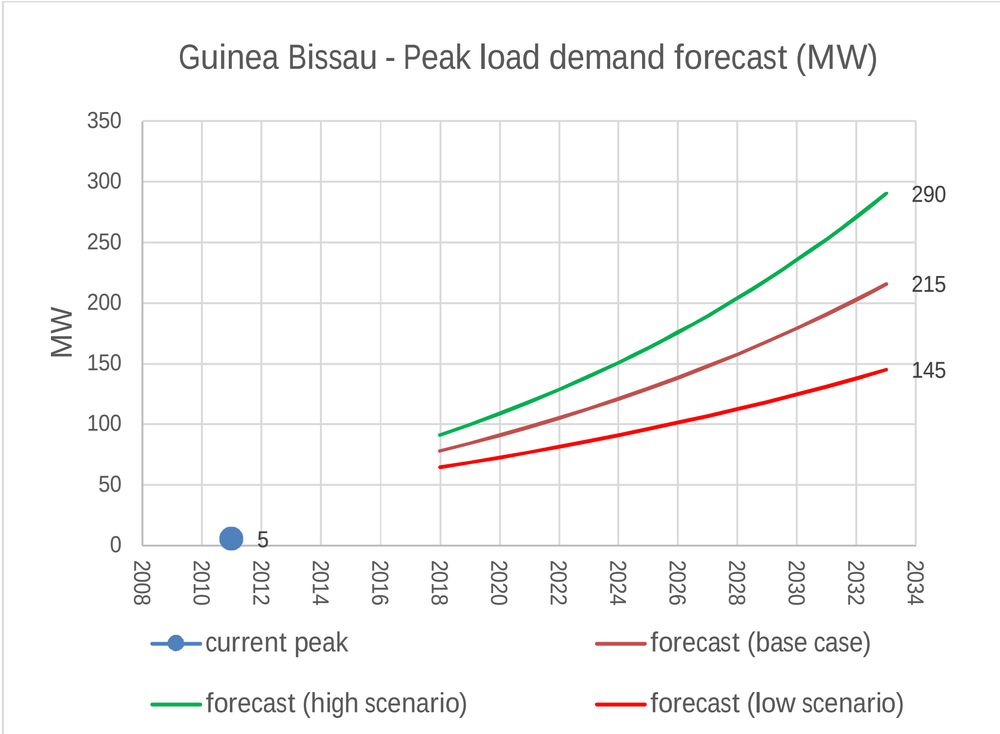

Figure 15: Peak load forecast for Guinea Bissau

3.3.8. Liberia

3.3.8.1. MACRO-ECONOMIC PARAMETERS

At the economic level, Liberia's GDP grew sharply after the civil war, with an average of 7% between 2004 and 2013 according to the IMF. The country's growth then experienced a slowdown caused by the Ebola epidemic and an increase in commodity prices in international markets (0.7% in 2014 and 0% in 2015). IMF forecasts of future GDP trends are quite favourable (5.1% average growth in the year 2022).

The population of Liberia, estimated at 4.5 million as of 2017, has risen upward since the end of the Civil War in 2003 with an average growth rate of 3.2 per cent from 2004 to 2013, according to United Nations figures. However, this rate declined in 2014-2015 due to the Ebola crisis. The IMF foresees an average future growth rate of the population of 2.3%.

3.3.8.2. HISTORICAL DEMAND ANALYSIS

Before the Civil War erupted in 1987, about 35 000 customers were served by the National Power Company (Liberia electricity Corporation, LEC), mainly around Monrovia, the capital that consumed 98% of the electricity production. The installed capacity was then of 182 MW to support a peak load of 63 MW.

The power grid and the means of production (including the Mt. Coffee hydroelectric dam) were significantly damaged during the Civil War Until 2003 and looting continued until 2005. The LEC was officially able to revive the electricity network's activities in 2007 through the importation of generators financed with the help of international partners. Today, the installed capacity is 141 MW, of which 88 MW are attributable to the rehabilitation of the Mount Coffee hydroelectric dam

According to World Bank figures, about 9% of the population was connected to the network in 2014. Although small, this figure still has significant growth. Indeed, the number of network connections has increased very significantly in recent years, from 2200 in 2010 to 36 500 in 2015.

In spite of these recent advances, many potential customers, especially industrial ones, prefer to continue to produce their electricity independently. At issue, the very high rates of more than 0.50 €/kWh (one of the most expensive in the world), as well as the lack of reliability of the network.

According to the master plan 2013, there are potentially 25 large industrial consumers, representing 31 MW, who could connect to the network once the latter is more reliable.

3.3.8.3. ELECTRICITY DEMAND FORECAST

Given the limited information on the history of electricity demand, it was decided to adopt an analytical approach in order to make the demand forecast. This technique starts from the specific consumption of households and enterprises and then reconstitutes the aggregate demand at national level, as explained in the introduction.

To implement this methodology, we will use the following elements:

- Evolution of the number of households: taken from the report "Household Income and Expenditure Survey 2014" published by the Liberia Institute of Statistics & Geo-Information Services (LISGIS), and to which the population growth rates foreseen by the IMF will be applied;
- Electrification rate: defined as the ratio of the number of clients to the number of households, Different electrification rates are to be distinguished for urban (Monrovia) and rural areas:
  - Urban area:
    - The initial rate (in 2014) is of 27.10% (LISGIS report)
    - The final rate (in 2033) is assumed to be 90%
  - Rural area:
    - The initial rate (in 2016) is assumed to be 5.80% (LISGIS)
    - The final rate (in 2033) is assumed to be 65%;
- Specific consumption: defined as the annual consumption of a household, a growth of 1.5% per annum will be considered
  - Urban area:
    - Specific consumption: 1000 kWh/y
  - Rural area:
    - Specific consumption: 500 kWh/y

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- Consumption of enterprises and industries: These consumptions will be expected to follow the growth rate of GDP with an elasticity of 1.3;
- Load factors: They will be assumed constant also throughout the projection horizon in question;
  - Residential consumers: 50%
  - Industrial consumers: 70%
- Network performance: assumed constant and equal to its 2016 value, i.e. 27.1%

For mining sites in project, we identified 80 MW of potential development at horizon 2020 and 500 MW in total at the end of the projection period of 2033.

According to this approach, the prediction of the energy injected into the network is 2098 GWh by the year 2033 in the base case scenario, an average growth rate of 8,8%. This forecast is above the one achieved in the Master Plan 2013, which forecasted the equivalent of 1704 GWh in 2033, a lower average growth rate of 7.7%.

To provide a sensitivity analysis, we will introduce a low scenario and a high scenario, varying the different factors as defined in the methodology presented in chapter 3.2.2.

According to these two scenarios, the energy injected into the network at horizon 2033 will be 1341 GWh in the low scenario, and 6755 GWh in the high scenario.

On the peak load, our forecasts indicate that it will reach 411 MW in 2033, an average growth rate of 8.8% as well.

The evolution of the peak load according to the two scenarios defined above will be 256 MW in 2033 in the low scenario and 1196 in the high scenario.

As far as energy not served is concerned, it was estimated by 2015 at 354 GWh, or 78% of the total demand. It is however forecasted to be completely absorbed by 2023, following the effective implementation of the planned projects.

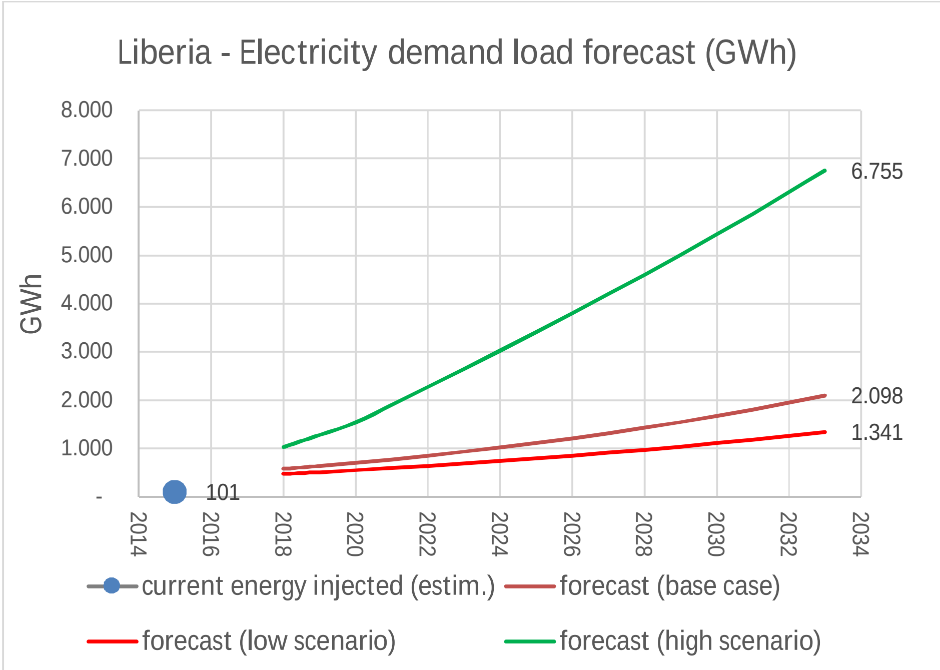

Figure 16: Electricity demand forecast for Liberia

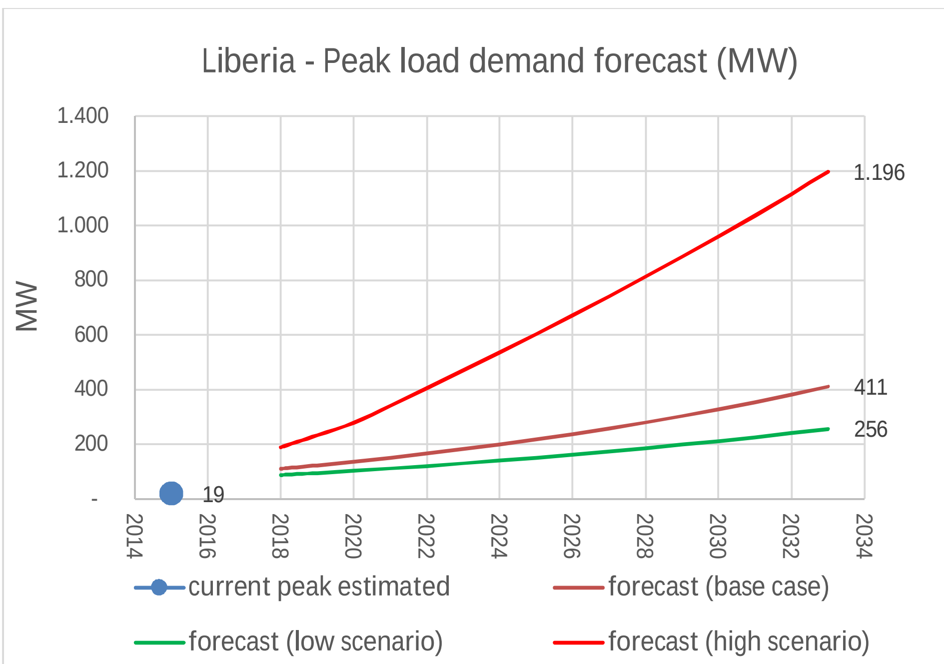

Figure 17: Peak load forecast for Liberia

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3.3.9. Mali

3.3.9.1. MACRO-ECONOMIC PARAMETERS

Mali's GDP growth has been quite volatile over the last few years, oscillating between periods of recession and economic boom, and averaging 4.5% in real terms between 2000 and 2017. GDP per capita, however, grew only by 1.4% on average during the same period, being especially affected during the security and political crisis that started in 2011.

As the political situation has since then stabilized, the IMF expects an average GDP growth of 4.8% in the medium term (until 2022).

The significant growth of the Malian population is also a real challenge for the country. It has indeed evolved by 3.2% on average between 2000 and 2017 and today peaks at about 18.9 million inhabitants according to the IMF figures. Prospects for medium-term growth are even higher (3.3%).

3.3.9.2. HISTORICAL DEMAND ANALYSIS

Mali's electrical system consists of:

- An interconnected network (RI) serving 35 localities, including the capital Bamako;
- 33 Isolated Centres (CI) for production and distribution, autonomous by locality;
- Two centres connected to the middle voltage network of the Côte d'Ivoire

In 2016, the final consumption of electricity in Mali reached a total of 1448.9 GWh. The RI accounted for 93.8% of this consumption, with 6.2% attributed to the CI. In the same year, 73% of the electricity consumed was in and around Bamako.

This consumption experienced an average growth rate of 9.5% between 2000 and 2016 and exhibited relatively high volatility, with a standard deviation of growth of 4.8% over the same period.

The RI peak load evolved with a similar rate of 9% per year between 2000 and 2016. The load factor was on average 73.1% over the same period, with a notorious decline during the crisis years (in 2012 and 2013).

Transport losses averaged 3.4% according to the available figures covering the period 1999-2013.

Cumulation of undistributed energy in 2015 was 3.8 GWh compared to 7.8 GWh in 2014 for the RI, which is 0.31% of the energy sold.

Also, there is currently the equivalent of about 200 MW consumed by mining sites in western Mali. These will therefore be directly integrated into the current potential consumption, accounting for 1277 GWh of annual energy, which will have to be added to the current consumption of the IR and CI.

	Expected [GWh]	of which RI [GWh]	of which CI [GWh]	Peak load RI [MW]	Load factor
2010	946	827	119	182	76%
2011	1040	913	127	199	75%
2012	999	902	97	217	67%
2013	1059	1.006	53	246	65%
2014	1.214	1.137	77	248	72%
2015	1.327	1.233	94	274	71%
2016	1.489	1.380	109	299	73%

Table 7: History of electricity demand in Mali

3.3.9.3. ELECTRICITY DEMAND FORECAST

In order to be consistent with the approach adopted for each country, the forecast of electricity demand will be realized at the level of net energy injected into the network, i.e. net of transport losses, but gross of distribution and business losses. The isolated centres will also be taken into account and aggregated in the demand forecast.

The starting point of the forecast therefore corresponds to a net electricity injected of 3126 GWh (1849 GWh RI and CI plus 1277 GWh for the mines) in 2016 (last available data).

Statistically, Akaïke's information criterion indicates that GDP is the optimum variable for explaining electricity consumption. The summary of the statistical model used is included in the table below. In particular, the explanatory power of the model is very good, given the R^2 of 0.99. The significance of GDP is also very important (P-value much less than 1%).

	Coefficients	Standard error	t-stat	P-value
Constant	-1199.33	66.22	-18.1	2.17E-08
GDP	0.65	0.02	37.9	3.57E-11
R^2	0.99			

Table 8: Summary of the statistical model used for Mali

According to this model, the forecast of demand for electricity in 2033 is 6722 GWh for the baseline scenario (taking into account the IMF GDP growth assumptions). This forecast corresponds to an average consumption growth rate of 6.6%.

This forecast is slightly below the last forecast of 2014 carried out by Artelia which provided 7602 GWh consumed in 2033. This latest forecast is fairly close to our high scenario (average growth of 8.2%).

The low and high scenarios, obtained by considering respectively 75% or 125% of the expected growth rates of the IMF, foresee an energy consumption of respectively 5551 GWh and 8127 GWh.

The peak load forecast was calculated by keeping constant the load factor from 2016, assuming that the repartition between residential and industrial loads will remain constant in the future. According to our calculations, this peak load will reach 1118 MW in 2033 in the base case scenario. This value is again below the forecast made by Artelia, expecting a peak load of 1326 MW at horizon 2033, which is in line with the high scenario calculated here.

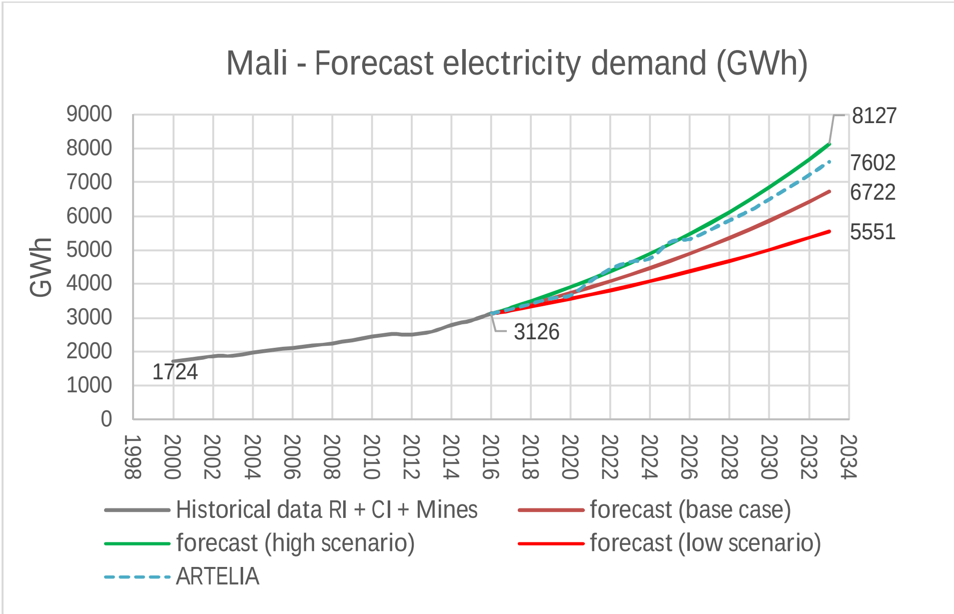

Figure 18: Electricity demand forecast for Mali

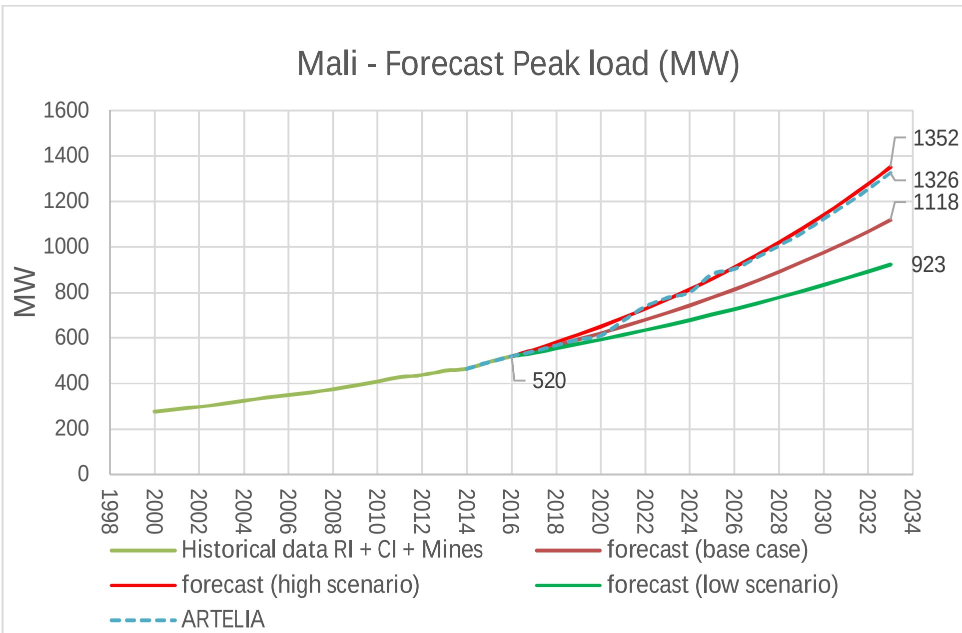

Figure 19: Peak load forecast for Mali

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3.3.10. Niger

3.3.10.1. MACRO-ECONOMIC PARAMETERS

Niger has the highest fertility rate in the world with 7.6 children per woman. The population has risen at a fairly constant rate of 3.3% over the last 15 years and reached 18.8 million in 2017. The IMF expects that this trend will continue, with a slight decrease, the growth being expected to stabilize to 3.1% in the next 5 years.

Niger's GDP is evolving erratically exhibiting years of high growth followed by periods of recession. Nevertheless, the general trend shows an increase in GDP with an average rate of 5.3% over the last 15 years. The IMF expects increased growth, of the order of 6.2% over the next few years.

3.3.10.2. HISTORICAL DEMAND ANALYSIS

The historical data is only available from the year 2008 onwards.

The demand for electricity throughout the Niger system (all regions combined) showed an increase at an average rate of 9.8% over the period 2008-2014. The energy delivered to the distribution networks reached 831 GWh in 2014.

In 2014, it is estimated that less than 10% of households are electrified. In the River Zone (Niamey), the electrification rate is in the order of 50%, while in other parts of the country the rate is very low, between 3% and 14%.

3.3.10.3. ELECTRICITY DEMAND FORECAST

Given the limited information on the history of electricity demand, as it begins in 2008, it was decided to adopt an analytical approach to the forecasting of demand. This technique starts from the specific consumption of households and enterprises and then reconstitute the aggregate demand at national level, as explained in the introduction.

To implement this methodology, we will use the following elements:

- Evolution of the number of households: 2014 data, taken from the master plan generation-transmission, and to which the population growth rates foreseen by the IMF will be applied;
- Electrification rate: defined for 2014 in the master plan, from the number of clients and the number of households, different electrification rates between Niamey (river area) and the rest of the country will be distinguished:
  - Niamey:
    - § The initial rate (in 2014) for Niamey is 51.3%
    - § The final rate (in 2033) is assumed to be 90%
  - Rest of the country: the average master plan scenario foresees an electrification rate of around 30%
    - § The initial rate (in 2014) is estimated at 4.9%
    - § The final rate (in 2033) is assumed to be 30%;
- Specific consumption: defined as the annual consumption of a household, a growth of 1.5% per annum will be considered
  - Niamey:

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        § Specific consumption: 1000 kWh/y
    - Rest of the country:
        § Specific consumption: 500 kWh/y
- Consumption of enterprises, industries and administrations BT and MT: These consumptions will be expected to follow the growth rate of Niger's GDP with a coefficient of elasticity of 1.3
- Load factors: They will be assumed constant also throughout the projection horizon in question;
    - LV consumers: 55%
    - MV consumers: 70%
- Network performance: assumed constant and equal to its 2016 value, i.e. 91%

According to this approach, the prediction of the energy injected into the network is 4 192 GWh by the year 2033, corresponding to an average growth rate of 9%. This forecast is below the one presented in the master plan, which forecasted 5 000 GWh in 2030.

To provide a sensitivity analysis, we will introduce a low scenario and a high scenario, varying the different factors as presented in section 3.2.

According to these two scenarios, the energy injected into the network at horizon 2033 will be 6245 GWh in the high scenario, and 2792 GWh in the low scenario.

Regarding the peak load, our forecast indicates that it will reach 1063 MW in 2033, an average growth rate of 9% as well.

The evolution of the peak load according to the two scenarios defined above will be 727 MW in 2033 in the low scenario and 1534 MW in the high scenario.

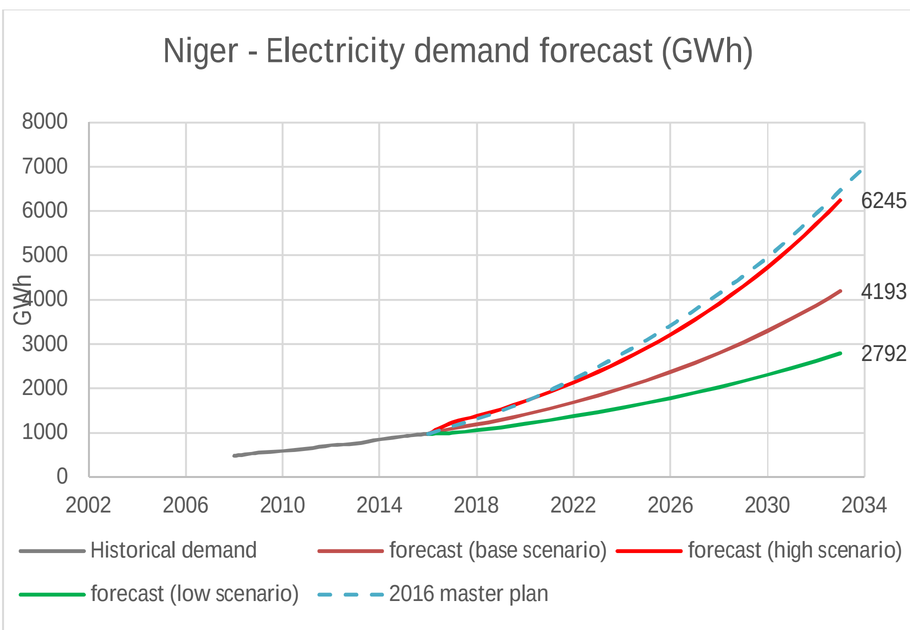

Figure 20: Electricity demand forecast for Niger

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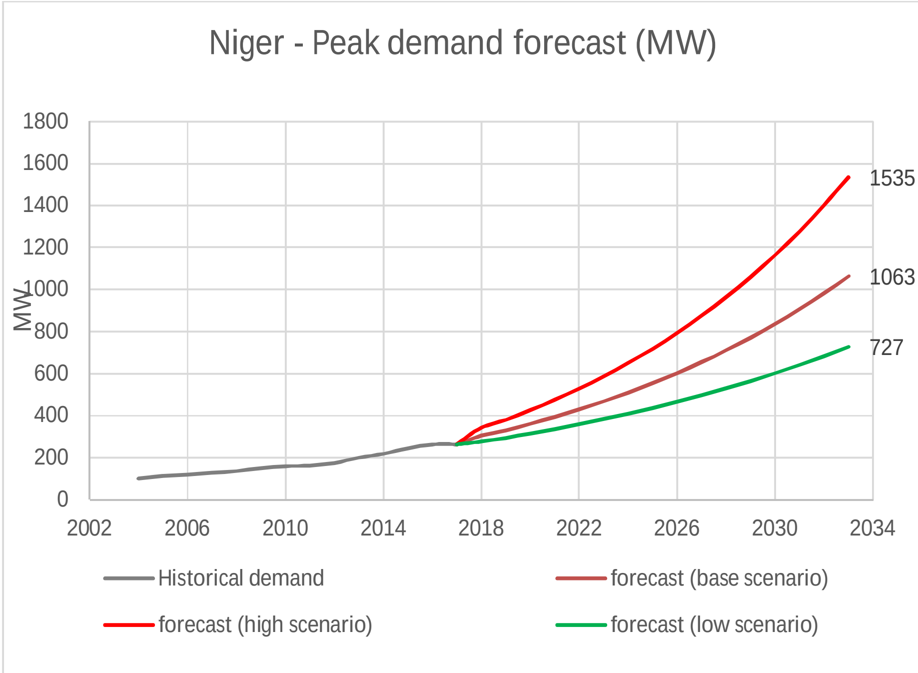

Figure 21: Peak load forecast for Niger

3.3.11. Nigeria

3.3.11.1. MACRO-ECONOMIC PARAMETERS

The growth rate of the Nigerian population is estimated at 2.75% since 1992 according to the IMF figures. The actual population (2017) is estimated at 188 million.

Since 2001, the growth of the Nigerian GDP fluctuated between 5% and 10%, with an average growth rate of 7.5% according to the IMF. The GDP went down by 1.62% in 2016, and then saw a slight increase of 0.84% in 2017. The IMF forecasts an increase of the GDP limited to 1.75% per year for the next 5 years.

3.3.11.2. HISTORICAL DEMAND ANALYSIS

According to the master plan of Nigeria (Fichtner, 2017), the total energy consumed in Nigeria reached 42 400 GWh in 2015.

The peak demand value was 6648 MW in 2015.

3.3.11.3. ELECTRICITY DEMAND FORECAST

Given the very limited information on the history of electricity demand, it was decided for this study to adopt the load demand forecast as planned in the master plan (Fichtner, 2017).

According to this forecast, the energy demand will reach 200 TWh in 2033 in the base scenario. This corresponds to an increase with an average rate of 9%.

The peak demand forecast shows an increase at an average rate of 9.2%, it will reach a value of 32.5 GW as of 2033.

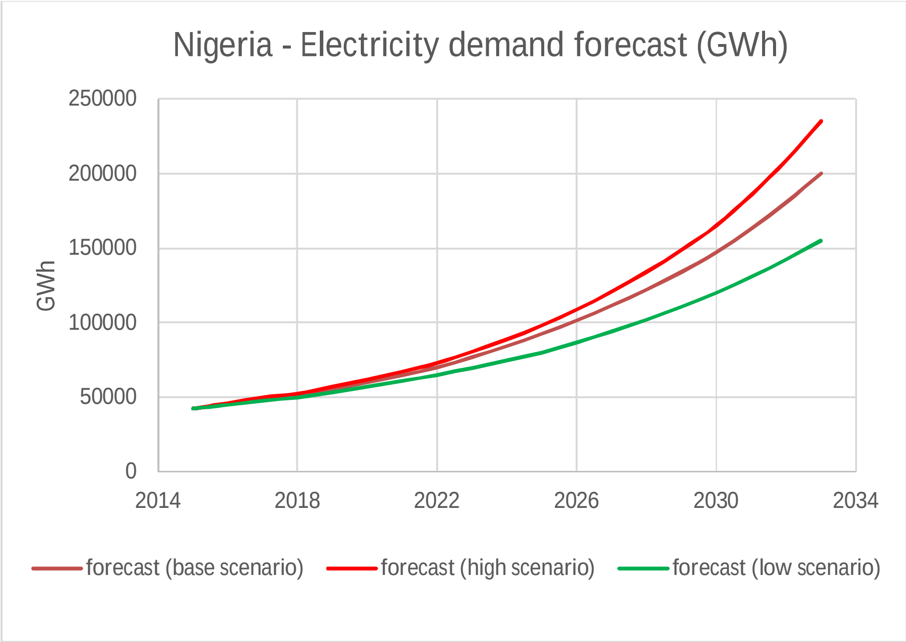

Figure 22: Electricity demand forecast for Nigeria

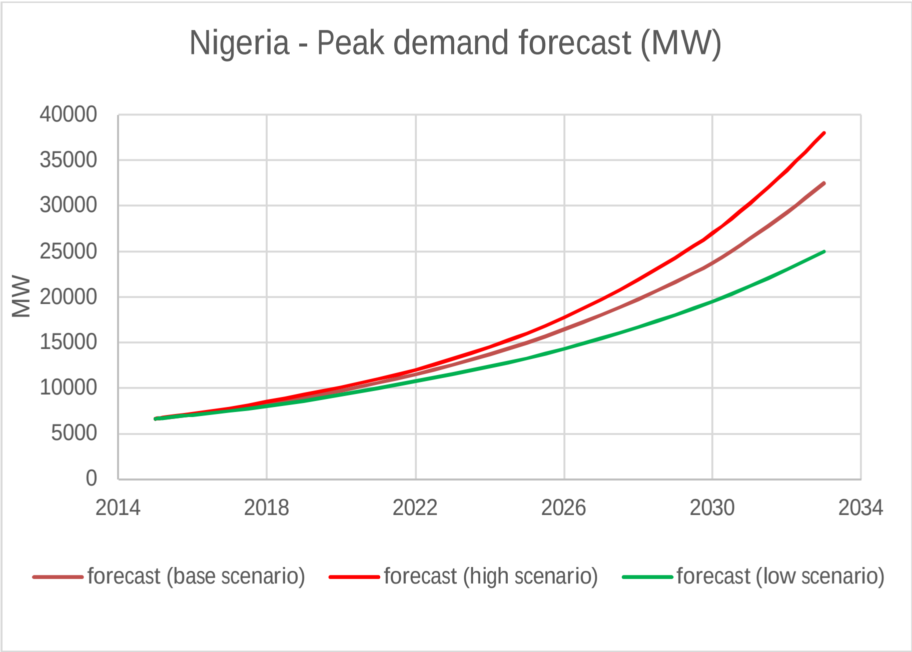

Figure 23: Peak load forecast for Nigeria

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3.3.12. Senegal

3.3.12.1. MACRO-ECONOMIC PARAMETERS

Senegal experienced a period of relatively long macroeconomic stability, with an average GDP growth rate of 4.4% between 2000 and 2017, according to the IMF. Nevertheless, GDP per capita growth was quite low during the same period (average 1.4%), which did not allow a sustainable reduction in poverty.

In 2014, the government set up the "Emerging Senegal Plan", which aims to bring the country to the status of emerging country on the horizon 2035. To achieve this, the country must be able to develop a GDP growth of 7% with a population growth limited to 3%. Since the introduction of this Plan, GDP growth is indeed more important (around 7%), and the IMF expects that this trend will continue in the years to come.

By the end of 2017, the Senegalese population was 16.1 million according to the IMF figures. It grew by an average of 2.9% between 2000 and 2017 and this growth accelerated recently (3.1% from 2010 to 2017). According to the IMF, this growth rate will stabilize to 3.1% in the future.

3.3.12.2. HISTORICAL DEMAND ANALYSIS

Electricity sales in Senegal experienced a growth rate of 5.70% between 1997 in 2016 and reached the level of 3149 GWh in 2017. This growth has further accelerated over the last few years, with a rate of 6.80% between 2010 and 2018 (budgeted). Nevertheless, this growth has shown a fairly large volatility of 3.8% over this recent period.

The Senegalese Interconnected Network (RI) accounts for more than 95% of these sales, with the remainder being attributed to the Non-interconnected network (CI for isolated centres) powered by Boutoute and Tamba regional power stations, as well as secondary centres.

The peak load of the Senegalese network increased from 319 MW in 2003 to 637 MW in 2017 (including 613 MW for the RI), at an average annual rate of 4.8%. The RI load factor increased from 63% in 2003 to 69% in 2017. For the Boutoute and Tamba networks, these load factors were 57.9% and 59.7% respectively in 2017.

The overall performance of the Senegalese electricity network has improved significantly over the last few years, from 78.81% in 2014 to 80.64% in 2016.

A lot of progress has also been made on the demand for unserved energy. Indeed, while it still represented a significant part of the demand (90 GWh in 2009, 166 GWh in 2010 and 267 GWh in 2011), it was able to be reduced to a much lower level around 30-40 GWh as early as 2012. This improvement is due to the decrease in the deficit due to lack of production, the strengthening of the production park and the securing of the fuel supply.

3.3.12.3. ELECTRICITY DEMAND FORECAST

In order to be consistent with the approach adopted for each country, the forecast of electricity demand will be realized at the level of net energy injected into the network, i.e. net of transport losses, but gross of loss of distribution and business losses.

The starting point for the forecast therefore corresponds to a net electricity injection of 3827 GWh in 2017.

The isolated centres will also be taken into account and aggregated in the demand forecast.

Statistically speaking, Akaïke's information criterion indicates that GDP is the optimum variable for explaining electricity consumption. The summary of the statistical model used is included in the table below. In particular, the explanatory power of the model is very good, given the R^2 of 0.99. The significance of GDP is also very important (P-value much less than 1%).

	Coefficients	Standard error	t-stat	P-value
Constant	-698.46	97.39	-7172.0	7.24E-06
GDP	0.65	0.02	34570.0	3.51E-14
R^2	0.99			

Table 9: Summary of the statistical model used for Senegal

According to this model, the forecast of demand for electricity in 2033 is 11 783 GWh for the baseline scenario (taking into account the IMF GDP growth assumptions). This forecast corresponds to an average consumption growth rate of 7.3%.

This forecast is relatively aligned with the 2016 forecast by SENELEC, which provided 12 476 GWh consumed in 2033 (average growth of 7.7%).

The low and high scenarios, obtained by considering respectively 75% or 125% of the expected growth rates of the IMF, foresee an energy consumption of respectively 9046 GWh and 15 229 GWh.

The peak load forecast was calculated by keeping constant the load factor of 2017 constant, i.e. 68.9%, assuming that the repartition between residential and industrial loads will remain constant in the future. According to our calculations, this peak load will reach 1961 MW in 2033 in the base scenario. This value is also close to the forecast made by SENELEC, expecting a peak of 2 065 MW in 2033.

Also, it must be said that the forecast made by SENELEC integrates mandatory electrification targets. Therefore, given that the 2033 consumption of the latter forecast is close to the one computed in the base case, we will consider the SENELEC forecast here.

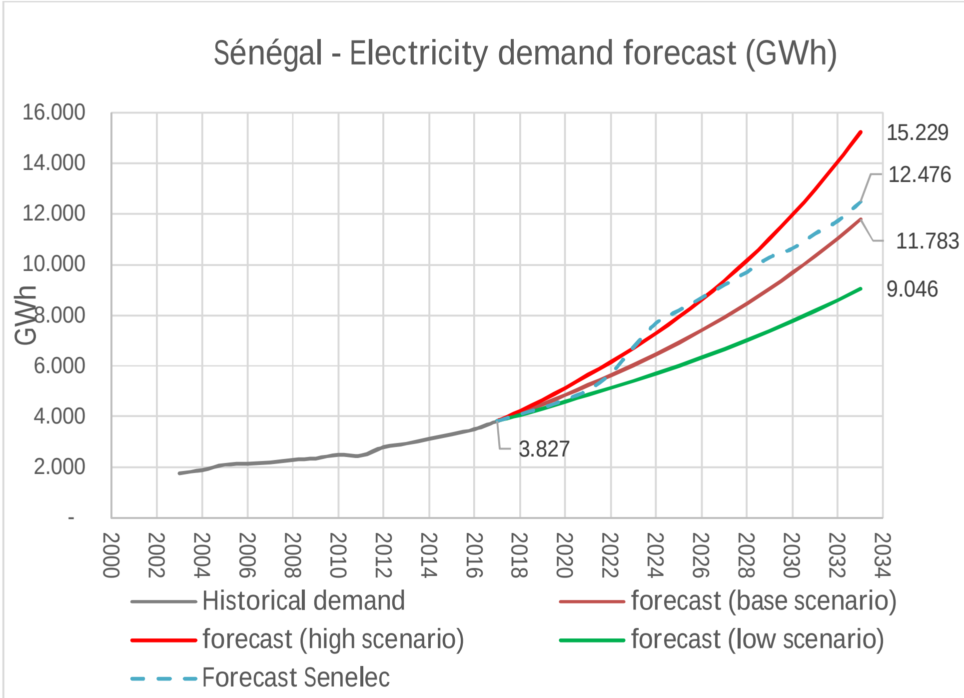

Figure 24: Electricity demand forecast for Sénégal

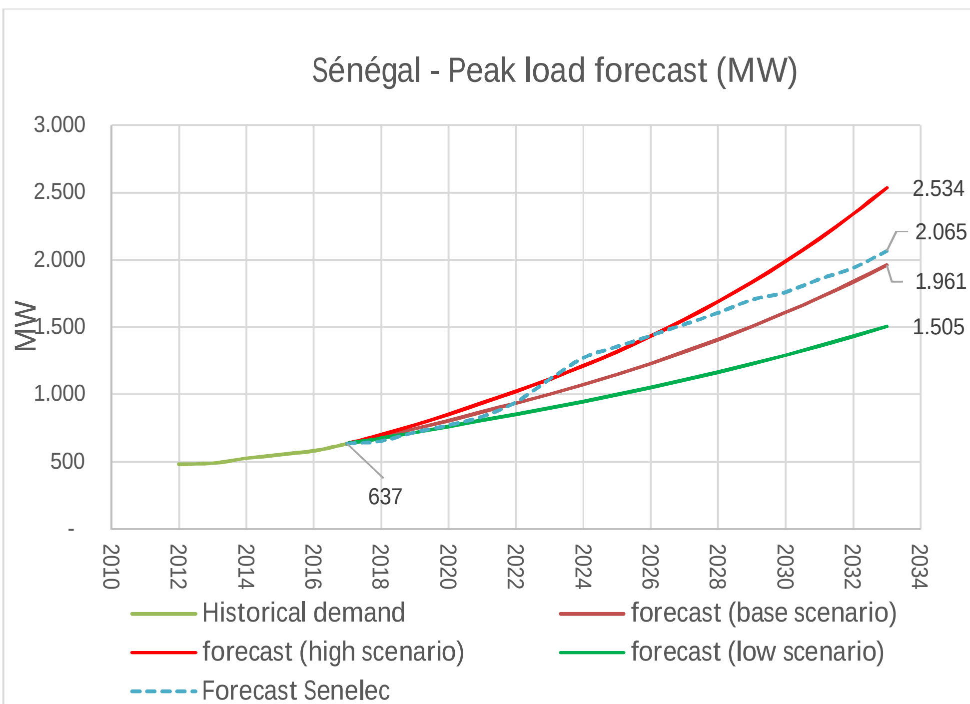

Figure 25: Peak load forecast for Sénégal

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3.3.13. Sierra Leone

3.3.13.1. MACRO-ECONOMIC PARAMETERS

After the civil war that lasted from 1991 until 2002, the economic activity of Sierra Leone was back on track with a strong GDP growth rate averaging 7.4% from 2000 until 2017, benefiting from improved policies and booming commodity prices on the international markets. In 2014 though, the Ebola crisis heavily impacted the economic growth with an estimated drop of 20% of the GDP in real terms. The collapse of iron ore prices contributed as well to this heavy economic recession.

After the World Health Organization declared Sierra Leone officially Ebola-free on March 2016, the medium-term expectations are positive, with the IMF expecting around 6.5% economic growth in the years to come. However, given the low international iron ore price, this recovery is expected to be led by non-iron ore and agriculture sectors, following the authorities' economic diversification effort and post Ebola recovery plan.

The population of Sierra Leone is estimated at 6.6 million people at the end of 2017. It experienced a boom after the civil war, with growth rates reaching 5% per year and stabilized afterwards to around 2% per year. The IMF foresees a growth rate of 1.7% of the population on the medium-term horizon.

3.3.13.2. ANALYSIS OF THE HISTORICAL ELECTRICITY DEMAND

Few information was transmitted regarding the historical electricity demand in Sierra Leone.

It was found in the 2014 annual report of the Bank of Sierra Leone that the total electricity consumption was amounting to 132 GWh over the year 2014. According to the same source, the energy produced that year was of circa 200 GWh, meaning a network performance of 66%.

Given those figures, the peak load is estimated at 34 MW in 2014.

Also, according to the last figures available in the World Bank data base, the electrification rate of the country was of 13% as of 2014, with 32% in the urban areas and only 1% in the rural areas.

Finally, the equivalent of 232 MW of electricity consumption from existing mining sites were identified close to decided transmission lines (CLSG and Free Town - Bumbuna). Those will be hence included in the base case scenario.

3.3.13.3. LOAD DEMAND FORECAST

Given the limited information on the history of electricity demand, it was decided to adopt an analytical approach in order to make the demand forecast. This technique starts from the specific consumption of households and companies and then reconstitute the aggregate demand at national level, as explained in the introduction.

To implement this methodology, we will use the following elements:

- Evolution of the number of households: taken from the “2015 Population and Housing Census” of Statistics Sierra Leone and to which the population growth rates foreseen by the IMF will be applied;
- Electrification rate: defined as the ratio between the number of customers and the number of households, different electrification rates for urban and rural areas will be distinguished:
  - Urban areas:
    - The Initial rate (2014) is of 31% (World Bank)
    - The Final rate (in 2033) is assumed to be 90%
  - Rural areas:
    - The Initial rate (in 2014) is of 1% (World Bank)
    - The Final rate (in 2033) is assumed to be 65%;
- Specific consumption: defined as the annual consumption of a household, a growth of 1.5% per annum will be considered
  - Urban areas:
    - Specific consumption: 1000 kWh/y
  - Rural areas:
    - Specific consumption: 500 kWh/y
- Consumption of enterprises, industries and administrations: The starting point for these consumers is the 109 GWh figure from 2014 (Bank of Sierra Leone) and it evolves according to the GDP, with an elasticity of 1,3 considered.
- Load factors: They will be assumed constant also throughout the projection horizon in question;
  - Residential consumers: 50%
  - Business consumers: 70%
- Network performance: distribution and commercial losses are assumed to be equal to 30% as of 2014 and will converge towards 20% by 2033.

Regarding the mining sites in project, a recent study of 2016 financed by the World Bank identifies around 373 MW of potential demand. Those will be integrated gradually in the high scenario, until 2033.

According to this approach, the prediction of the energy injected into the network is of 3692 GWh by the year 2033, corresponding to an average growth rate of 8.6%.

To provide a sensitivity analysis, we will introduce a low scenario and a high scenario, varying the different factors as presented in section 3.2.

According to these two scenarios, the energy injected into the network at Horizon 2033 will be 2808 GWh in the low scenario, and 6963 GWh in the high scenario.

Regarding peak load, our forecast indicate that it will reach 696 MW in 2033, which corresponds to an average growth rate of 8.6% as well.

The evolution of the peak load in the two scenarios defined above will be of 511 MW in 2033 in the low scenario and 1279 in the high scenario.

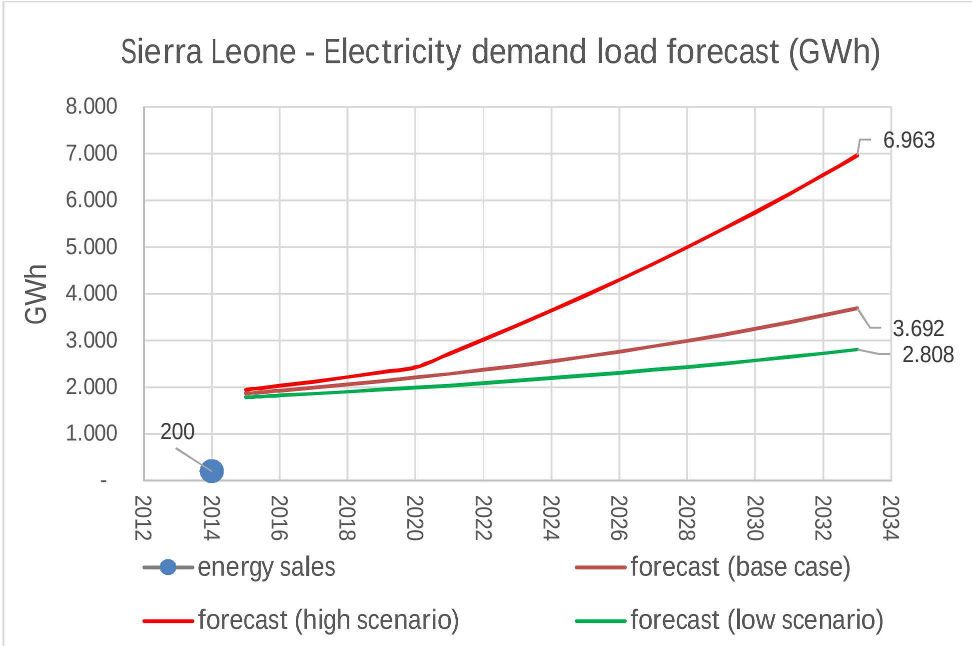

Figure 26: Electricity demand forecast for Sierra Leone

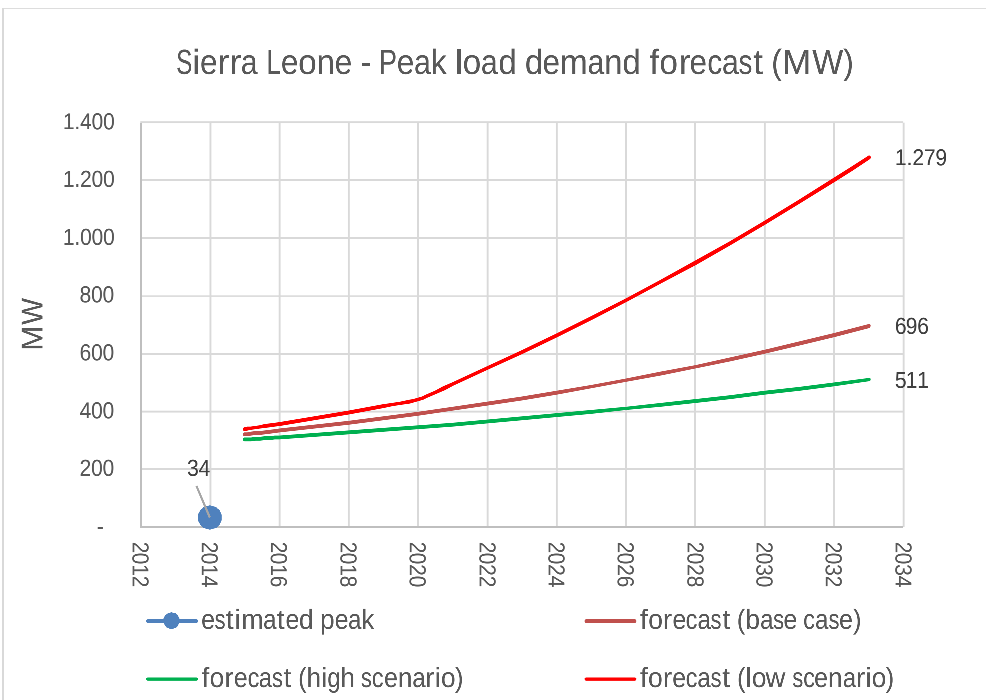

Figure 27: Peak load forecast for Sierra Leone

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3.3.14. Togo

3.3.14.1. MACRO-ECONOMIC PARAMETERS

According to the IMF, the economic growth of GDP in Togo averaged 3.2% between 2000 and 2017 in real terms. The latter has however accelerated and stabilized at 5.2% on average since 2010, thanks in particular to productivity gains in agriculture and investments in infrastructure (in particular the road network, the port of Lomé and the international airport). The IMF anticipates that GDP will continue to grow in this way, at a medium-term rate of 5.5%.

The recent good pace of the Togolese economy has contributed to the improvement of human development indicators, even though poverty is still high, especially in rural areas. The main challenge facing the country is to continue to support this economic growth, while making it more inclusive.

At the end of 2017, the Togolese population is estimated at 7.7 million inhabitants. The latter experienced an average growth rate of 2.9% between 2000 and 2017.

3.3.14.2. HISTORICAL DEMAND ANALYSIS

The electricity supply in Togo comes mainly from two sources:

- The CEB, which is the transmission network operator of Benin, also providing Togo with electricity;
- The CEET, the Togolese distribution network operator, which has its own production means ;
- The Central Contour Global Togo S.A. (CGT);

The history of electricity consumption at the point of injection is included in the table below. It is therefore made up of the CEB's electricity sales to the CEET, to which the own production of the CEET and the CGT must still be added. We have also taken into account the production provided by the WACEM industry.

	CEB sales to CEET [GWh]	CEET + CGT Net production[GWh]	WACEM [GWh]	Total [GWh]
2008	756			756
2009	845			845
2010	852			852
2011	982	73		1055
2012	1041	186		1227
2013	1037	175		1212
2014	1104	81	4	1189
2015	923	343	9	1275
2016	686	668	13	1367

Table 10: Historical electricity demand in Togo

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According to these figures, the growth of consumption in Togo has been 5.52% on average over the last 6 years.

To estimate the peak load on the Togolese network, we will take up the last known load factor for the CEET network taken from the report "Elaboration of the master plan for the development of electrical energy infrastructures of Togo" written by SNC-Lavalin, i.e. 72% in 2012, which corresponds to an industrial type of load.

If this load factor is applied to the electrical energy consumed in 2016, it gives a peak load of 217 MW, which will therefore be the starting point of the projection.

3.3.14.3. ELECTRICITY DEMAND FORECAST

Statistically speaking, Akaïke's information criterion indicates that GDP is the optimum variable for explaining electricity consumption. The summary of the statistical model used is included in the table below. In particular, the explanatory power of the model is relatively good, given the R^2 of 0.87. Also, the GDP coefficient is significant at the 1% threshold (P-value less than 1%).

	Coefficients	Standard error	t-stat	P-value
Constant	-374,71	219,35	-1,71	0,13
GDP	1,14	0,17	6,72	0,00
R^2	0.87			

Table 11: Summary of the statistical model used for Togo

According to this model, the forecast of the demand for electricity in 2033 is of 4070 GWh for the baseline scenario (taking into account the IMF GDP growth assumption). This forecast corresponds to an average consumption growth rate of 6.5% and is relatively aligned with the one made by IED in 2014.

The high and low scenarios (calculated as a reminder by applying an increase or a 25% decrease in the growth rate expected by the IMF respectively) lead to a forecast of the demand of respectively 5172 GWh and 3177 GWh in 2033.

These forecasts fall below a 2014 forecast by the IED consultant, which provided 4186 GWh consumed in 2033 (an average annual growth of 5.3%).

The peak load forecast was calculated by keeping the 2016 load factor constant, or 72%, which assumes that the nature of the load will not change in the future. According to our calculations, this peak load will reach 646 MW in 2033 in the base case, 821 MW in the high scenario and 504 MW in the low scenario. The base case scenario is once again in line with the forecast made by IED, anticipating a peak of 664 MW in 2033.

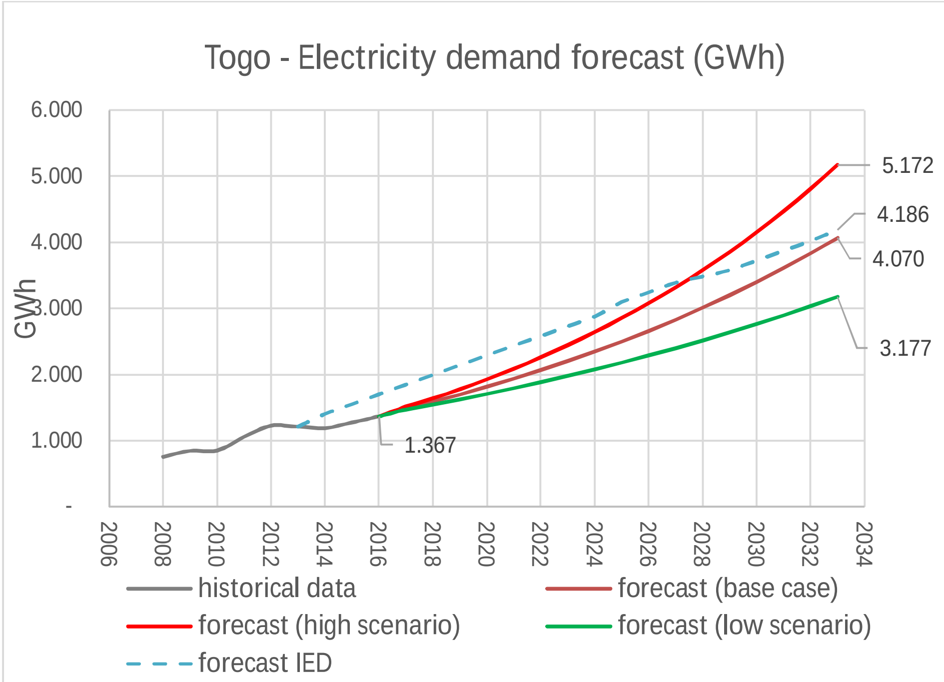

Figure 28: Electricity demand forecast for Togo

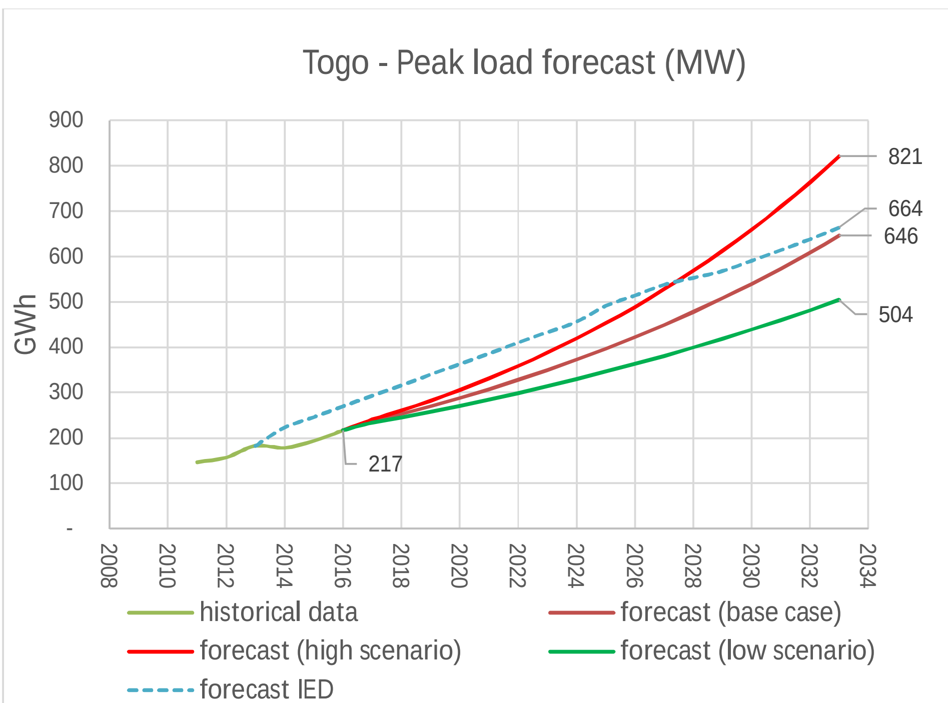

Figure 29: Peak load forecast for Togo

Final version

3.3.15. Cape Verde

3.3.15.1. MACRO-ECONOMIC PARAMETERS

According to the IMF, GDP growth in Cape Verde averaged 4.3% between 2000 and 2017, in real terms. The latter was affected by the global economic crisis and suffered a decline in 2009, following a decade of strong growth, boosted by the rise of tourism from 1999. The explosion of tourism has had a significant impact in the hotel industry, and strongly boosted the real estate services and catering sectors. The IMF anticipates a gradual return of GDP growth from 2017 and considers an average rate of 4% over the medium term.

At the end of 2017, the population of Cape Verde is estimated at 540 000 inhabitants. The latter experienced a growth rate of 1.2% on average between 2000 and 2017, with strong annual variations

3.3.15.2. ANALYSIS OF HISTORICAL DEMAND

Electricity generation recorded a growth rate of 8.8% between 2002 and 2006. In 2008, electricity generation reached 275 GWh with losses estimated at 73 GWh or 26.6% of total generation. Electricity generation grew in average of 6% between 2005 and 2009, as shown in the graph below.

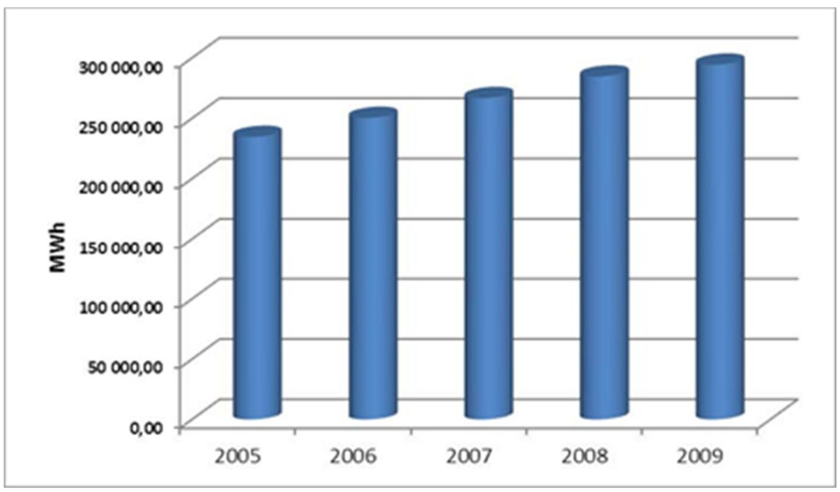

Figure 30: Evolution of Cape Verde's electricity generation in MWh

Subsequently, demand continued to grow. Annual consumption is currently estimated at 727 kWh / inhabitant.

There is no interconnected network in Cape Verde. The load peaks recorded are therefore indicated by island and are a function of the installed power. Although island peak loads are below the capacity installed in the different islands, the quality of the electricity service remains degraded. The average cut-off time was 1708 min in 2009 against 3055 in 2008.

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3.3.15.3. PREDICTING DEMAND FOR ELECTRICITY

The baseline scenario of Cape Verde's demand forecast anticipates a doubling of electricity demand by 2030 (source: SE4ALL), representing growth of around 6% / year.

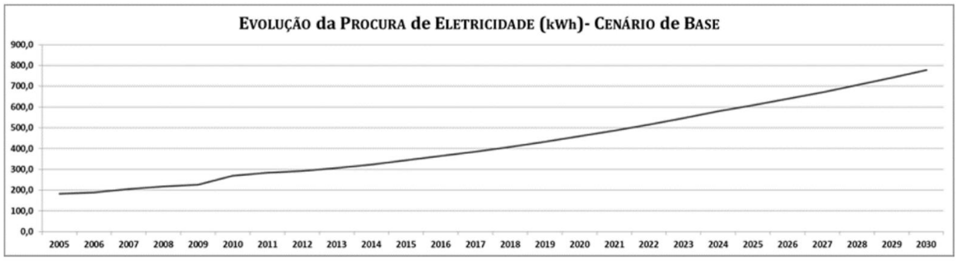

Figure 31: Evolution of total electricity consumption in Cape Verde by 2030

3.4. Synthesis of load demand forecast

The ranking of the different countries according to the growth rates of the demand for electricity is given hereunder for the base case scenario. We have also taken up the rankings of these countries according to the growth rates of GDP and population.

Nigeria has the highest rate of growth in electricity consumption but it should be recalled that this forecast was taken directly from the last master plan (finalized in 2017). Note also that this forecast is based on the energy served. Given the current level of load shedding in the country, it includes a gradual catch-up of unserved energy.

For the rest, the countries with the highest real demand growth rates are those who are characterized by a significant delay in the electrification rate. The increase in demand served will be even greater as soon as unserved energy will be reduced

For example, Liberia, Sierra Leone and Niger occupy the top ranking, with growth of more than 8.5%. This is also due to the fact that these countries have the most significant expected growth rates of GDP (1st and 2nd position for Sierra Leone and Liberia, 5Th Position for Niger, see table below).

Next comes Guinea with an expected growth of 7.5%. Gambia and Guinee-Bissau are somewhat lower in the ranking, given their lower expected growth of GDP.

The countries to which the global methodology has been applied exhibit lower growth rates of electricity demand, except Burkina Faso and Senegal whose electricity consumption is expected to grow above 7% and Côte d'Ivoire (6.9%).

According to the data collected, Cape Verde is expected to register a load growth of about 6% per year.

Country	Future average growth electricity demand	Method
NIGERIA	9,2%	-
LIBERIA	9,0%	Analytical
SIERRA LEONE	8,8%	Analytical
NIGER	8,8%	Analytical
SENEGAL	7,7%	Global
GUINEE	7,5%	Analytical
BURKINA	7,3%	Global
COTE D'IVOIRE	6,9%	Global
GUINEE BISSAU	6,9%	Analytical
GAMBIE	6,9%	Analytical
MALI	6,5%	Global
TOGO	6,5%	Global
BENIN	6,4%	Global
GHANA	5,8%	Global

Table 12: Ranking of the countries according to the future average growth rate of electricity demand in the base case scenario

Country	Future average growth of GDP		Country	Future average growth of population
SIERRA LEONE	7.4%		GAMBIA	3.3%
LIBERIA	6.8%		MALI	3.3%
CIV	6.5%		SENEGAL	3.1%
SENEGAL	6.4%		NIGER	3.1%
NIGER	6.2%		NIGERIA	2.8%
BENIN	6.2%		TOGO	2.7%
BURKINA FASO	6.0%		BURKINA FASO	2.7%
TOGO	5.6%		CÔTE D'IVOIRE	2.6%
GHANA	5.4%		GHANA	2.6%
GUINEA	5.2%		GUINEA	2.5%
GUINEA BISSAU	5.0%		GUINEA BISSAU	2.2%
GAMBIA	4.8%		LIBERIA	2.2%
MALI	4.7%		BENIN	2.0%
NIGERIA	1.7%		SIERRA LEONE	1.7%

Table 13: Ranking of the countries according to the average growth rate of GDP and population up to 2022 (source : IMF)

The table below summarizes the forecast of electricity demand in the base case scenario for each country.

Electricity Demand (GWh)	BENIN	BURKINA FASO	CÔTE D'IVOIRE	GAMBIA	GHANA	GUINEA	GUINEA BISSAU
2018	1381	1753	9785	584	14527	2093	448
2019	1472	1901	10530	623	16987	2232	482
2020	1575	2059	11299	666	18601	2382	518
2021	1691	2228	12069	713	20254	2544	556
2022	1799	2393	12871	764	20998	2702	596
2023	1913	2569	13718	817	21783	2871	639
2024	2035	2756	14615	875	22610	3051	683
2025	2165	2953	15564	936	23481	3242	730
2026	2302	3163	16568	1001	24399	3446	779
2027	2448	3385	17630	1070	25366	3663	831
2028	2602	3620	18755	1144	26385	3894	885
2029	2767	3869	19946	1222	27459	4141	942
2030	2941	4134	21207	1306	28590	4403	1003
2031	3126	4414	22543	1395	29782	4681	1066
2032	3323	4711	23958	1490	31038	4978	1133
2033	3531	5026	25458	1590	32361	5294	1203
Average Growth	6,4%	7,3%	6,9%	6,9%	5,8%	7,5%	6,9%

Electricity Demand (GWh)	LIBERIA	MALI	NIGER	NIGERIA	SENEGAL	SIERRA LEONE	TOGO
2018	581	3414	1185	51250	4095	2062	1592
2019	640	3571	1287	55404	4357	2135	1698
2020	706	3735	1414	59896	4671	2208	1814
2021	777	3907	1543	64751	5057	2288	1937
2022	854	4087	1685	70000	5707	2374	2066
2023	936	4275	1837	76815	6735	2464	2203
2024	1023	4473	2002	84293	7694	2559	2347
2025	1115	4679	2179	92500	8192	2660	2500
2026	1214	4896	2371	101479	8691	2766	2661
2027	1318	5122	2577	111330	9193	2877	2831
2028	1429	5359	2799	122137	9711	2995	3010
2029	1547	5607	3038	133993	10293	3120	3200

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Electricity Demand (GWh)	LIBERIA	MALI	NIGER	NIGERIA	SENEGAL	SIERRA LEONE	TOGO
2030	1673	5867	3295	147000	10636	3251	3400
2031	1806	6139	3573	162888	11218	3390	3611
2032	1948	6424	3871	180492	11720	3537	3835
2033	2098	6722	4193	200000	12476	3692	4070
Average Growth	9,0%	6,5%	8,8%	9,2%	7,7%	8,8%	6,5%

Table 14: Synthesis of the electricity demand forecast in the base case scenario

The table below summarizes the peak load forecast in the basic scenario for each country.

Peak Load (MW)	BENIN	BURKINA FASO	CÔTE D'IVOIRE	GAMBIA	GHANA	GUINEA	GUINEA BISSAU
2018	276	318	1.420	106	2.225	421	78
2019	294	350	1.647	114	2.602	450	84
2020	314	385	1.767	122	2.849	482	91
2021	337	427	1.887	131	3.103	517	98
2022	359	471	2.013	140	3.217	551	105
2023	382	515	2.145	150	3.337	587	113
2024	406	562	2.285	161	3.464	625	121
2025	432	613	2.434	173	3.597	666	129
2026	459	656	2.591	185	3.738	710	138
2027	488	703	2.757	198	3.886	756	148
2028	519	751	2.933	212	4.042	805	158
2029	552	803	3.119	227	4.206	858	168
2030	587	858	3.316	243	4.380	914	179
2031	623	916	3.525	260	4.562	973	191
2032	663	978	3.747	278	4.755	1.037	203
2033	704	1.043	3.981	297	4.957	1.104	215
Average Growth	6,4%	8,3%	7,1%	7,0%	5,6%	7,5%	7,1%

Peak Load (MW)	LIBERIA	MALI	NIGER	NIGERIA	SENEGAL	SIERRA LEONE	TOGO
2018	111	568	304	8.250	656	362	253
2019	123	594	329	8.964	721	378	270
2020	137	621	361	9.740	773	393	288

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Peak Load (MW)	LIBERIA	MALI	NIGER	NIGERIA	SENEGAL	SIERRA LEONE	TOGO
2021	151	650	394	10.584	837	410	307
2022	166	680	430	11.500	944	428	328
2023	182	711	468	12.565	1.115	446	350
2024	200	744	510	13.729	1.273	466	373
2025	218	778	554	15.000	1.356	487	397
2026	238	814	603	16.444	1.438	508	422
2027	258	852	655	18.027	1.521	531	449
2028	280	891	711	19.762	1.607	555	478
2029	303	933	771	21.665	1.703	581	508
2030	328	976	836	23.750	1.760	607	540
2031	354	1.021	906	26.368	1.857	635	573
2032	382	1.069	982	29.274	1.940	665	609
2033	411	1.118	1.063	32.500	2.065	696	646
Average Growth	9,2%	6,4%	9,1%	9,5%	7,7%	9,1%	6,5%

Table 15: Synthesis of the peak load forecast in the base case scenario

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4. SUPPLY ANALYSIS

The supply analysis will be achieved in two steps:

First of all the list of existing and planned power plants will be established based on the data collected in the countries. On this basis the gap between the expected future power consumption and the installed capacity will be estimated.

Then, additional candidate options of power generation (thermal, hydro and RES sources) will be described that will be proposed to the optimisation. A dedicated attention will be paid to the availability of natural resources in the region (natural gas, solar irradiation, wind speed,…). The regional projects are classified in the country where they are geographically located.

4.1. Inventory of generation per country

This chapter has as an objective to provide an overview of the situation of all of the 14 WAPP countries by detailing the characteristics of current and future generation plants.

For each member state, a list of generation units is provided, making the distinction between the existing plants and the future ones (decided or candidate) :

- **Existing Units** : generating units commissioned before March 2018.
- **Decided Units** : generating units under construction or for which a fixed commissioning data has been acted (studies closed and financing secured).
- **Candidate Units** : generating units for which studies are not yet completed or for which financing is not guaranteed yet.

Data related to existing plants in the different countries present both the installed capacity and the available capacity:

- **Installed Capacity**: nominal power of the units as foreseen by the constructor
- **Available Capacity:** available capacity when considering the state and the conditions of operation of the plant. This includes the consideration of the obsolescence of the plants as well as the derating due to the non-optimal conditions of operation (different from ISO conditions for gas turbines for example).

The abbreviation used for the different types of plants in the graphs and tables of this section are explained here after.

Abbreviation	Unit Type
CC	Combined Cycle
GT	Gas Turbine
ST	Steam Turbine
HYD	Hydroelectric Plant
ROR	*Run of River*

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Abbreviation	Unit Type
DAM	*With Reservoir*
DI	Diesel Unit
WT	Wind Farm
PV	Photovoltaic Plant
CSP	Concentrated Solar Plant
BIO	Biomass Plant

Table 16 : Abbreviations of unit types

The abbreviations for the types of fuel used by current and future units are summarized in the following table :

Abbreviation	Unit Type
(D)DO*	(Distillate) diesel oil
GO*	Gas Oil
HFO	Heavy fuel oil
HVO*	Hydrotreated vegetable oil
JET	Jet A1
LCO	Light Crude Oil
LFO*	Light fuel oil
NG	Natural gas
COAL	Coal

Table 17 : Abbreviations of types of fuel considered

In order to simplify the modelling and given the similarity of their thermodynamic properties, the fuels indicated by an asterisk will be considered as DDO in the section devoted to fuel costs.

All the listed generation units are given in tables in APPENDIX B and C along with the considered techno-economic characteristics.

The missing data for existing units were firstly supplemented by values identical to those of similar units in the same country (with comparable size and commissioning date).

These assumptions are indicated by italic characters in the tables. When such assumptions were not possible, the following standard values were assumed:

Unit Type	CC	GT	ST	DI (HFO)	DI (DDO)	HYD	PV	WT
Net heat rate [GJ/MWh]	8.8	12.7	10.8	9.5	10.4	/	/	/
Lifetime [years]	25	25	35	30	30	50	25	25
Forced outage rate [%]	8%	8%	8%	10%	10%	5%	0.5%	1%
Planned unavailability [h/year]	613	613	613	960	960	570	80	350
Variable O&M costs [$/MWh]	2	2.5	3.1	10	10	2	/	9.5
Fixed O&M costs [$\kW/y]	35	7	70	17	8	100	20	17
Hydro capacity factor	/	/	/	/	/	49.2%	/	/
Yearly firm energy for hydro	/	/	/	/	/	76% * yearly energy average	/	/

Table 18 Standard values considered for existing units

These standard values were based on the data available in the various countries and on the consultant's experience on similar projects. They are indicated by "VS" in the tables. However, the obsolescence of the plants will be taken into account through a derating factor applied to the oldest plants.

Regarding future units, for which only the type of technology and the installed capacity are generally known, other standard values were used. Those are state of the art values for new units. They are explained in detail in section 4.3.

The discount rate proposed as a basis for this study is 10%. The exchange rates considered are:

- 1€ =1.23 US$
- 1€=655.957 FCFA

All the generation units listed are listed in the tables below, each with the relevant techno-economic characteristics.

4.1.1. Benin

4.1.1.1. DIAGNOSIS OF THE CURRENT SITUATION

In Benin, most of the effective capacity is connected to the distribution network (144MW out of 290 MW available in the country). The only power plant owned by the CEB is the 24 MW gas turbine of Maria-Gleta. This capacity is almost exclusively composed of thermal origin and mainly supplied with DDO. In particular, given the structural gas deficit in the WAGP pipeline, gas turbines from the CAI plant of Maria Gleta (70 MW) are operated with Jet A1, a very costly fuel for base or semi-base operation.

The resulting energy mix is shown in the figure below. The details of the generation units are presented in Appendix B.

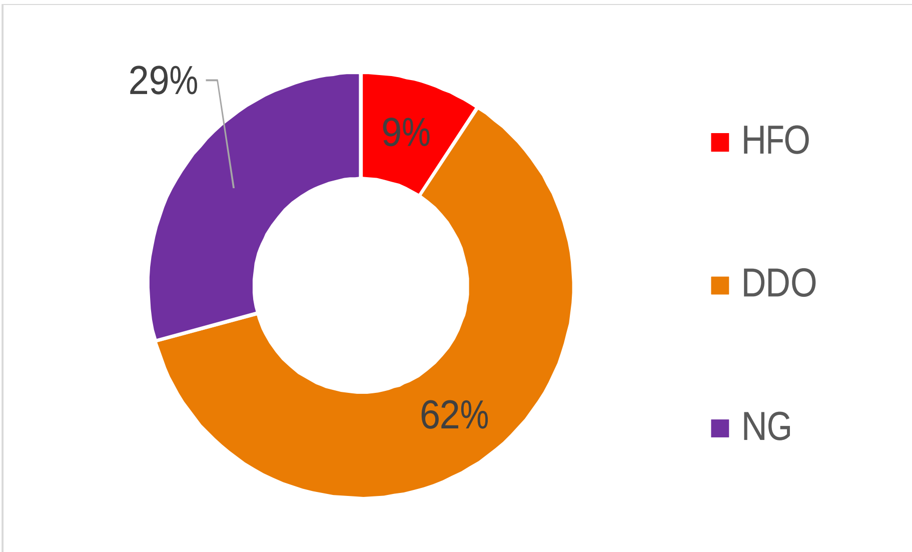

Figure 32: Installed Capacity of Benin (2018) by fuel

It is important to note that the electrical demand of Benin is supplied not only with the power plants of the CEB and the SBEE, but also and above all by Energy purchases at TCN, VRA, and CONTOUR GLOBAL.

4.1.1.2. GENERATION EXPANSION PLAN

Given the fragility of the Beninese electrical system and the country's dependence to electricity imports on the one hand and natural gas import on the other, the country wants to review its energy strategy:

- Diversification of fossil resources used for supplying the thermal power plants (LNG or coal);
- Development of hydroelectric potential if it is economically justified;
- Development of renewable projects, mainly in the northern part of the country;
- Importation from other neighbouring countries (e.g. Niger);

In this master plan, these different options will be investigated.

4.1.1.2.1. Decided units

With the securing of gas supply from Nigeria, the development of gas-fired power plants at Maria Gleta should be confirmed. Thus, the extension of the CAI project of 50 MW is decided and will be put into service in 2020. This project will not be challenged as part of this study.

Technologie (combustible)	Nom de la centrale (localisation)	Capacité Installée [MW]	Date de mise en service
GT (NG)	Maria Gleta	50	2020
CC (NG)	BWSC	120	2020
BIOMASSE	PNUD	4	2020
PV	INNOVENT DJOUGOU	1.5	2020
PV	AFD	25	2020
PV	MCA	45	2020

Table 19: Decided Generation Projects: Benin

4.1.1.2.2. Candidate Units

In addition to the project mentioned above, the following projects are envisaged for the country. For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS Master plan update.

It should be noted that, given the uncertainty associated with the gas supply of the Maria Gleta site and the importance of proposing a robust master plan, Maria Gleta's Combined cycle project will be questioned, particularly as to its size and the origin of the fuel used.

Technologie (combustible)	Nom de la centrale (localisation)	Capacité Installée [MW]	Date de mise en service
CC (NG)	Maria Gleta	2*120	-
CC (NG)	Maria Gleta (WAPP)	450	
CC (NG)	Centrale thermique145 MW IPP	145	
CC (NG)	Genesis	20	
HYD	Béterou	23.2	-
BIOMASSE	Projet	10	
BIOMASSE	Negoce international	11	
GNL	ALECHE	4*300	
PV	SOBES	5	
PV	GREENHEART POWER AFRICA	10	
PV	Centrale PV IPP	100	

Technologie (combustible)	Nom de la centrale (localisation)	Capacité Installée [MW]	Date de mise en service
HYDRO	BETEROU	18.2	
HYDRO	BETHEL	42.4	
HYD	Vossa	60.2	-
HYD	Olougbé	30	-
HYD	Dogo Bis	128	-
HYD	Dyodyonga	26	-

Table 20: Candidate Generation Projects: Benin

It is worth adding to this list the many PV solar projects in the north of the country that are currently under study for installed capacities ranging from 2 to 35 MW (Natitingou, Djougou, Parakou, Bohicon, Onigbolo, Bembéréké, Sakété, Natitingou-Kandi, Kandi,…)

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.2. Burkina Faso

4.1.2.1. DIAGNOSIS OF THE CURRENT SITUATION

The power system of Burkina Faso is mainly made of fuel-fired thermal power plants. A part of the thermal park arrives at the end of life, so the plants of Fada, Dedougou, Gaoua and Ouaga These plants will be decommissioned before 2020. The country's hydroelectric power stations account for 9% of the installed capacity.

In 2017, Burkina Faso also commissioned two solar power plants (Zagtouli and Ziga), with a total installed capacity of 34.1 MW.

The following figure illustrates the distribution of the installed capacity of Burkina Faso by technology. The details of the generation units are presented in Appendix B.

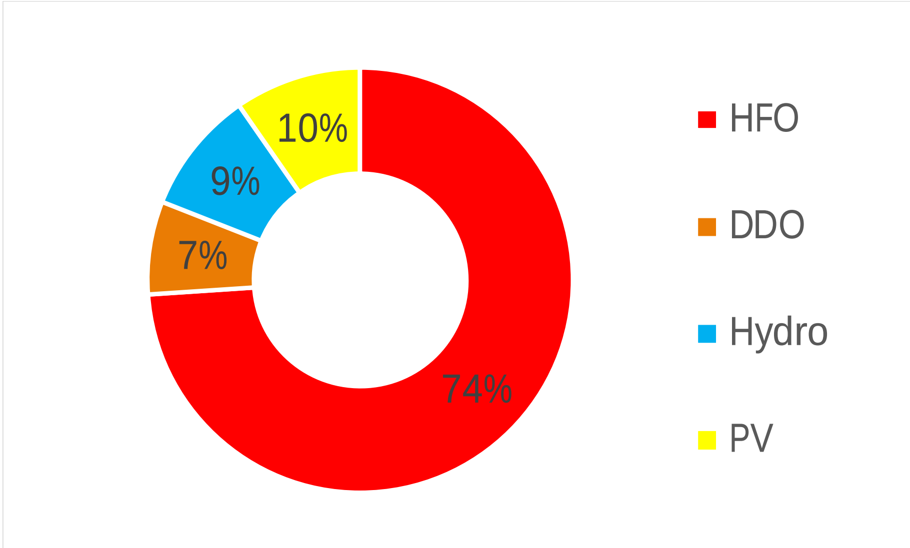

Figure 33: Installed Capacity of Burkina Faso (2018) per fuel

4.1.2.2. GENERATION EXPANSION PLAN

The development plan of Burkina Faso foresees the replacement of the plants that arrive at the end of their lifetime by new plants fired with HFO.

It is also planned to strengthen the country's hydropower capacity with the development of new dams.

Finally, Burkina Faso will continue to develop solar power plants in the country.

4.1.2.2.1. Decided units

As part of this study, the following plants are considered to be decided and will not be questioned:

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
HFO	Fada	7.5	2018
HFO	Kossodo	50	2020
HFO	Ouaga-Sud	100	2021
PV	Kaya	10	2020
PV	Zina	26.6	2020
PV	Foot PIE 1	68.24	2020
PV	Zagtouli 2	17	2020
HYDRO	Samendeni	2.76	2019

Table 21: Decided Generation Projects: Burkina Faso

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4.1.2.2.2. Candidate Units

In addition to the projects mentioned above, the following projects are envisaged for the country. For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS master plan update.

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
HYDRO (DAM)	Bagré	14	-
HYDRO (DAM)	Bontioli	5.1	-
HYDRO (DAM)	Gongourou	5	-
HYDRO (DAM)	Folonzo	10.8	-
HYDRO (DAM)	Ouéssa	21	-
PV	Koudougou	20	
PV	AFD	40+10	
PV	WAPP	150	
PV	Foot PIE 2	100	-

Table22: Candidate Generation Projects: Burkina Faso

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.3. Côte d'Ivoire

4.1.3.1. DIAGNOSIS OF THE CURRENT SITUATION

As illustrated in the Figure 34 Below, the generation system of Côte d'Ivoire mainly consists of hydraulic and thermal power plants.

The hydraulic power plants account for 40% of the total installed power with an installed capacity of 879 MW, including Soubré (275 MW), which was commissioned in 2017.

The thermal park, located almost exclusively around Abidjan, consists of gas turbines (Vridi, Ciprel) and combined cycles (Azito, Ciprel). The installed thermal power is 1320 MW. AGGREKO is a 210 MW leasing plant whose contract ends in 2020. The total installed capacity in Côte d'Ivoire in 2017 was hence of 2199 MW.

The details of the generation units are presented in Appendix B.

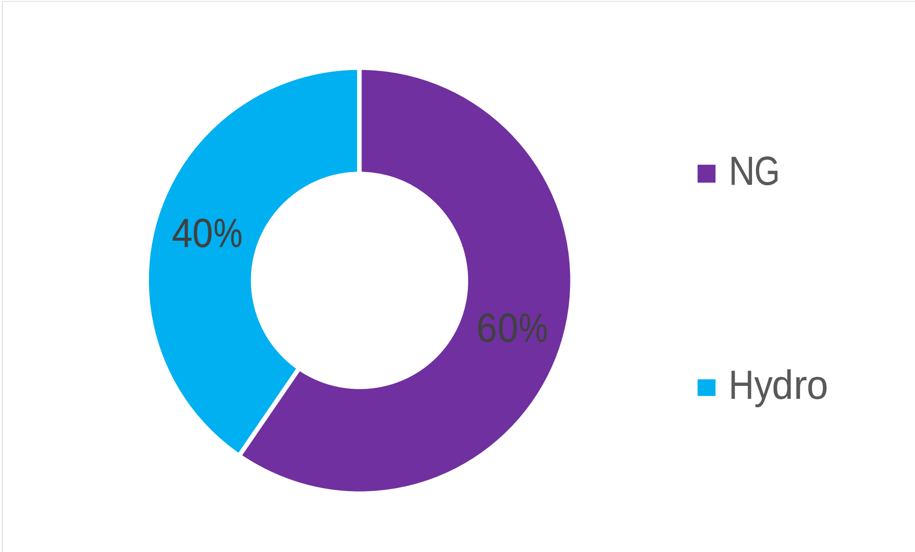

Figure 34: Installed capacity of Côte d'ivoire (2018) by fuel

4.1.3.2. GENERATION EXPANSION PLAN

Côte d'Ivoire plans to continue the development of the gas sector with the introduction of new combined cycles, but also to diversify the country's energy mix.

- Development of country's solar potential, mainly in the northern part of the country;
- Development of coal-fired power plant projects;
- Development of the biomass chain.

New hydropower projects are also planned.

4.1.3.2.1. Decided units

As part of this study, the following plants are considered to be decided and will not be questioned:

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
CC-GT (NG)	Azito IV- TAG	161	2020
CC-GT (NG)	Azito IV - TAV	81	2021
CC-GT (NG)	Ciprel V - 1er Tranche TAG	255	2020
CC-GT (NG)	Ciprel V - 2eme Tranche TAV	135	2021
HYDRO	Gribopopoli	112	2021/2022
HYDRO	Singrobo	44	2022
PV	Korhogo Solar (RECA)	20	2019
PV	Poro Power (CANADIAN SOLAR)	50	2020

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Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
PV	Centrale solaire BOUNDIALI (KFW)	30	2020
BIOMASS	BIOKALA	46	2023
COAL	Centrale à charbon (S-Energies)	350	2026
COAL	Centrale à charbon (S-Energies)	350	2029
HYDRO	Louga I	120	2024
HYDRO	Louga II	126	2026

Table 23: Decided Generation Projects: Côte d'Ivoire

4.1.3.2.2. Candidate Units

In addition to the projects mentioned above, the following projects are envisaged for the country. For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS master plan update.

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
CC-GT (NG)	Songon - 1ere tranche TAG	123	
CC-GT (NG)	Songon - 2ème tranche TAG	123	
CC-GT (NG)	Songon - 3ème tranche TAV	123	
HYDRO	Boutoubre	150	
HYDRO	Tiboto	113	
HYDRO	Tayaboui	80	
PV	Centrale solaire FERKE	25	
PV	Centrale solaire DAOUKRO (SERES)	30	

Table 24: Candidate Generation Projects: Côte d'Ivoire

Final version

It is worth adding to this list the many PV solar projects in the north of the country that are currently under study for installed capacities ranging from 25 to 75 MW.

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.4. Gambia

4.1.4.1. DIAGNOSTIC OF THE CURRENT SITUATION

The Gambia's installed generation capacity is currently 99 MW, which is entirely heavy fuel oil (HFO) thermal power plants (see details in Appendix B). A lack of resources for maintenance has led to a deterioration in available capacity in the Greater Banjul Agra (GBA) to about 45 MW available today. 100% of this capacity is running with HFO as shown in the picture here below.

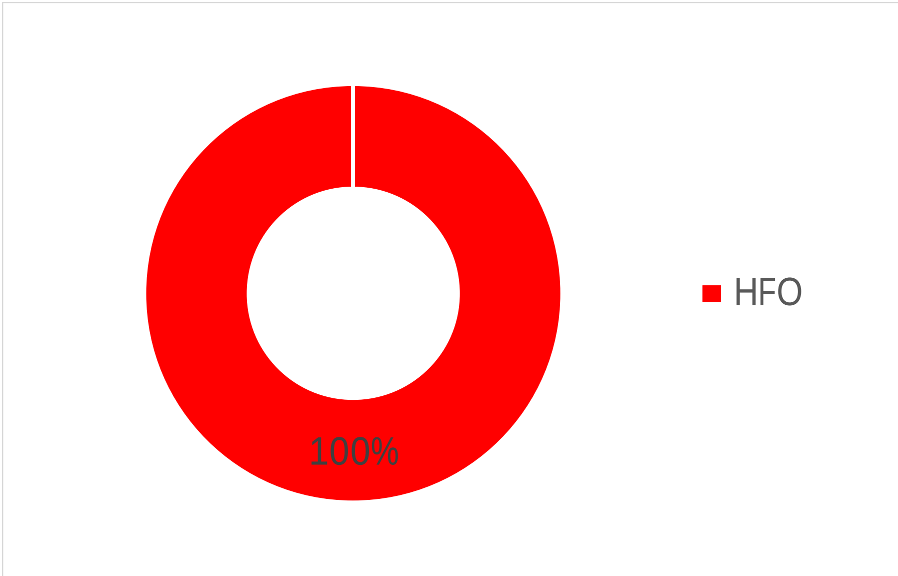

Figure 35: Installed Capacity of the Gambia (2018) per fuel

4.1.4.2. GENERATION EXPANSION PLAN

New generation capacity in the pipeline is expected to relieve the shortages in the country at medium term. In addition a roadmap has been developed to support the development of the electricity sector at long-term.

4.1.4.2.1. Decided units

As part of this study, the following plants are considered as decided and will not be questioned :

Technology (fuel)	Name of the power plant (localisation)	Installed Capacity [MW]	Commissioning Date
DI (HFO)	Kotu	11	2018
DI (HFO)	Brikama I	6.4	2018
DI (HFO)	Brikama II	8	2019
DI (HFO)	Brikama III	20	2020
PV	World bank	20	2019
PV	Brikama	10	2020

Table 25: Decided Generation Projects: the Gambia

Final version

4.1.4.2.2. Candidate Units

In addition to the projects mentioned above, the following strategy is planned for the country.

- Development of new HFO-based thermal units in the Greater Banjul Area
- Development of solar PV plants, including a 200 MW plant with storage to be financed by the World Bank ;
- Import of hydroelectricity from regional projects (Kaleta, Souapiti, Sambangalou,..), as well as potentially thermal energy from coal or gas plants.

For these projects, the commissioning date, technology and installed capacity will be optimized as part of the update of the ECOWAS Master Plan.

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.5. Ghana

4.1.5.1. DIAGNOSIS OF THE CURRENT SITUATION

Ghana is facing a shift in his energy mix. Historically dominated by hydro power, the electricity generation is now mainly based on thermal capacity as the hydro potential of the country is almost fully exploited.

The crisis of 2012-2015, caused by the rupture of the Nigerian gas supply through the WAGP, severely impacted the Ghanaian electricity sector and delayed the implementation of certain projects. The energy crisis has been solved through the use of IPPs and a government-supported contingency plan. These IPPs have signed take-or-pay type of energy purchase agreements (PPA) for the most part. Consequently, the installed capacity has risen from almost 3000 MW in 2015 to 4400 MW in 2018. The detailed list of generation units is provided in Appendix B.

The following figure illustrates the current energy mix of Ghana. The share of hydro is decreasing compared to the past and represents currently about one third of the installed capacity in the country.

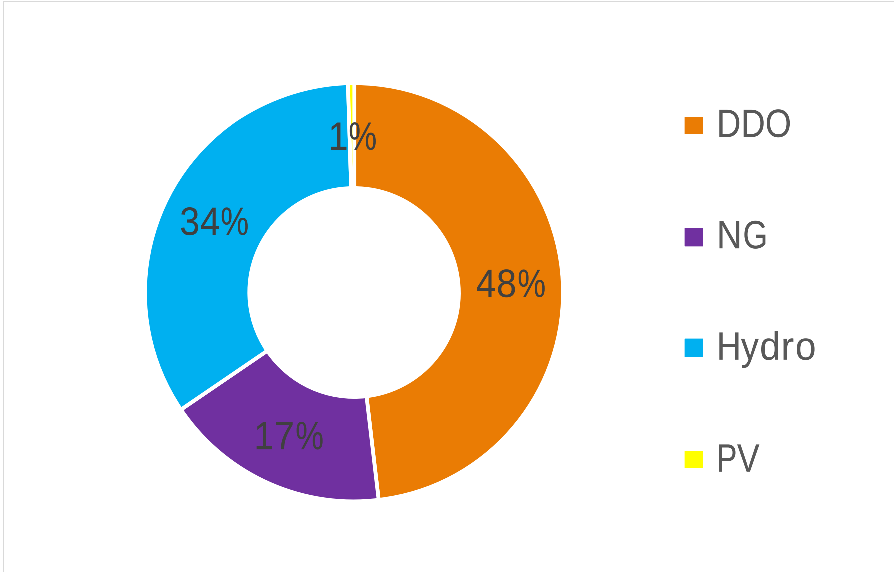

Figure 36: Installed Capacity of Ghana (2018) per fuel

4.1.5.2. GENERATION EXPANSION PLAN

The current reserve in the Ghanaian system is higher than 100%, and new projects are committed to increase the capacity of an additional 1000MW over the period 2018-2019. Consequently, in addition to these committed projects, no new plant is foreseen at short and mid-term.

4.1.5.2.1. Decided units

As part of this study, the following plants are considered as decided and will not be questioned

Technology (fuel)	Name of the power plant (localisation)	Installed Capacity [MW]	Commissioning Date
CC	CENPOWER	360	2018
CC	AMANDI	240	2019
CC	GPGC	170	2019
CC (ST)	KTPP	120	2020
CC	ROTAN	330	2022
CC	EARLY POWER	147	2018
CC	EARLY POWER	153	2019
PV	KALEO VRA	20	2019
PV	MI ENERGY	20	2018
PV	BUI PHASE 1	50	2019
PV	BIO THERM	20	2019
WIND	ASSOGLI	50	2020

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Technology (fuel)	Name of the power plant (localisation)	Installed Capacity [MW]	Commissioning Date
GT	TROJAN 3	50	2018

Table 26: Decided Generation Projects : Ghana

4.1.5.2.2. Candidate Units

In addition to the projects mentioned above, the following projects are planned for the country. For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS master plan update.

Technology (fuel)	Name of the power plant (localisation)	Installed Capacity [MW]	Commissioning Date
HYDRO	Juale	87	-
HYDRO	Pwalugu	48	-
HYDRO	Hemang	93	-
HYDRO	Kulpawn	36	-
HYDRO	Daboya	43	-
HYDRO	Noumbiel (shared with BF)	60	
PV	BUI PHASE 2	200	
PV	BONGO SOLAR	40	
CC	MARINOS	100	
COAL	ATUABO	700	
WIND	ADA	150	
CC	CENIT ENERGY & VRA	110	

Table 27: Candidate Generation Projects : Ghana

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.6. Guinea

4.1.6.1. DIAGNOSIS OF THE CURRENT SITUATION

The Guinean system (managed by EDG) is articulated around 2 networks:

- Conakry interconnected Network which groups the main hydroelectric plants of the country as well as the entire thermal generation of EDG. This system brings together the vast majority of electricity consumption.

Final version

- The Tinkisso network in the interior of the country, connecting the thermal power plants of Tinkisso, Faranah and the locality of Dinguiraye. Given its size (< 2MW of Installed Capacity) in relation to the demand of the interconnected system, this isolated system is not treated in detail in this study.

In the interconnected network, the installed capacity reaches about 550 MW of which 365 MW of hydroelectric origin. The Kaleta hydroelectric power plant alone represents 240 MW. It is expected that 30% of Kaléta's generation will be dedicated to OMVG member countries (Senegal 20%, Guinea-Bissau 4% and Gambia 6%) as soon as the OMVG Loop will be commissioned. The details of the generation units are presented in Appendix B.

The following figure illustrates the current energy mix of Guinea (including the total capacity of Kaléta). Two-thirds of the generation is of hydroelectric origin while the last third comes from thermal power plants.

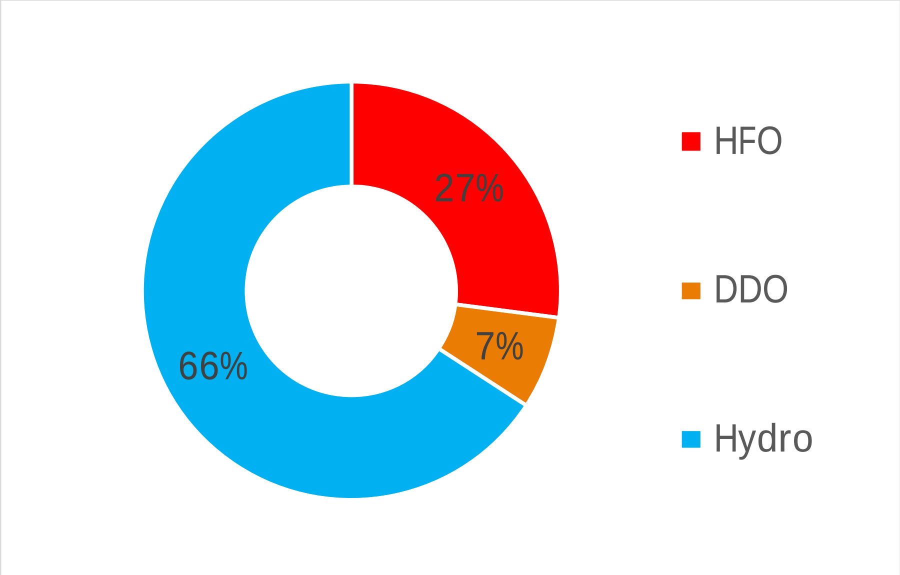

Figure 37: Installed Capacity of Guinea (2018) by fuel

4.1.6.2. GENERATION EXPANSION PLAN

Given the country's hydroelectric potential, the national strategy is focused on the optimal exploitation of these resources. In addition some solar projects were identified.

4.1.6.2.1. Decided units

As part of this study, the following plants are considered to be decided and will not be questioned:

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
HYDRO	Souapiti	450	2020
HYDRO	Amaria	300	2023
HYDRO	Kogbedou / Frankonedou	102	2023

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Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
HYDRO	Keno	7	2023
HYDRO	Touba	5	2022
PV	Touba	5	2022
PV	Khoummaguély	40	2019
PV	Sougéta	30	2019

Table 28: Decided Generation Projects: Guinea

4.1.6.2.2. Candidate Units

In addition to the projects mentioned above, the development of other hydroelectric projects is envisaged for the country. For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS master plan update.

These projects are described in Appendix C.

It is also worth mentioning the PV solar project of Pecos, for an installed capacity of 12 MW and another PV solar project in Morisakano for an installed capacity of 100 MW (combined with the hydro project).

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.7. Guinea Bissau

4.1.7.1. DIAGNOSIS OF THE CURRENT SITUATION

Guinea-Bissau is facing a chronic deficit of installed capacity. On the EAGB network, electrical generation comes exclusively from rental groups (15MW), while many consumers develop their own generation facilities in Bissau and elsewhere in the country. The details of the generation units are presented in Appendix B.

The capacity installed on the EAGB network is now exclusively of thermal origin (diesel), as illustrated below.

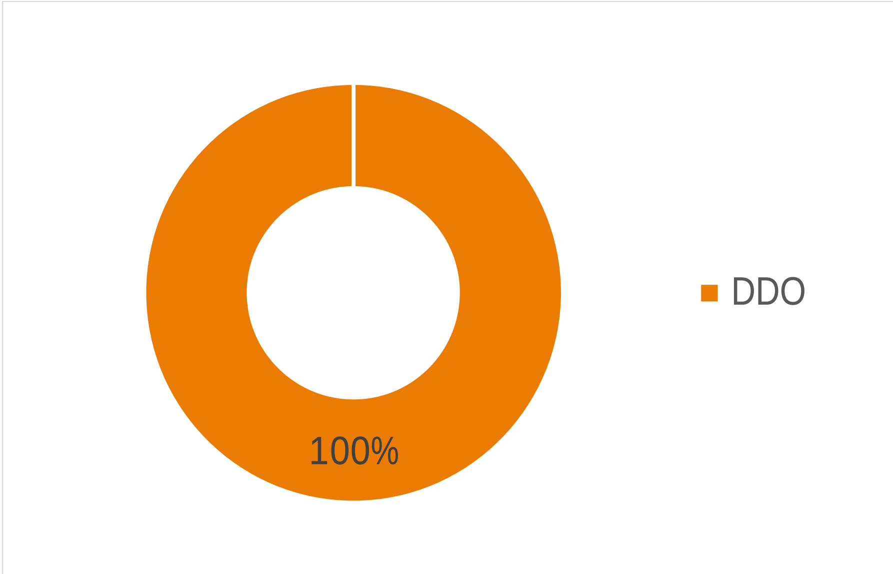

Figure 38: Installed Capacity of the Guinea Bissau (2018) by fuel

4.1.7.2. GENERATION EXPANSION PLAN

The country, supported by donors, has established a short-term strategy to improve the situation of the electricity sector and improve energy security. This strategy will significantly increase the country's installed capacity on the 20-year horizon. Nevertheless, given the very low recovery rate (linked to the billing issue) and significant financial costs (related to non-concessional loans), the financial situation in the sector will remain precarious. Moreover, the subsidy granted by the Ministry of Finance (8% of the cost of fuels) will increase in absolute terms with the installation of additional installed capacity in the country.

Therefore, the country envisages a diversification of the medium and long-term energy mix.

4.1.7.2.1. Decided units

As part of this study, the following plants are considered to be decided and will not be questioned:

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
DI (HFO)	Bor	15	2019
Of (DO)	BADEA	22	2019
PV	BOAD	20	2020

Table 29: Decided Generation Projects: Guinea Bissau

4.1.7.2.2. Candidate Units

In addition to the projects mentioned above, the following projects are envisaged for the country. Diesel will be gradually abandoned and replaced by solar power plants, hydro and HFO.

Final version

- Thermal Power plant firing HFO 55 MW
- PV Solar Power Plants: 59 MW

It should be added to these projects the regional hydroelectric power plants for which a part of the producible is dedicated to Guinea Bissau (Souapiti, Sambangalou,..). These projects are described in section 4.2.2. The importation of thermal energy (HFO and NG) from Senegal is also envisaged.

For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS master plan update.

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.8. Liberia

4.1.8.1. DIAGNOSIS OF THE CURRENT SITUATION

Liberia is facing a chronic deficit of installed capacity, coupled with a very high cost of electricity, creating a high rate of self-consumption in the country. The country's installed capacity is only of thermal origin (DDO) and is limited to 22.6 MW (see Appendix B and figure below).

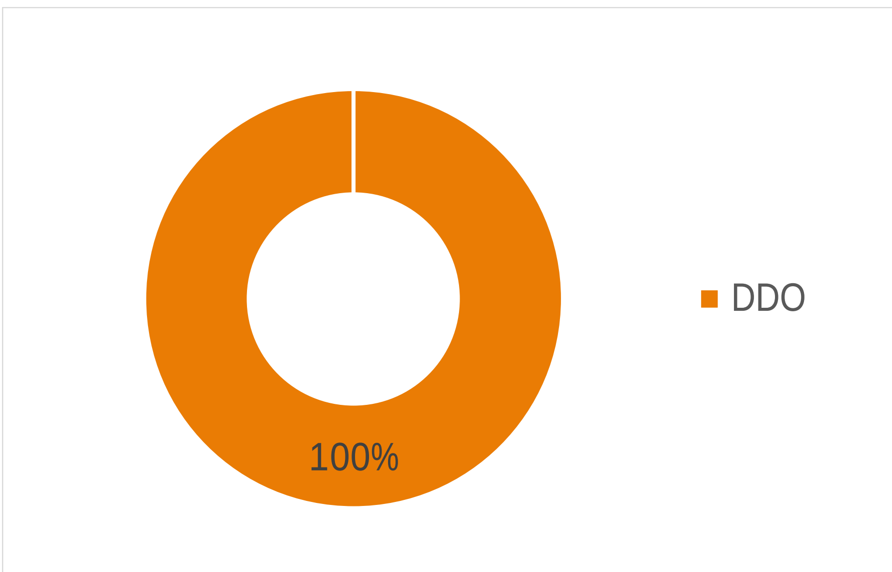

Figure 39: Installed Capacity of Liberia (2018) by fuel

4.1.8.2. GENERATION EXPANSION PLAN

The country's priority, in the short term, is to recover the pre-war situation in the country.

Final version

4.1.8.2.1. Decided units

Several investments to reduce costs and increase installed capacity are currently planned: 48 MW of thermal generation (HFO) at Bushrod and the rehabilitation of Mount Coffee Hydro – both located in Monrovia. These plants are considered to be decided and will not be questioned:

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
DI (HFO)	Bushrod	48 (38+10)	2017 (already commissioned)
HYDRO	Mount Coffee (rehabilitation)	88 MW	2018 (already commissioned)

Table 30: Decided Generation Projects: Liberia

4.1.8.2.2. Candidate Units

The country's generation projects are aimed at the development of the estimated 2300 MW hydroelectric potential (see Appendix C). It should be noted, however, that hydroelectric potential is subject to strong intra-annual variations with a significant reduction in generation during the dry season requiring a combination with other sources of generation.

For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS master plan update.

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.9. Mali

4.1.9.1. DIAGNOSIS OF THE CURRENT SITUATION

Malian power system is composed of an interconnected network and a large number of isolated centres. The interconnected network which is directly concerned by this study has the peculiarity of being divided into two pockets, for questions of stability of the transmission network. Thus, the Kalabankoro-Sirakoro 150kV line in the city of Bamako is open, with part of the network connected to Côte d'Ivoire and the other part connected to the Manantali network.

The thermal capacity available in the interconnected network reaches 240 MW of which 83 MW are rental groups. This capacity is fed for half by heavy fuel oil and half by diesel. The details of the generation units are presented in Appendix B.

The country's hydroelectric potential is developed at a national level (Selingual and Sotuba projects) at a level of 53 MW.

In addition, the hydroelectric power plants of Manantali and Félou are located in Malian territory but these plants are managed by the OMVS and the producible is shared between the various member countries of this Organization (share of Mali: respectively 104 and 27 MW for Manantali and Félou).

The following figure illustrates the current energy mix of Mali (including the participation of Manantali and Félou). Installed capacity is distributed between hydropower and thermal capacity

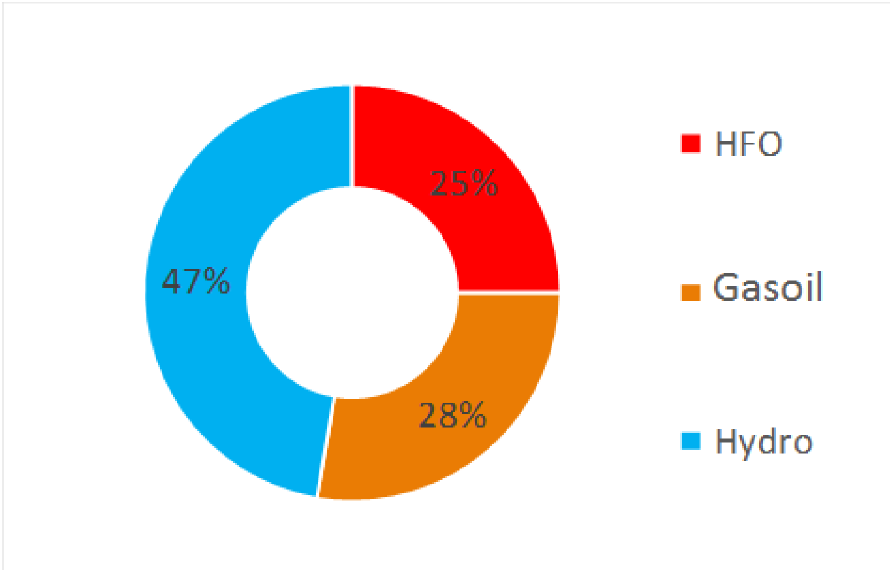

Figure 40: Installed Capacity of Mali (2018) per fuel

4.1.9.2. GENERATION EXPANSION PLAN

In order to reduce its dependence to fossil fuels and considering the country's hydroelectric and solar potential, Mali envisages the development of these two streams.

- Development of hydroelectric projects;
- Development of PV power plant projects.
- In addition, the development of thermal projects, in particular in order to replace the rental plants remains topical

4.1.9.2.1. Decided units

As part of this study, the following plants are considered to be decided and will not be questioned:

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
PV	Kita	50	2020
HFO	Bamako (Serakolo)	100 (8 units between 11 and 15 MW)	2021
DI (HFO)	Albatross (Kayes)	92	2018

Table 31: Decided Generation Projects: Mali

In addition, the Gouina hydropower plant is under construction within the framework of the OMVS and the energy will be allocated between Mali (34%), Senegal (33%) and Mauritania).

Final version

4.1.9.2.2. Candidate Units

In addition to the projects mentioned above, the following ones are envisaged for the country. For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS master plan update.

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
HYDRO	Markala	10	-
HYDRO	Sotuba 2	5.7	-
HYDRO	Kenie	42	-
HYDRO	Kourouba	4	
HYDRO	Baoulé 3 et 4	24	
HYDRO	Bagoué 2	19	
HFO	Bamako (Serakolo)	100	
HFO	Bamako (Sanakroba)	100	
PV	Kati	65	
PV	Fana	50	
PV	Tenkele	40	
PV	Bia	40	
PV	Kurikolo	50	
PV	Segou	33	
PV	Sikasso	50	-
PV	Koutiala	25	-
PV	Medium	40	-
PV	WAPP Regional Project	150	-

Table 32: Candidate Generation Projects: Mali

In addition to these projects are the hydroelectric power stations of the OMVS, for which part of the generation should be dedicated to Mali. These projects are described in section 4.3.1.1.

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

Final version

4.1.10. Niger

4.1.10.1. DIAGNOSIS OF THE CURRENT SITUATION

Niger is divided into 5 zones:

- The River Zone (Niamey) is powered by the groups of Niamey, Goudel and most recently by the Gorou Banda plant of 80 MW (commissioning in 2017).
- The NCE zone, fuelled by the diesel groups of Maradi, Tahoua, Mabaza and Zinder
- The Northern zone, supplied by the Sonichar coal plant (37.6 MW) and the Agadez groups.
- The Eastern zone powered by the diesel groups of Diffa.
- And the border area of Gaya, also powered by diesel groups.

The following figure illustrates the distribution of Niger's installed capacity by fuel. The details of the generation units are presented in Appendix B.

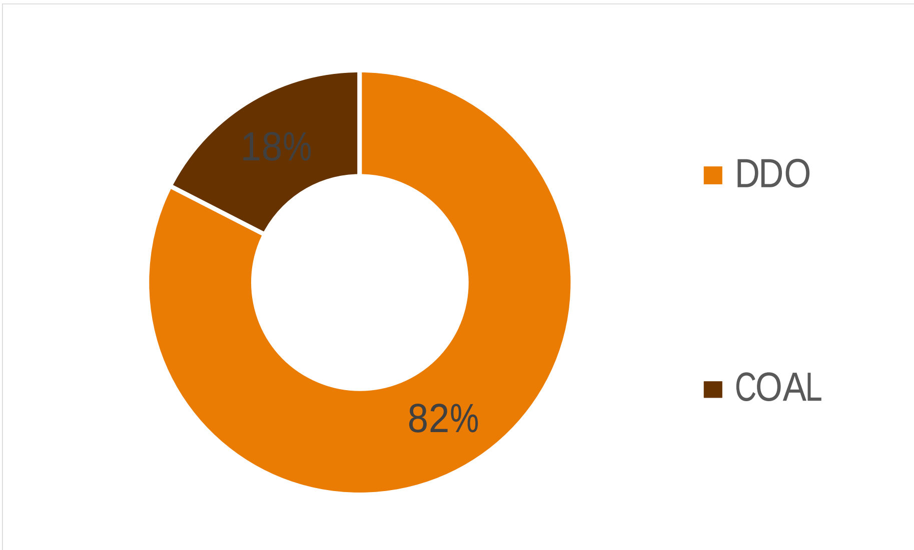

Figure 41: Installed Capacity of Niger (2018) per fuel

4.1.10.2. GENERATION EXPANSION PLAN

The development of the generation fleet, as currently planned, is mainly made up of coal-fired power plant projects.

- Rehabilitation of the Sonichar plant in the north
- New Salkadamna plant, 200 MW for phase 1, expandable to 600 MW in the future.

Three hydroelectric power projects were also defined, the sites of Donald, Kandadji and Dyondyong.

Finally Niger also plans to develop solar power plants, a first 20MW is expected on the site of Gorou Banda.

4.1.10.2.1. Decided units

As part of this study, the following plants are considered to be decided and will not be questioned:

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
COAL	Sonichar (réhab.)	68.8	2018
DO	Gorou Banda	20	2020
PV	Gorou Banda	20	2020
Hydro	Kandadji	130	2021
PV + diesel	Agadez	13 MW PV + 6 MW Diesel	2020
PV	Malbaza	7	2019
COAL	Salkadamna	200	2022

Table33: Decided Generation Projects: Niger

4.1.10.2.2. Candidate Units

In addition to the projects mentioned above, the following projects are envisaged for the country. For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS master plan update.

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
COAL	Salkadamna ph.2	400	
COAL	Sonichar	50	
PV	Lossa	10	
PV	NCE (Maradi)	30	
Hybride PV CC	Zinder	60	
PV	Dosso	10	
PV	Niamey	30	
CSP	Agadez	100	
HYDRO (DAM)	Gambou	105	-
HYDRO (DAM)	Dyondyong	26	-
HYDRO (DAM)	Kandadji	130	-
PV	Gorou Banda	30	-
PV	NCE	30	-

Table 34: Candidate Generation Projects: Niger

Final version

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.11. Nigeria

4.1.11.1. DIAGNOSIS OF THE CURRENT SITUATION

In Nigeria, the generating capacity is mostly made of thermal units using gas, and of several hydro power plants. It is the WAPP country with the highest installed capacity.

- 1967 MW of hydro units
- 6748 MW of OCGT
- 1848 MW of steam turbines
- 1936 MW of CCGT

Unfortunately, a large part of the generation park is not available. Several units are not available due to various kinds of problem.

The available capacity is thus considered as follows :

- 1216 MW of hydro units
- 4215 MW of OCGT
- 1408 MW of steam turbines
- 1731 MW of CCGT

The following figure illustrates the distribution of Nigeria's installed capacity by fuel. The details of the generation units are presented in Appendix B.

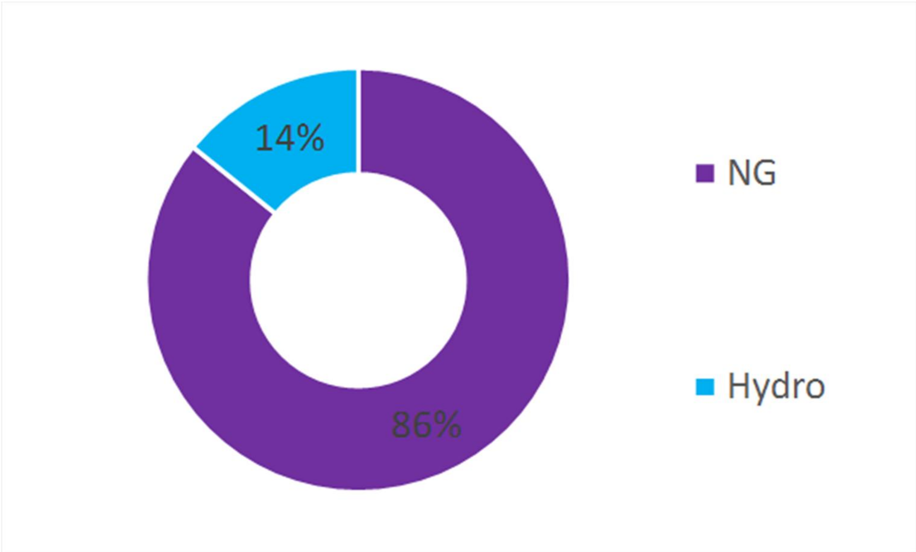

Figure 42: Installed Capacity of Nigeria (2018) per fuel

Final version

4.1.11.2. GENERATION EXPANSION PLAN

A lot of new projects are foreseen in the Nigerian generation expansion. Most of those are open-cycle and combined-cycle gas turbines. In the long run, projects for several coal units are also planned.

4.1.11.2.1. Decided units

As part of this study, the following plants are considered to be decided and will not be questioned. Those are the units under construction according to the master plan 2017.

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
GT - NG	GBARAIN/UBIE I	113	2017
GT – NG	EGBEMA I - NIPP	339	2018-2019
GT – NG	OMOKU - NIPP	226	2018-2019
GT – NG	KADUNA IPP	215	2019
ST	ALAOJI 2+ NIPP	285	2025
HYDRO	GURARA	30	2017
HYDRO	KASHIMBILLA	40	

Table 35: Decided Generation Projects: Nigeria

4.1.11.2.2. Candidate Units

In addition to the projects mentioned above, other projects are envisaged for the country. For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS master plan update.

The complete list of projects is displayed in Appendix C.

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.12. Senegal

4.1.12.1. DIAGNOSIS OF THE CURRENT SITUATION

Senegal currently does not have a single electricity transmission system. The interconnected network feeds the Dakar region as well as thecenter, north and east regions. The Regional centres in Ziguinchor and Tambacounda form independent networks that are not connected to the interconnected network. Finally, secondary centres feed local communities in the country.

Interconnected Network

On the interconnected network, generation is mainly thermal. It is dominated by a few independent producers and by the Bel-Air and Cap-des-biche plants.

The thermal capacity available in the interconnected network reaches 491 MW. The whole capacity is Powered by heavy fuel oil. The details of the generation units are presented in Appendix B.

In addition, for several years the country has been developing solar photovoltaic projects all over the country. The total capacity connected to the interconnected network reaches 143 MW in 2018 (CICAD 2 MWc, Solaire Bokhol 20 MWc, Malicounda 22 MWc, Santhiou Mékhé 29,5 MWc, Ten Mérina Mékhé 29,5 MWc, Kahone 20 MWc, Sakal 20 MWc.).

Finally, to the capacity installed in the territory of Senegal, it is necessary to add the Manantali plant in Mali. According to the OMVS agreements, Senegal has 33% of the plant's producible. The plant is 200 MW, so 66 MW are available for Senegal. Similarly, 12 MW of the 60 MW of the Félou plant return to Senegal.

Networks Secondary

Two secondary centres have a significant installed capacity. This is Boutoute (28.8 MW of installed thermal capacity of which 10 MW are rental units) and Tambacounda (8.8 MW of installed thermal capacity of which 6 MW are rental units). In these centres, the primary fuel is diesel. Currently, these centres operate in islanded but will be connected to the interconnected network with the commissioning of the OMVG loop.

Assessment of installed Capacity

The following figure illustrates the current energy mix of Senegal (including the participation of Manantali and Félou). The country is heavily dependent on fossil fuels, and in particular heavy fuel oil, but this dependence tends to decrease due to the development of solar projects.

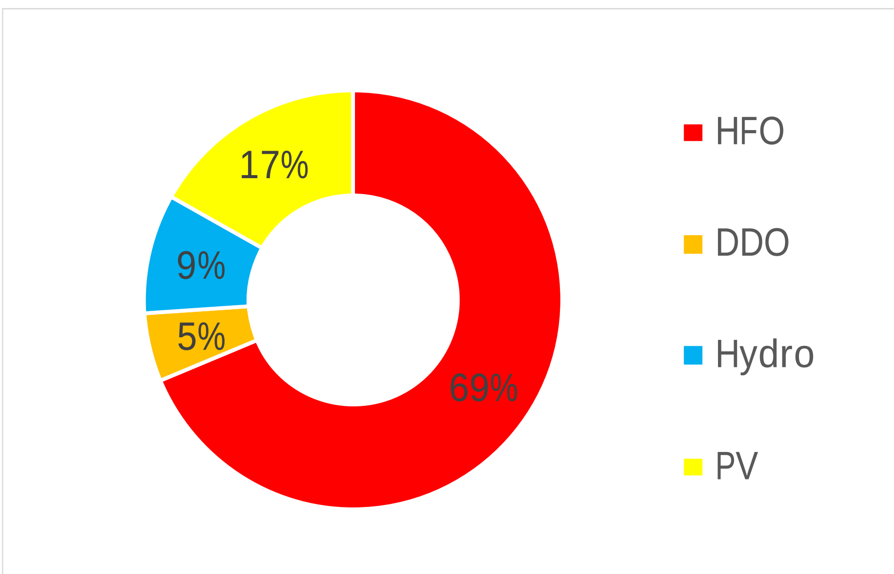

Figure 43: Installed Capacity of Senegal (2018) per fuel

Final version

4.1.12.2. GENERATION EXPANSION PLAN

In order to reduce its dependence on heavy fuel oil, Senegal is considering diversifying the country's energy mix.

- Development of the country's solar potential in the continuity of what has been put in place in recent years;
- Development of coal-fired power plant projects;
- Exploitation of recently discovered offshore gas reserves at the coast of Senegal and Mauritania;
- Participation in the development of hydroelectric projects with regional scope (projects OMVG and OMVS)

4.1.12.2.1. Decided units

As part of this study, the following plants are considered to be decided and will not be questioned:

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
PV	Diass	25	2019
PV	Touba (scaling solar)	25	2019
PV	Kaloack (scaling solar)	35	2019
COAL	Sendou	115	2018
Diesel	Malicounda	120	2020
HYDRO	Sambangalou	128	2021
WIND	Project	50	2019
WIND	Project	50	2020
WIND	Project	50	2021

Table 36: Decided Generation Projects: Senegal

In addition, the Gouina hydropower plant is being constructed in the OMVS framework and Senegal will benefit from a portion of its producible starting in 2020.

The beginning of the construction of Sambangalou is planned for the 4th quarter of 2018.

4.1.12.2.2. Candidate Units

In addition to the projects mentioned above, the following projects are envisaged for the country. For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS master plan update.

Final version

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
PV	World Bank project	100	-
PV	(scaling solar)	40	-
COAL	Mboro	90	-
CC (NG)	Kayar (Konoune)	115	-

Table 37: Candidate Generation Projects: Senegal

In addition to these projects are the hydroelectric power stations of OMVS and OMVG, part of which should be returned to Senegal. These projects are described in section 4.3.1.1.

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.13. Sierra Leone

4.1.13.1. DIAGNOSIS OF THE CURRENT SITUATION

The data on the electricity sector are difficult to obtain in Sierra Leone, despite the consultant's visit in the country. According to public information collected, the country has a little less than 150 MW of installed capacity available across the country for about 150 000 connected customers.

The Sierra Leone system is divided in several networks.

- The Bumbuna hydroelectric power station feeds the city of Freetown and the surrounding western region as well as the town of Makeni in the Port Loko district. In the wet season, the Bumbuna hydroelectric plant generates approximately. 30-40 MW and during the dry season 10-18 MW, leading to frequent power cuts in the months of February to April. A 37 MW thermal power plant is also connected to this system
- The towns of Bo and Kenema, in the southeast of the country, are powered by a local 33kV network supplied with the Dodo hydroelectric power station (6MW) and, since 2017, with the hydroelectric power plants of Bankasoka, Charlotte and Makali, covering together a installed capacity of 5 MW.

The following figure illustrates the current energy mix of Sierra Leone (networks of Bubmuna and Bo-Kenema on the basis of the identified public data). Installed capacity is distributed between hydropower and thermal capacity

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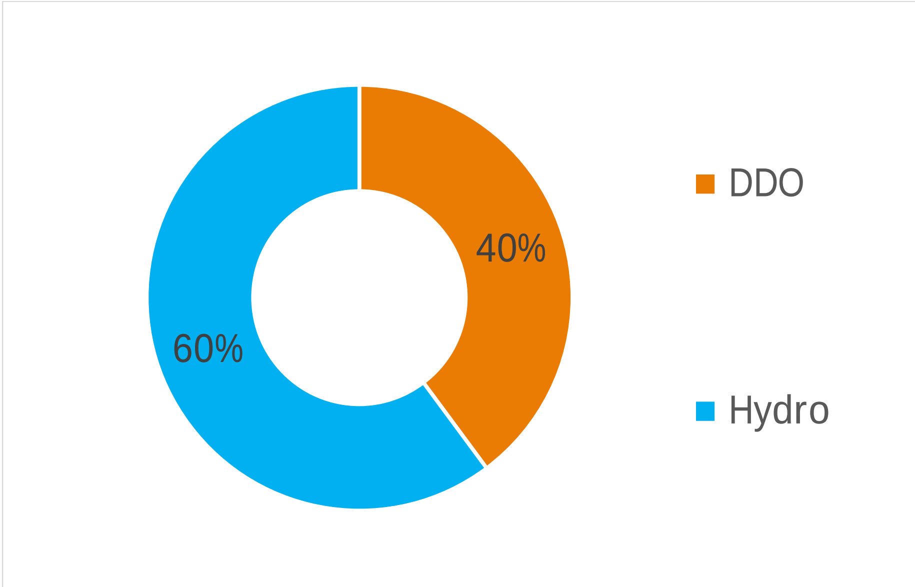

Figure 44: Installed Capacity of Sierra Leone (2018) by fuel

4.1.13.2. GENERATION EXPANSION PLAN

Little information was sent to the consultant about the projects being developed in the country. However, the sector roadmap is very ambitious as it aims to develop 900MW of thermal power, 650MW of large hydropower, 130 MW of small hydropower and 120 MW of other renewable energy. Such capacity will not only focus on the supply of residential and commercial demand but also on the exploitation of the country's mining resources. It should be noted, however, that mining demand is excluded from the scope of this study.

4.1.13.2.1. Decided units

As part of this study, the following plants are considered to be decided and will not be questioned:

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
HYDRO	Bumbuna II	132	2023
HYDRO	Bumbuna III (Yiben)	66	2023
HFO	CEC Africa Phase 1	50	2018
PV	Newton Solar	6	2019

Table 38: Decided Generation Projects: Sierra Leone

4.1.13.2.2. Candidate Units

The country's generation projects are aimed at the development of the country's hydroelectric potential estimated at 2000 MW (see Appendix C).

Final version

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
Diesel	Port loko	2	
Diesel	Kambia	2	
Diesel	Lunsar	2	
PV	Heron Energy	5	
Diesel	Makeni	6	
Diesel	Kabala	2	
Diesel	Magbururka	2	
Diesel	Kailahun	2	
Diesel	Kenema	6	
HFO	**Bo**	6	
Solar	**Bo**	5	
Diesel	Pujehun	2	
Diesel	Moyamba	2	
Diesel	BontHe	1	
HFO	CEC Africa Phase 2	39	
HFO	CEC Africa Phase 3	39	

Table 39: Candidate Generation Projects: Sierra Leone

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.14. Togo

4.1.14.1. DIAGNOSIS OF THE CURRENT SITUATION

In Togo, approximately 30% of the installed capacity comes from the Nangbeto hydroelectric dam. In addition, the independent producer Contour Global covers an installed capacity of 90MW (gas turbines fuelled by the West Africa gas pipeline). The rest of the generation comes from diesel groups or small gas turbines belonging to the CEET or the CEB.

The resulting energy mix is shown in the figure below. The details of the generation units are presented in Appendix B.

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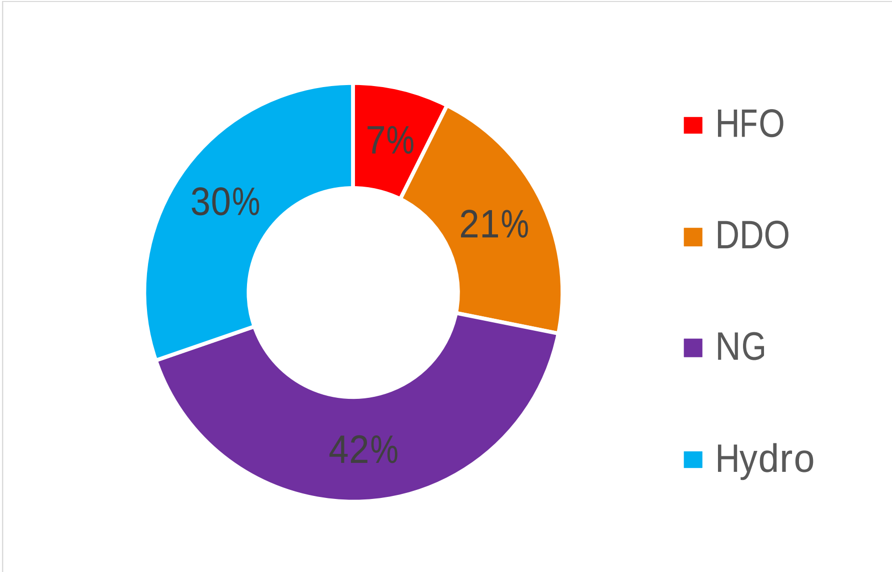

Figure 45: Installed Capacity of Togo (2018) by fuel

It is important to note that the electrical demand of Togo is fuelled not only by the power plants of the CEB, CEET and CONTOUR GLOBAL but also and above all by Energy purchases in TCN and VRA.

4.1.14.2. GENERATION EXPANSION PLAN

In addition to the development of new thermal projects in the Lomé region, Togo has carried out an analysis of the country's untapped hydroelectric potential. All of these projects will be proposed for optimization.

4.1.14.2.1. Decided units

With the securing of gas supply from Nigeria, the development of gas-fired power plants in the Lomé periphery should be confirmed. Thus, the 50 MW gas turbine is decided and will be put into service by 2020. This project will not be challenged as part of this study.

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
GT (NG)	Lomé	60	2020
HYD	Sarakawa	24.2	2023

Table 40: Decided Generation Projects: Togo

4.1.14.2.2. Candidate Units

In addition to the projects mentioned above, the following projects are envisaged for the country. For these projects, it is considered that the date of commissioning, the technology and the installed capacity can be optimized as part of the ECOWAS master plan update.

Final version

It should be noted that, given the uncertainty associated with the gas supply of the Lomé site and the importance of proposing a robust master plan, the Contour Global extension will be questioned, in particular as to its size and the origin of the Fuel used.

Technology (fuel)	Name of the plant (location)	Installed Capacity [MW]	Date of commissioning
HYD	Adjarala	147	-
HYD	Tététou	60	-
HYD	Titira	23.8	-
HYD	Kpessi	15.9	-
HYD	Wawa	8.4	-
HYD	Baghan	5.8	-
HYD	Kolo-Kopé	17.1	-
HYD	Seregbene	3.6	-
PV	Dapaong	30	
PV	Blitta	20	
COAL	TBD	450	

Table 41: Candidate Generation projects: Togo

Finally, standard thermal and renewable generation projects will be proposed for optimization to complement the decided and envisaged projects and to meet the country's demand (see section 4.3).

4.1.15. Cape Verde

4.1.15.1. DIAGNOSIS OF THE CURRENT SITUATION

In 2008, the total installed capacity was estimated at 91.4 MW and distributed as follows: 89.1 MW from fossil thermal resources and 2.1 MW from wind energy. The largest thermal power plant with a capacity of 38.5 MW is located in Praia, followed by S. Vicente (18.3 MW) and Sal (9 MW).

The installed capacity then increased considerably to reach 156.2 MW in 2012 and as of December 31, 2016, ELECTRA held a set of 13 thermal power plants of variable size for an installed capacity of 160 MW (125 MW available), 1 wind farm and 2 solar parks to which must be added the installed capacity of 4 power plants managed by independent producers (3 wind projects and 1 solar project).

In terms of producible, 80% of the energy produced is thermal, while 17.5% comes from wind energy and 1.5% from solar energy.

Final version

4.1.15.2. GENERATION EXPANSION PLAN

Given the country's insular situation and the lack of fossil resources in the country, the cost of thermal energy is particularly high in the country. Therefore, the country is considering the large-scale development of renewable energies. Thus, the government aims to achieve a 100% renewable energy mix thanks to advanced technologies and innovative business practices.

This energy mix will be mainly based on solar and wind energy, potentially supported by storage options to offset the variability of renewable resources.

4.2. Potential of natural resources

4.2.1. Fossil Resources

4.2.1.1. AVAILABILITY OF FOSSIL RESOURCES

Natural Gas

Historically, Natural Gas has represented a large share of the energy mix on the Nigeria, Benin, Togo, Ghana and Côte d'Ivoire axis.

In addition to Nigeria, which has a huge gas potential, Ghana and Côte d'Ivoire are also Natural Gas producing countries. Thus, according to the most recent estimates, Ghana and Côte d'Ivoire each have gas fields with a potential of respectively 270 and 176 mmscfd in 2018. The following table shows the aggregate cumulative supply of gas fields certified in each of these 2 countries for the next 12 years.

	2018	2019	2020	2021	2022	2023	2024	2025	2030
Côte d'Ivoire	176	172	165	153	142	140	135	134	130
Ghana	270	310	300	310	310	300	290	280	230

Table 42: Proven Reserves of Natural Gas (Ghana + Côte d'Ivoire)

In the coastal countries, the exploitation of National Gas fields and the import of Nigerian Natural Gas through the WAGP gas pipeline have allowed the development of several gas-fired power plants.

Nevertheless, the region is currently facing a deficit of Natural Gas which, in some cases, induces the use of liquid fuels or load shedding. In Nigeria, the leading Natural Gas exporting country in the sub-region, gas supply is frequently interrupted by the sabotage of transmission infrastructure (gas pipelines).

The recent discovery of an important offshore gas field at coastal borders of Senegal and Mauritania (Grand Tortue-Ahmeyim - estimated reserves of 450 billion cubic meters) nevertheless changes the paradigm. The map below shows proven reserves in the subregions (in trillion cubic meters).

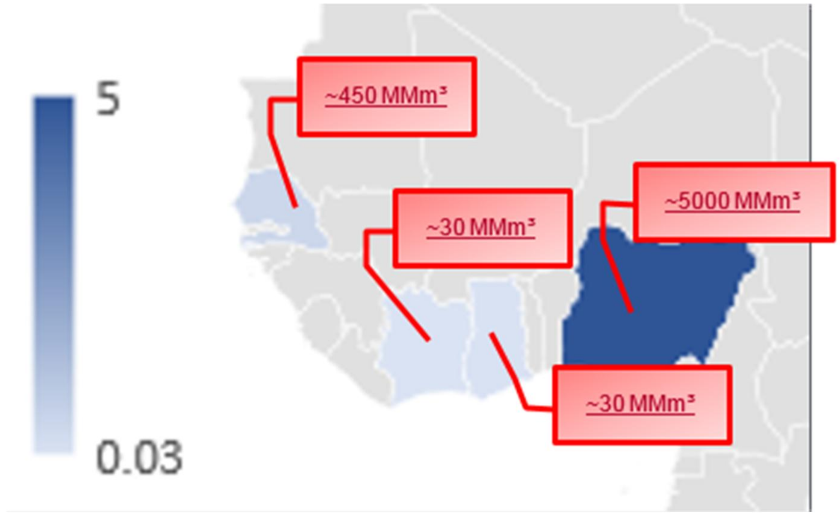

Figure 46: Natural Gas proven reserve in the sub-region (trillions cubic meters)

Liquid Fuel

Nigeria, Ghana, Côte d'Ivoire are fuel oil producers. However, due to prohibitive cost of the resource, the use of liquid fuels in coastal countries is only considered in case of unavailability of gas resources (temporary measure).

In other countries of the subregion, however, dependence to liquid fuels is much more important, especially in the absence of any accessible alternative. For these countries, exposure to the international oil price market and price volatility exacerbate the deficit of the electricity sector.

Coal

In order to diversify the energy mix, to reduce the dependence to liquid fuel and to decrease fuel cost, the coal will be considered for the electricity generation within the framework of this master plan. This option is already envisaged by several countries of the sub-region including Niger, Senegal and Côte d'Ivoire.

Some of these projects are aimed at developing Salkadamma coal reserves (Niger), estimated at 69 million tonnes, including the construction of an open-cast mine.
However, it is important to note that coal-fired plants have an important environmental impact, given the level of greenhouse gas emissions (CO_2, NO_X and SO_2) that is significantly higher than other technologies (gas and diesel). The table below summarizes the typical CO_2 emissions for different technologies (coal, natural gas and diesel). Note that coal plants emit 4-5 times more nitrogen oxide than other technologies and substantial amounts of sulphur dioxide.

Technology	CO2 Emissions [kg/MMBTU]
Coal	95.35
Natural Gas	53.07
Diesel	71.3

Table 43: CO2 Emissions per type of fuel (source: IEA)

Final version

The development of coal-fired power plant projects therefore requires consideration of environmental aspects through the development of specific mitigation measures. In addition, international financial institutions are increasingly reluctant to finance these projects and international pressure is growing for the closure of coal-fired power plants.

4.2.1.2. EXISTING INFRASTRUCTURES

Pipeline WAGP

The figure below presents the WAGP pipeline allowing for transporting Nigerian gas to markets in Benin, Togo and Ghana.

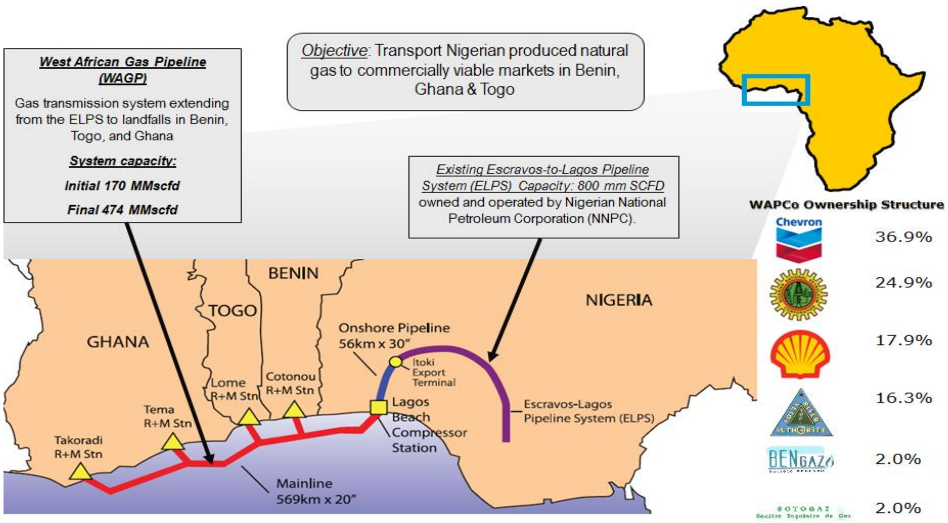

Figure 47: WAGP Pipeline (source: WAGPA)

Ghana is the main beneficiary of the Nigerian Natural Gas since it consumes more than 90% of the gas delivered, while Benin and Togo share 8% equally. Note, however, that the pipeline, commissioned in 2009, does not allow for the exchange of volumes contracted, as shown in the figure below. Since the start of trade in 2011, less than 50% of contracted volumes have actually been delivered. This difference is due to many factors including the unavailability of gas resources upstream of the pipeline, the default of payment of certain consumers and major offshore incidents.

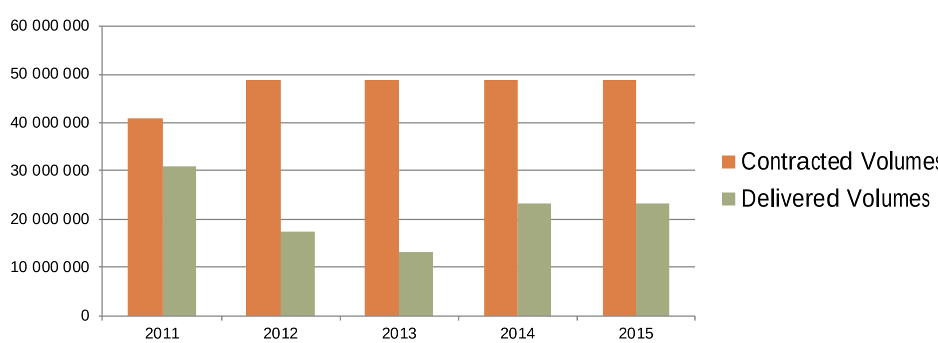

Figure 48: Exchanges volumes of Natural Gas (source: WAGPA)

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Development of LNG infrastructures

Given the limited or non-existent reserves of most countries in the sub-region and the unreliability of the WAGP pipeline, many countries are considering the development of Liquefied Natural Gas projects. There are generally two broad categories of regasification stations including:

- Onshore regasification stations;
- Floating and Storage Regasification Unit (FSRU): Receipt of Gas deliveries, Storage and Transformation of LNG and transmission on the network through a pipeline (offshore stations).

In the sub-region, FSRU technology is favoured for matters of cost and manufacturing time.

The following map illustrates some projects planned in the subregion.

Figure 49: FSTU Projects (source: Interfax)

Final version

4.2.1.3. FOSSIL FUEL PRICES

Fuel Prices

This section aims at providing price projections for all fossil fuels used by the power sector in West Africa or considered for investment project. Theses fuels are natural gas (NG), heavy fuel oil (HFO), distillate diesel oil (DDO), light crude oil (LCO) and coal. For each fuel type, the same fuel price is assumed for all countries within the sub-region (excluding transportation cost which differs for landlocked countries compared to coastal countries). The reasoning is that international or regional fuel prices should be used as all the countries have access to the same fuel markets. Moreover, even in case the fuel is available locally, international or regional prices should be considered as these fuels could be sold on these regional or international markets. Considering these fuels at costs instead of at price, would promote this fuel to be used for power generation compared to imported fuels and would therefore neglect the welfare impact of the indigenous fuels. In other words, the opportunity costs of these natural resources would be neglected. The only exception considered here is the local future extraction of coal in Niger and the Northern part of Nigeria which is not foreseen to be exported outside the area of production and therefore have no possible link with the international market and cannot represent an opportunity cost.

The different types of fuels available for power generation depend on the location: **Liquid fuels** are assumed to be available for all countries integrating higher transport cost for hinterland countries Mali, Burkina and Niger reflecting the expensive transfer by tanker truck from coastal refineries and harbours. **Natural gas** is assumed to be available for coastal countries from Senegal to Nigeria. Three types of gas have to be distinguished: locally produced gas in Cote d'Ivoire, Ghana, Nigeria and possibly Senegal; Nigerian gas, supplied through the West African Gas Pipeline WAGP in Benin, Ghana, and Togo, and possibly to Cote d'Ivoire) ; and imported liquefied natural gas (LNG) in all coastal countries. As explained here above, locally produced **coal** is available in Niger and Nigeria. Imported coal is assumed to be available to all coastal countries.

The assumptions regarding the fuel prices and their evolution during the study period are provided in Figure 50. Note that the natural gas and coal prices are significantly lower than the liquid fuels prices. For 2017, liquid fuels are in average more than 50% more expensive than natural gas and imported coal is about 40% cheaper per GJ than natural gas. Liquid fuels imported by tanker trucks to the hinterland countries are 23% more expensive in average than at the coast.

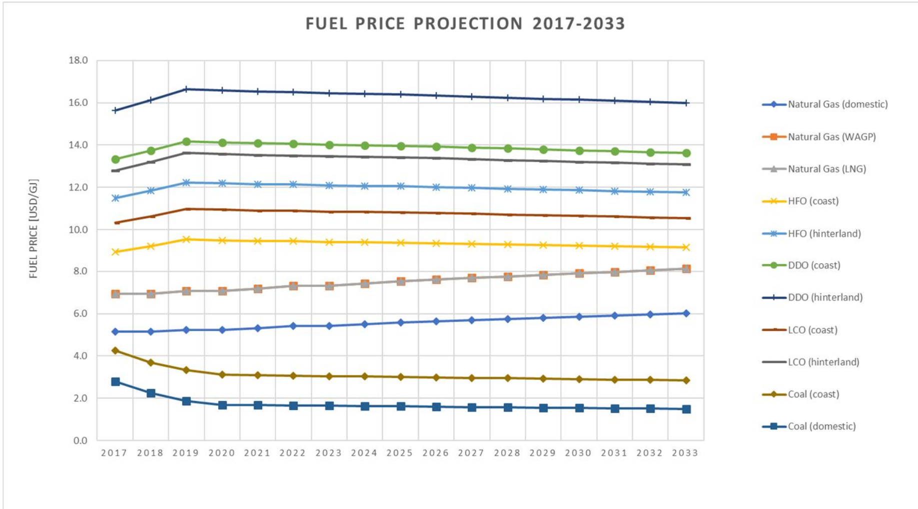

Figure 50 : Fuel costs over the planning horizon in West Africa

The fuel price evolution over the planning horizon results from the October 2017 World Bank estimations[4]. The long-term evolutions of the fuel prices follow directly from their estimates by World Bank. These trends on the international market are provided for representative products for the period 2014-2030 in Commodity Markets Outlook and are depicted at Figure 51. The forecasted evolution is presented considering constant US dollars. The trends were extrapolated to cover the studied horizon up to 2033.

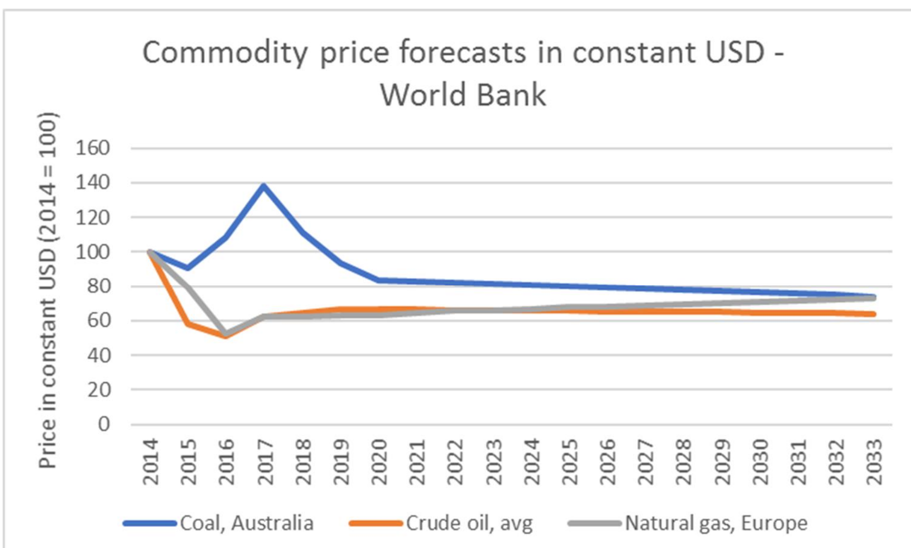

Figure 51: Commodity price forecasts (source: World Bank)

[4] Commodity Markets Outlook, World Bank Group, October 2017.

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The 2017 prices in West Africa for the different fuel types is based on international market prices and back calculated taking into account transport cost to reflect price levels in West Africa. From these prices “at the coast”, tanker truck transport costs to the inland countries is added in order to obtain the “hinterland” prices for the liquid fuels. The costs related to fuel transportation across sea or land are detailed in next section.

The NG price is based on the limited LNG export from Nigeria to the US in 2017 which was adjusted with maritime transport costs. The price level was validated with the prices encountered in Europe, the closest reference market. The long-term trend follows the forecast by WB.

The Coal price in West Africa is obtained as the average of 2017 coal spot prices in Colombia and South Africa, the closest reference coal exporters, adjusted to take into account the transport costs from Puerto Bolivar terminal or from Richards Bay coal terminal. The long-term trend follows the forecast by WB. As explained above, a domestic price is considered for the local coal in Niger and Nigeria as no export is possible for these resources. The considered price reflects local production costs provided by Nigelec for representative mines. Same long-term trend is applied.

For the liquid fuels, average 2017 spot prices at New York stock Exchange, reference market for petroleum products and important importer of West African oil were considered and corrected for freight rate differential to reflect intra West African transport from Nigeria. Ratios between the different liquid fuels prices considered here, DDO, HFO and LCO are based corresponding ratios in WAPP MP 2011 and ensuing IRENA analysis. The long-term trend follows the forecasted trend for world average crude oil price presented at Figure 51.

Transportation costs

The fuels prices in West Africa are presented for two particular conditions, “delivered to the coast” and “delivered to the hinterland”. “Delivered to the coast” corresponds to the fuel delivery for all coastal countries from Senegal to Nigeria “delivered to the hinterland” corresponds to the delivery for Mali, Burkina Faso and Niger. For each case, average fuel prices are presented net of tax and except subsidies.

Fuels prices at the borders of an exporting country are given by analysis above-mentioned. It is thus necessary to add the cost of maritime transport to get the price of fuel “delivered to the coast” and the road transport cost to get the price of fuel “delivered to the hinterland”

The transport costs are estimated on basis of the consultant’s experience, recent projects in the region and on IEA publications:

- Maritime transport costs of liquid fuels per 30 000 tons tanker are estimated at 5.9 USD/kton/mile
- Maritime transport costs of coal between South Africa or Colombia and West Africa are estimated at 30 USD/ton
- The road transport costs of liquid fuel by tanker are estimated at 0.11USD/ton/km
- Concerning the transport cost of natural gas, three different prices are to be considered according to the source (excluding any contractual arrangement like lease and operate contract)

- WAGP: 2 USD/MMBTU;
- Local gas: about 0.1 USD/MMBTU;
- LNG: Liquefaction: 0.9 USD/MMBTU; transport: 0.9 USD/MMBTU; Gasification & Storage: 0.2 USD/MMBTU.

Taking into account these transport costs and the relations from the correlation study, it is possible to estimate average costs of various fuel "delivered to the coast" and "delivered to the hinterland" (net of tax and subsidies). The values for some years of the study period are presented at the Table 44 Fuel Price Projections [USD/GJ].

[USD/GJ]	2017	2025	2033
Natural Gas (domestic)	5.1	5.6	6.0
Natural Gas (WAGP)	6.9	7.5	8.1
Natural Gas (LNG)	6.9	7.5	8.1
HFO (coast)	9.0	9.4	9.2
HFO (hinterland)	11.5	12.0	11.8
DDO (coast)	13.3	14.0	13.6
DDO (hinterland)	15.6	16.4	16.0
LCO (coast)	10.3	10.8	10.5
LCO (hinterland)	12.8	13.4	13.1
Coal (coast)	4.3	3.0	2.8
Coal (domestic)	2.8	1.6	1.5

Table 44 Fuel Price Projections [USD/GJ]

4.2.2. Hydroelectric resources

West Africa has 28 transboundary river basins. The most important are Niger (shared between 11 countries if the non-active part of the basin is taken into account), Senegal (4 countries), Volta (6 countries), Lake Chad and Comoe (4 countries). With the exception of Cape Verde, each ECOWAS country shares at least one watercourse with one of its neighbours. Fourteen cross-border basins are listed in Guinea, where a large number of rivers originate. There are eight in Côte d'ivoire, seven in Liberia, five in Nigeria and Sierra Leone. In total, cross-border basins cover 71% of the total area of the region (source: OECD).

One of the objectives of this master plan and of the national master plans of most West African countries is the development of untapped hydro-electric resources.

Many hydro-electric projects have been identified in previous studies and are listed as part of this study. Each project has its own characteristics (cost, ,...) and it is not possible to present standard costs for hydroelectric works. The list of projects identified is presented in Appendix C, compiling the information collected on these projects.

4.2.3. Renewable Resources

4.2.3.1. RES INTEGRATION OBJECTIVES

In order to offer " *Affordable, reliable, durable and modern energy for all* " thanks to the vast untapped potential of renewable energies (solar, wind and water), the ECOWAS Renewable energy policy has set the following objectives for renewable energies connected to the network:

1. Increase the share of renewable energy penetration in the electricity mix including large hydropower to 35% by 2020 and 48% in the horizon 2030;
2. Increase the share of renewable energy penetration while excluding large hydropower to 10% by 2020 and 19% by 2030. This will contribute to the development of an installed capacity of 2424 MW of renewable energy from wind, solar, bioenergy and small hydropower at the 2020 horizon and 7606 MW by 2030.

These objectives are translated in the various national policies as follows:

Country	2020	2030
Benin	20%	44%
Burkina Faso	23%	50%
Côte d'Ivoire	0%*	16%*
The Gambia	35%	48%
Ghana	10%*	20%*
Guinea	25%*	30%*
Guinea-Bissau	30%	50%
Liberia	25%	30%
Should	0%*	30%*
Niger	40%	57%
Nigeria	20%	30%
Senegal	20%*	30%*
Sierra Leone	30%	50%
Togo	15%	30%

Table 45: Objectives for integrating renewable energies into the interconnected network (Source: Irena)

** Excluding large hydropower*

It should be noted that these goals come mostly from national energy policies. They were collected by Irena during seminars on generation planning in 2015/2016. For countries for which no objective has been transmitted, the figures come from the SE4ALL reports.

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As part of this update, the rate of integration of renewable energies will be determined by the economic study and will take technical constraints into account. Penetrations could be higher than the objectives of ECOWAS and the breakdown by country would depend on the potential of each.

4.2.3.2. AVAILABILITY OF RESOURCES

Solar Resources

In recent years solar projects have multiplied in the different countries of West Africa. Initially devolved to individual solutions (solar kits), solar energy is now becoming widespread as a large-scale source of generation connected to interconnected transmission networks, despite the difficulties inherent to these technologies such as the management of the intermittent nature of the resource and the important ground grip of the PV panels.

Indeed, given the energy deficit of the subregion and the presence of landlocked areas without oil or water resources, solar energy is a valuable resource and, moreover, more and more economically affordable. In addition, in recent years, in the different countries, the procedures have improved and standardized and the deadlines have automatically been shortened for the implementation of PV projects.

But the main strength of this resource is its potential, immense across the continent and particularly in West Africa. In fact, the Northern areas of the subregion benefit from a solar irradiation exceeding 2000 kWh/m^2.

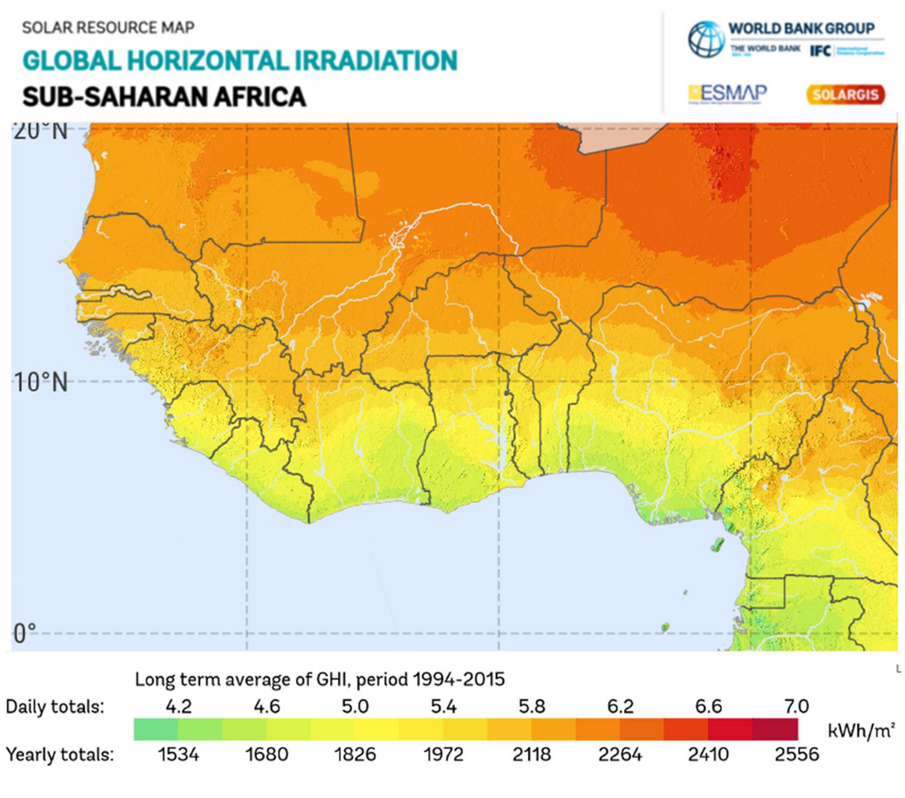

Figure 52: GHI West Africa 1994-2015 (© 2017 The World Bank, Solar resource data: Solargis)

The PV potential in this region varies between 1300kWh/kWp in the south of the zone and 1800 kWh/kWp in the north.

For CSP Technologies, normal direct irradiation (DNI in kWh/m²/y) is an essential criterion for defining the potential of sites. In a standard way, the development of CSP plants is concentrated in areas with a DNI greater than 2000kWh/m²/year (ideally at 2200kWh/m²/y).

Based on Lilliestam et al., 2017.

Figure 53: DNI on the site of the CSP projects put into service between 2009 and 2016 (Source: Irena)

In West Africa, only the northernmost areas meet this criterion, thereby limiting the actual potential of the subregion, especially since these areas are poorly populated and the infrastructure is virtually non-existent.

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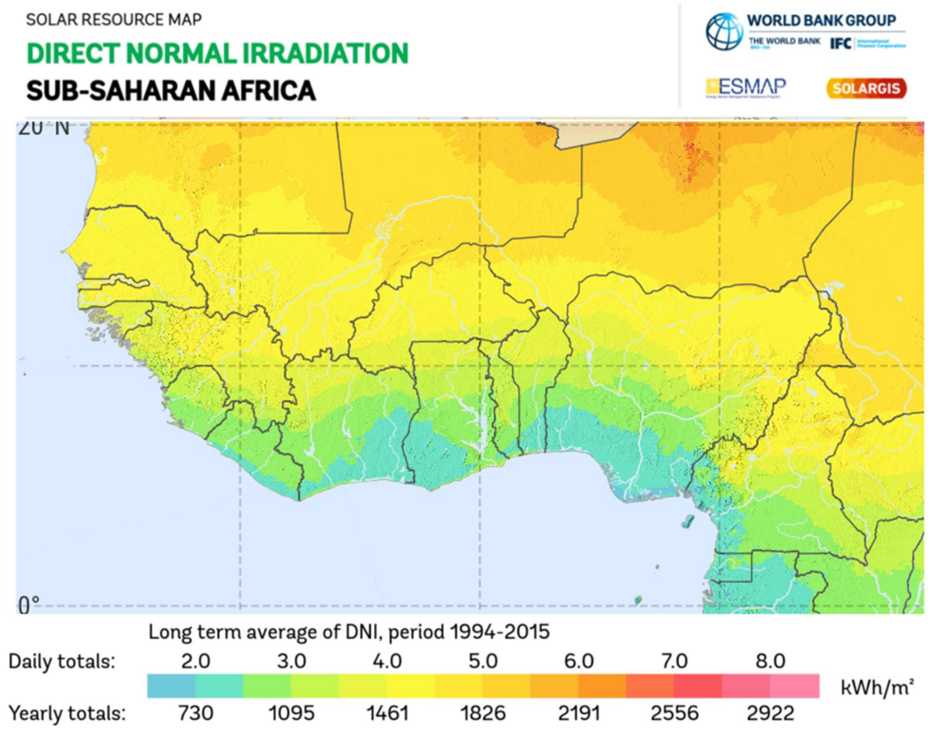

Figure 54: DNI West Africa 1994-2015 (© 2017 The World Bank, Solar resource data: Solargis)

Details of GHI and DNI by country (© 2017 the World Bank, Solar Resource Data: Solargis) is presented in appendix D.

Aeolian Resources

Although wind resources are overall significantly lower than solar resources in West Africa, some areas benefit from strong winds that would allow the deployment of wind energy.

In order to identify these areas, the Consultant used the VORTEX INTERFACE wind mapping software internationally recognized by the wind energy sector. This software allows to model the winds in different parts of the world in order to conduct orientation studies.

The model was used for each of the 14 WAPP countries to identify regions of each country with wind potential. The maps shown in Appendix E take up each of these areas. The table below represents the average producible for the best sites in each country.

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Countries	Average wind speed [m/s]	Producible [MWh/MW/an]
Benin	6.5	3006
Burkina Faso	6.5	2599
Côte d'Ivoire	4.8*	1565
Gambia	6	2588
Ghana	6	2588
Guinea	8	4051
Guinea Bissau	5*	1717
Liberia	Too low * *	
Should	7.2	3531
Niger	8	4051
Nigeria	7.8	3933
Senegal	6	2588
Sierra Leone	Too low * *	
Togo	5.8	2451

Table 46 : Wind potential by country (best identified sites)

* This level of generation is generally too low to motivate an investment in a standard technology

* * Wind development compromised: low wind speeds (between 3 and 3.5 m/s) and presence of dense forests or significant reliefs

Biomass resources

In accordance with the EC 2009 RES directive on the promotion of the use of renewable energy sources, biomass is defined as « *The biodegradable fraction of products, wastes and residues from organic farming (animal and plant substances), forestry and assimilated industries, fishing, crops and municipal and industrial wastes* ».

The use of bio-fuel instead of traditional fossil fuels has two advantages:

- The CO_2 Fossil is replaced by CO_2 Green, giving the possibility of obtaining neutral units from the point of view of CO_2 Issued;
- It also helps to reduce the dependence on fossil fuels.

The main sources of biomass are:

- Agricultural crops and residues;
- Wastewater;
- Industrial residues;
- Livestock residues;
- Municipal solid waste.

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Three types of biomass can be distinguished:

- Solid biomass (waste, wood biomass and solid residues in general);
- Liquid biomass (vegetable oils, bioethanol and biodiesel);
- Gaseous biomass (synthesis gas and biogas).

The main criterion for selecting biomass as a source of energy is the "Sustainable Development". This means that biomass should be considered an ethical source of energy without interference with agricultural and food production. As mentioned above only residues can be used as a source of energy.

Wood residues, agricultural industry residues and energy crops are, for the most part, reliable sources of "durable" biomass that can be used for heating and generating electricity. Prior to any commitment to the use of biomass as a source of energy, in-depth studies on aspects of sustainability must be carried out.

In West Africa, the main agricultural resources are as follows:

Figure 55: Agricultural Resources (Source: World Bank)

Synthesis

In the Report "*Planning and prospects for Renewable Energy*", IRENA has synthesized the renewable potential of all 14 West African countries. This potential is summarized in the table below.

Country	Mini Hydro	CSP	Solar PV	Biomass	Wind 20%*	Wind 30%*
	MW	TWh	TWh	MW	MW	MW
Burkina Faso	140	18.1	77.4	*2 250*	4 742	29
Côte d'Ivoire	242	2.2	103	1 530	491	0
Gambia	12	3.2	4.74	23.75	197	5
Ghana	1	2.3	76.4	1 133	691	9

Country	Mini Hydro MW	CSP TWh	Solar PV TWh	Biomass MW	Wind 20%* MW	Wind 30%* MW
Guinea	332	4.7	52.0	656	2.4	0
Guinea-Bissau	2	9.0	14.9	71	142	0
Liberia	1 000	0.0	6.67	459	0	0
Mali	67	36.2	79.1	*1 031*	2 195	0
Niger	50	88.3	157	*1 115*	16 698	5 015
Nigeria	3 500	100	325	10 000	14 689	363
Senegal	104	15.4	75.2	475	6 226	1 243
Sierra Leone	85	2	15	166	0	0
Togo/Benin	336	0	51.6	957	551	0
TOTAL	5 871	281	1 038	19 867	46 624	6 664

Table 47: Renewable potential of the 14 member countries of the Wapp in terms of energy mix (Source: Irena)

* Load factor of 20% and 30% respectively

In relation to biomass potential, it should be noted that IRENA distinguishes two price categories for this resource: In countries characterized by sufficient agricultural activity to potentially produce biomass, this resource is considered to be affordable. It will therefore be taken into account in the present study. On the contrary, in landlocked countries characterized by low agricultural activity (Mali, Burkina Faso and Niger in particular), the cost of the resource is prohibitive and will not be considered here.

In addition, both for mini-hydro and biomass, the potential is very often dispersed in the territory and destined to the satisfaction of local demand, in a decentralised way. The development of biomass and small hydro potential at the utility scale is therefore excluded and the only projects that will be considered will have a local scope (limited size and potential).

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4.3. Characteristics of generation options

The economic cost of electricity production generally has two main components: the **Investment expenses** (CAPEX) and the **Operating expenses** (OPEX). If thermal power plants based on Internal Combustion Engines result in low CAPEX and high OPEX (fuel cost), the inverse is true for solar power plants. An optimization of the mix of the different means of generation and storage to be installed must therefore take into account these two components.

The purpose of this chapter is to present, for the different technologies, current and future costs of investment and operations taking into account the costs of the plants, the possible cost and availability of fuels and the resources available. In order to be able to establish a plan for the development of generation which is optimal from the economic point of view.

4.3.1. Characteristics and costs of reference thermal power plants

4.3.1.1. THERMAL TECHNOLOGIES AVAILABLE

The different technologies available for the implementation of a thermal power plant with an installed capacity of max. 150-200 MW per generator are as follows:

- Solid Fuel Boilers ;
- Liquid or gaseous fuel boilers ;
- Gas turbines (open cycle or combined cycle) ;
- Internal Combustion Engines.

On the basis of tables presented in Appendix G and comparing the different fossil fuel technologies available, we observe the following elements:

- The number of MW sold in 2016 in the world by technology is comparable for gas engines and turbines 35 GW vs. 46GW and substantially lower for steam turbines (12.5GW) ;
  - For technology **Turbine**, 85% of the power comes from turbines of more than 100 MW operating primarily on Natural Gas. Fifty (50) gas turbines fuelled mainly by natural gas were purchased in Africa in 2016 for a total capacity of about 2 500 MW.
  - For technology **Internal Combustion Engine**, 75% of the power comes from the sale of engines of less than 2 MW running on light fuel (diesel). However, twenty-five (25) engines with a power range of 7.5 MW to 20 MW were purchased in Africa (Central, east and West and South Africa) in 2016 for an approximate total power of 350 MW. A large majority of internal combustion engines with a power greater than 7.5 MW sold in 2016 in Africa (Central, East and West and South Africa) use HFO as a fuel;
  - A very small number of steam turbines were sold in 2016 in Africa. The same observation appears if we take the 2015 database

A comparison of the different technologies is presented in the Table 48:Comparison table of the different fossil fuel technologies available for installations of 45 to 450 MW of electrical production:

	Open Cycle (GT -Heavy Duty Or Aeroderivative)	Combined Cycle (GT + HRDG + ST)	Internal combustion engine	Solid Fuel Boiler	Liquid Fuel Boiler
Planning between NTP and COD	18 months	24 months	22 to 26 months	36 months	36 months
Yield net	30 to 42%	50 to 52%	40 to 43%	36 to 38%	36 to 38%
CAPEX	++	+	+	--	-
Fuel cost	--	--	0	++(*)	0
Availability/Reliability	+	+	++	+	+
Easy to maintain	+	-	+	+	+
Relocation	+	+/-	++	--	--

(*) Only valid for the establishment of the plant along inland waterways

Table 48:Comparison table of the different fossil fuel technologies available for installations of 45 to 450 MW of electrical production

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Comments:

- The combined cycles of power between 300 and 450 MW in the 2-2-1 configuration (2 gas turbines, 2 recovery boilers and one steam turbine) are considered in this study. This 2-2-1 configuration is imposed by the maximum size of the largest generator to be considered. For this power range, the turbines considered are class E (GE 9 E, GE TG11N2, Siemens SGT 5 – 2000 E or Ansaldo ae 94.2).
- Gas turbines in open cycle (without recovery boiler/steam water cycle) are to be considered. Two types of technologies usually distinguish them. Heavy Duty technology and aeroderivative technology. Although with higher yields, aéroderivative technology has not been retained in this study given the higher capex and O&M for this technology.
- Fluidized-bed or Pulverized-Carbon solid-fuel boilers have operating costs per MWh that are usually less important than other technologies considered (low fuel cost). This is only valid if one considers a significant number of hours of operation per year and if the transport of fuel does not strike its cost.
- Liquid or gaseous fuel boilers, in addition to presenting the disadvantages of solid fuel boiler technology (capex, relocation, construction time) has fuel costs comparable to fuel costs Internal combustion engines for lower yields. For these reasons, this technology will not be retained as an alternative to internal combustion engines.

In the case of this study, Combined Cycles, Internal Combustion Engines, solid fuel boilers and to a lesser extent open-cycle gas turbines are to be considered for power between 45 and 450 Mw and for DDO, HFO and Natural Gas fuels. The technical reason for limiting power per generator is related to the maximum power that the network can withstand, following the compensation required for the loss of the largest connected generator. In the first approach, this value is set at 10% of the value of the interconnected network.

4.3.1.2. FUEL CONSIDERED

Fuel availability

In this study, we considered the use of the following fuels:

- Natural Gas
- Heavy Fuel Oil (HFO)
- Light fuel Oil-Diesel (DDO)

The compositions of the fuel impacts performance, frequency of maintenance and emissions of the plants so that it must be taken into account when choosing the origin of the fuels. Appendix G presents a typical composition for all fuels.

4.3.1.3. FEATURES AND COSTS OF NEW TECHNOLOGIES

4.3.1.3.1. Internal Combustion Engine Technology

1) Technology Description

A large majority of ECOWAS countries use diesel-fuelled diesel groups (DDO) or heavy fuel oil (HFO). These groups have powers varying from less than 1 MW to about 20 MW.

The benefits of internal combustion Engines are their relatively low investments costs, the speed of construction and the ease of storage and supply of fuels (HFO/DDO). Their big disadvantages are the high costs of fuel (HFO/DDO), their relatively high specific consumption and costly maintenance.

When optimizing the generation development plan, a series of Internal Combustion Engines will be considered as an investment option. This series is proposed so as to cover a wide range in terms of size as well as technology.

2) Investment data

The table below presents the investment data of the technologies Combustion engines:

Final version

Engines					
		1		2	3
Characteristics of the plant	Unit	DF (gas + heavy fuel oil) Wärtsilä 18V50 DF OPENCYCLE		SG (GAZ) Wärtsilä 18V50 SG Opencycle	SG (GAZ) Wärtsilä 20V34 SG Opencycle
Fuel		HFO	The	The	The
Total Nominal Gross Power Output	MW	**16, 64**	**16, 64**	**18, 38**	**9, 31**
Total Nominal Net Power Output	MW	**16, 01**	**16, 15**	**17, 99**	**9, 15**
Net Electrical Efficiency	%	**39, 58**	**42, 84**	**44, 60**	**43, 39**
Contractor's (EPC) Price	MUSD	**16, 31**		**16, 2**	**7, 4**
Contractor's Price/kW_{net}	USD/kW_{NET}	**1 019**		**903**	**809**
Expected lifetime of the plant	Years	20		20	20
Expected # of running hours	#	6000		6000	6000
Fixed O&M cost	USD/kW/an	**18, 5**			
Variable O&M Cost (fuel excluded)	USD/MWh	**6.5 (Lubricating oil tax included)**			
Fuel		HFO	Gas	HFO	Gas
LHV net heat rate	KJ/kwh	**9 095**	**8 404**	**8 072**	**8 296**
Emission level $C0_2$	kg/MWh	715	476	457	470
Emission level NO_x (without SCR)	mg/Nm ^{3} @ 15% O2	2 000	400	400	400
Planned unavailability (maintenance)	%	7%		7%	7%
Unplanned unavailability (forced outage)	%	10%		10%	10%

Budget offers (Benin Maria GLETA-open cycle, Temp. = 26 °c, RH = 80%)

Source Thermoflow version 26

Table 49: Performance, Costs Investments totals and O&M costs of internal combustion engines

For comparison, some examples of published investment costs for fuel-fired power plants in different African countries are listed below. These values confirm the order of magnitude considered. They also illustrate that costs do not depend solely on unit sizes. The choice of the site impacts for example also the costs in a meaningful way.

Final version

Countries	Config.	Total investment Announced	Year	Investment in €/kW	Source
Madagascar(Mandroseza)	4 x 10 MW	40 M €	2006	1000 €$_{2006}$/kw	http://fr.allafrica.com/stories/200609110840.html
Senegal	2 x 17 MW	41 M $	2016	1168 €$_{2016}$/kw	http://www.ContourGlobal.com/Asset/Cap-des-biches
Senegal	9 x 7,5 MW	67, 5m €	2008	1000 €$_{2008}$/kw	http://www.industcards.com/IC-Gambia-Senegal.html
Liberia	10 x 1 MW	11 M $	2010	864 €$_{2010}$/kw	http://www.industcards.com/IC-Africa-Northwest.htm
Kenya	10 x 8 MW	80 M €	2012	1000 €$_{2012}$/kw	http://www.industcards.com/IC-Kenya-Tanzania.htm
Angola	3 x 2,5 MW	15, 9 M $	2012	1715 €$_{2012}$/kw	http://www.industcards.com/IC-Africa-Southern.htm
Angola	4 x 2,5 MW	19, 7 M $	2012	1474 €$_{2012}$/kw	http://www.industcards.com/IC-Africa-Southern.htm
Uganda	7 x 7,8 MW	66 M €	2008	1209 €$_{2008}$/kw	http://www.industcards.com/IC-Rwanda-Uganda.htm

Table 50: Costs Investments totals of internal combustion engines installed in different African countries

4.3.1.3.2. Gas turbine technology in open cycle or combined cycle

1) Technology DESCRIPTION

Several ECOWAS countries currently have gas turbines (TG) in open cycle (OC) and/or in Combined Cycle (CC) running either Natural Gas (Côte d'Ivoire, Ghana, Nigeria) or liquid fuel (Togo, Ghana, Côte d'ivoire, Senegal...). The majority of these GT in OC and CC are bifuels for burning either gas or liquid fuels. Different manufacturers are represented on the mainland (GE, Siemens, Alstom...) and different sizes of gas turbines Open Cycles are installed from 7.9 MW to 150 MW. Similarly, different Combined Cycles are installed with powers varying from 50 MW (Senegal) to 450 MW (Nigeria).

When optimizing the generation development plan a series of GT In OC and CC so-called standards will be considered as an investment option. This series of GT in OC or CC is proposed so as to cover a wide range as well in terms of size as of technology.

The proposed sizes for combined cycles (CC) are 60 MW, 300 MW and 450 MW. These sizes correspond to the orders of quantities of the standards used in some ECOWAS countries such as Senegal (50MW), Ghana (90MW and 300 MW) and Nigeria or Côte d'ivoire (450 MW). No size greater than 450 MW was proposed for systemic considerations. Indeed, a 450 MW CC has a sizing incident of 225 MW (1 GT and ½ ST) which is therefore due to the size of the West African networks.

The sizes proposed for GT correspond to the GT of the combined cycles proposed: 45 MW, 100 MW and 150 MW.

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In terms of technology, the selection of GT in OC and CC was made in a manner that facilitates maintenance and minimizes investment costs rather than maximizing performance. It would be possible to reach one or two additional points of return but at a very high cost.

For CC, two cooling methods are proposed, cooling by cooler and direct water intake. The direct water intake allows to increase the overall yield by one to two points.

The Consultant used the Thermoflow software® Version 26 to estimate the expected thermodynamic performance of the various power plant configurations as well as the cost of investments of different configurations.

The details of the simulations are given in Appendix F but the main assumptions can be summarised below:

- Ambient temperature of 33 °c
- All GT in OC and CC are bifuels
- All CC's have a by-pass to allow the GT to turn in case of ST unavailability
- Planned and fortuitous unavailability were adapted to local conditions

The fuels modelled in the water flow are on the one hand natural gas and on the other hand the distillate #2. This distillate is used to represent the performance of the diesel or LCO burning plant.

2) Investment data

The table Below presents Technology investment data for gas turbines in open cycle and com

bined cycle.

Final version

Thermoflow® 26 - # Cases – Combined Cycle Gas Turbine

Plant Characteristics	Unit	1		2		3		4		5		6	
		CCGT (300MW) 2 GT + 1 ST		CCGT (300MW) 2 GT + 1 ST		CCGT (450MW) 2 GT + 1 ST		CCGT (450MW) 2 GT + 1 ST		CCGT (60MW) 1 GT + 1 ST		CCGT (60MW) 1 GT + 1 ST	
Cooling method	-	Air Cooled Condenser		Open Cooling		Air Cooled Condenser		Open Cooling		Air Cooled Condenser		Open Cooling	
GT manufacturer + model	-	GE 9E.03		GE 9E.03		Siemens SGT 5 - 2000E (41MAC)		Siemens SGT 5-2000E (41MAC)		Siemens SGT-800		Siemens SGT-800	
		Natural Gas	Distillate # 2	Natural Gas	Distillate # 2	Natural Gas	Distillate # 2	Natural Gas	Distillate # 2	Natural Gas	Distillate # 2	Natural Gas	Distillate # 2
Gross GT Power @ Reference Site Condition	MW	**117**	**113**	**117**	**113**	**153**	**149**	**153**	**149**	**42**	**41**	**42**	**41**
Number of Steam Turbine	#	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Gross ST power @ Reference Site Condition	MW	**118**	**115**	**134**	**128**	**146**	**143**	**166**	**158**	**17**	**16**	**19**	**19**
Total Nominal Gross Power Output	MW	**351**	**345**	**367**	**354**	**452**	**440**	**472**	**456**	**59**	**57**	**62**	**60**
Total Nominal Net Power Output	MW	**344**	**337**	**360**	**347**	**443**	**430**	**464**	**448**	**58**	**56**	**61**	**59**
Net Electrical Efficiency	%	**49,65**	**49,00**	**51,98**	**50,88**	**49,76**	**49,17**	**52,17**	**51,14**	**49,20**	**48,71**	**51,79**	**51,33**
Contractor's (EPC) Price	MUSD	**343**		**312**		**415**		**371**		**88**		**86**	
Contractor's Price/kW net	USD/kW net	**996**		**866**		**937**		**799**		**1 516**		**1 484**	
Expected lifetime of the plant	years	25		25		25		25		25		25	
Expected # of running hours	#	6000		6000		6000		6000		6000		6000	

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Thermoflow® 26 - # Cases – Combined Cycle Gas Turbine													
		1		2		3		4		5		6	
Plant Characteristics	Unit	CCGT (300MW) 2 GT + 1 ST		CCGT (300MW) 2 GT + 1 ST		CCGT (450MW) 2 GT + 1 ST		CCGT (450MW) 2 GT + 1 ST		CCGT (60MW) 1 GT + 1 ST		CCGT (60MW) 1 GT + 1 ST	
Fixed O&M cost	USD/kWnet/year	**6,65**		**6,20**		*6,21*		*5,79*		**39,83**		**37,14**	
Variable O&M Cost (fuel excluded)	USD/MWh	**3,765**		**3,510**		*3,519*		*3,281*		**6,98**		**6,51**	
Fuel		Natural Gas	Distillate # 2	Natural Gas	Distillate # 2	Natural Gas	Distillate # 2	Natural Gas	Distillate # 2	Natural Gas	Distillate # 2	Natural Gas	Distillate # 2
LHV net heat rate	kJ/kWh	**7 251**	**7 348**	**6 926**	**7 075**	**7 234**	**7 322**	**6 901**	**7 039**	**7 316**	**7 391**	**6 952**	**7 014**
Emission level CO_2	kg/MWh	**407**	**543**	**388**	**527**	**404**	**546**	**386**	**525**	**414**	**553**	**393**	**525**
Emission level NO_x (without SCR)	mg/Nm^3 @ 15% O_2	< 30	< 152	< 30	< 152	< 50	< 152	< 50	< 152	< 50	< 152	< 50	< 152
Planned unavailability (maintenance)	%	**8,20%**		**8,20%**		**8,20%**		**8,20%**		**8,20%**		**8,20%**	
Unplanned unavailability (forced outage)	%	**4,40%**		**4,40%**		**4,40%**		**4,40%**		**4,40%**		**4,40%**	
Alternative GT Manufacturer + model	-	GE GT11N2		GE GT 11 N2		Ansaldo AE 94.2		Ansaldo AE 94.2		GE 6B.03		GE 6B.03	

Source Thermoflow version 26 - CAPEX Best Estimate based on Thermoflow Version 26 & Tractebel database (Mauritania SPEG, Ciprel in Côte d'Ivoire, WAPP Maria Gleta, Benin)

Ciprel 340MW Côte d'Ivoire

Offres O&M Mauritanie SPEG SGT-800 (2-2-1)

Extrapolation

Source : VGB POWERTECH, Technical-Scientific Report, Availability of Power Plants 2007 - 2016, Combined cycle units, operation time ≥ 4000 h/a

Table 51: Performance, total investment costs and O&M costs of Combined Cycle power plants

Thermoflow ® 26-# cas – open-cycle gas turbine							
		7		8		9	
Plant Characteristics	Unit	OCGT (45 MW)		OCGT (100 MW)		OCGT (150 MW)	
Cooling method	-	n.a.		n.a.		n.a.	
GT manufacturer + model	-	GE 6B. 03		GE 9e. 03		SGT Siemens 5-2000e (41MAC)	
		Natural gas	Hfo – Residual	Natural gas	Residual heavy fuel oil	Natural gas	Residual heavy fuel oil
Gross GT Power @ Reference Site Condition	MW	**39**	**38**	**117**	**113**	**154**	**149**
Number of Steam Turbine	#	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**
Gross ST power @ Reference Site Condition	MW	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**
Total Nominal Gross Power Output	MW	**39**	**38**	**117**	**113**	**154**	**149**
Total Nominal Net Power Output	MW	**38**	**37**	**116**	**112**	**152**	**147**
Net Electrical Efficiency	%	**31, 83**	**31, 30**	**33, 43**	**32, 89**	**34, 18**	**33, 65**
Contractor's (EPC) Price	MUSD	**34**		**68**		**83**	
Contractor's Price/kW_{net}	USD/kW_{net}	**890**		**606**		**567**	
Expected lifetime of the plant	years	25		25		25	
Expected # of running hours	#	2000		2000		2000	
Fixed O&M cost	USD/kWnet/year	*17,40*		*16,26*		15,20	
Variable O&M Cost (fuel excluded)	USD/MWh	*4,68*		*4,38*		4,09	

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Thermoflow ® 26-# cas – open-cycle gas turbine							
		7		8		9	
Plant Characteristics	Unit	OCGT (45 MW)		OCGT (100 MW)		OCGT (150 MW)	
Fuel		Natural Gas	HFO - Residual	Natural Gas	HFO - Residual	Natural Gas	HFO - Residual
LHV net heat rate	kJ/kWh	**11 310**	**11 503**	**10 768**	**10 945**	**10 532**	**10 698**
Emission level $C0_2$	kg/MWh	**641**	**865**	**603**	**830**	**592**	**816**
Emission level NO_x (without SCR)	mg/Nm³ @ 15% O_2	< 50	< 152	< 50	< 152	< 50	< 152
Planned unavailability (maintenance)	%	**7,50%**		**7,50%**		**7,50%**	
Unplanned unavailability (forced outage)	%	**2,30%**		**2,30%**		**2, 30%**	
Alternative GT Manufacturer + model	-			GE GT 11 N2		Ansaldo AE 94.2	

Source Thermoflow version 26

Reference Power Plant GDF_SUEZ - 2000 hours - 35% fixed O&M cost, 65% variable O&M cost

Extrapolation

Source : VGB POWERTECH, Technical-Scientific Report, Availability of Power Plants 2007 - 2016, Gas turbine units, 2000 h/a ≤ operation time < 4000 h/a

Table 52: Performance, total investment costs and O&M costs of OCGT power plant

Final version

4.3.1.3.3. Coal

1) Technology DESCRIPTION

No major coal-fired power plant is currently operating in West Africa. There are however projects under development (Côte d'Ivoire 2 x 350 MW for example).

When optimizing the generation development plan, a series of so-called standard coal-fired power plants will be considered as an investment option. These coal-fired power plants are proposed to cover a suitable range in terms of size and technology.

The proposed sizes for coal-fired power plants are 125 MW and 250 MW. The 125 MW unit corresponds more or less to the size of the large GT present on the mainland. The 250 MW range has a lower cost to the installed kW and a higher yield. No size greater than 250 MW was proposed for systemic considerations. Indeed, a 250 MW unit creates a 250 MW sizing incident for the interconnected system. For this reason, no 400 MW unit is proposed as an investment option.

"Circulating fluidized bed" (CFLs) and "pulverized coal" (PC) technologies are proposed.

CFL technology can be explained in two stages. In a fluidized bed, the charcoal is burned in a mixed self-suspension of gas and solid materials (limestone) in which the air penetrates from the bottom. In a circulating fluidized bed, the solid materials captured including unconsumed coal are reinjected directly into the combustion chamber. The internal circulation of CFLs allows a longer stay of coal and limestone in the combustion chamber, allowing for better combustion and better capture of sulphides.

The pulverized coal technology will first use coal mills that will dry, grind and spray (< 80 µm) coal. This pulverized charcoal is directly injected with the primary air into the burners at different levels of the boiler.

In terms of technology, the selection of units was made in order to facilitate maintenance and minimize investment costs rather than maximizing performance. It would be possible to reach one or two additional points of return but at a very high cost.

The Consultant used the Thermoflow software to estimate the investments and operating costs of the various configurations. This software simulates the thermodynamic cycle of the plant on the basis of the selected plant components. It tells of the expected net efficiency and therefore of the specific consumption.

The details of the simulations are given in Appendix F But the main assumptions can be summarised below:

- Ambient temperature of 33 °c
- Planned and fortuitous unavailability were adapted to local conditions

2) Investment data

The table Below presents the investment data of coal technologies.

Thermoflow Cases					
		10		11	
Characteristic of the plant	Unit	Coal (125 MW) Type : CFB		Coal (250 MW) Type: PC	
Cooling method		Air Cooled Condenser	Open Cooling	Air Cooled Condenser	Open Cooling
Number of Steam Turbine	#	**1**	**1**	**1**	**1**
Total Nominal Gross Power Output @ RSC	MW	**125**	**125**	**250**	**250**
Total Nominal Net Power Output @ RSC	MW	**114**	**115**	**231**	**233**
Net Electrical Efficiency (LHV)	%	**33,65**	**37,00**	**35,52**	**38,44**
Contractor's (EPC) Price	MUSD	**190**		**378**	
Contractor's Price/kW$_{net}$	USD/kW$_{net}$	**1 652**		**1 622**	
Expected lifetime of the plant	years	35		35	
Expected # of running hours	#	8000		8000	
Fixed O&M cost	USD/kW/year	*31,7*		**27,5**	
Variable O&M Cost (fuel excluded)	USD/MWh	*5,3*		**4,6**	
Fuel		Coal South Africa - Kleinkopje	Coal South Africa - Kleinkopje	Coal South Africa - Kleinkopje	Coal South Africa - Kleinkopje
LHV net heat rate	kJ/kWh	10 699	9 730	10 136	9 364
Emission level CO_2	kg/MWh	1 025	932	971	897
Emission level NO_x (with SCR)	mg/Nm³ @ 15% O_2	as per required (< 200)		as per required (< 200)	
Planned availability (maintenance)	%	**10,50%**		**10,20%**	
Unplanned availability (forced outage)	%	**10,80%**		**9,80%**	

Source Thermoflow version 26

Source : VGB POWERTECH, Technical-Scientific Report, Availability of Power Plants 2007 - 2016, Fossil-fired units, 100 MW ≤ nominal capacity < 200 MW

Source : VGB POWERTECH, Technical-Scientific Report, Availability of Power Plants 2007 - 2016, Fossil-fired units, 200 MW ≤ nominal capacity < 600 MW

CAPEX based on Chinese EPC price + western OEM turbine (Côte d'Ivoire & Tanzania)

O&M best estimate based on O&M offer in African countries (Côte d'Ivoire & Tanzania)

Table 53 Performance, total investment costs and O&M costs of coal power plants

Final version

3) Availability of coal

Some countries such as Ghana or Senegal are considering a future coal supply in their energy mix.

No limitation applies to the quantities of coal available for the African market, the main limitation is the non-existence of delivery and storage infrastructures. So there is a certain cost of entry to allow a coal supply.

4.3.2. Plant characteristics and costs of reference for RES

4.3.2.1. PV SOLAR POWER PLANTS

These latest months, many Solar PV plants have been put into service in the sub-region. Senegal inaugurated two Mékhé and Mérina Dakhar while, at the same time, Burkina Faso inaugurated its first PV plant in Zagtouli. Of a power of 30 MW each, these projects are currently among The biggest in Sub-Saharan Africa.

4.3.2.1.1. Brief Presentation of technology

Photovoltaic (PV) is a power generation system by converting solar radiation directly into electricity through the use of semiconductors. The method uses solar panels composed of many cells containing a photovoltaic material.

Photovoltaic installations must be placed in a sunny environment. The installation must be placed in such a way that the panel is not shaded by its environment. Finally, to exploit the irradiation optimally, the installation must be oriented as far as possible in front of the sun (with monitoring systems or an optimised inclination). For easier mounting of the installation, it is recommended to install it on a flat surface with a low slope (< 5%).

4.3.2.1.2. Investment data

Although Africa currently houses a relatively small number of large-scale solar photovoltaic projects, costs have declined over time. The cost range was between 3400 and 6900 USD/kW in 2012. The costs of installing utility scale solar photovoltaic projects in Africa have then declined by 61% between 2012 and 2015 to reach a global average of 1800 USD/kW in 2015.

The connected and planned PV projects connected to the transmission network between 2014 and 2018 in Africa range from about 1200 to 4900 USD/kW and the project announcements in 2016-2017 that target the commissioning dates in 2018 are aimed at a competitive total installation price range of 1200 to 1900 USD/kW. As a result, an installed cost of 1500 USD/kW is assumed in the summary table here below.

Figure 56: Investment costs for PV projects for commissioning between 2011 and 2018 (Source: IRENA)

Conventional investment data for a photovoltaic facility in West Africa are presented at the Table 54: Solar PV production unit – investment data. The costs considered in this table are 2018 costs.

Characteristics of the plants	Units	Solar PV
Nominal power (local conditions)	MW	10
Average Energy available	GWh	20
Payment schedule	%/an	100% Y0
Investment cost	MUSD	15
Investment cost/KW	USD/kW	1500
Lifetime	an	25
Fixe O&M cost	USD/kW/an	20
Variable O&M cost	USD/MWh	-
Efficiency	%	16%
Planned unavailability (Maintenance)	Could	0.50%
Unplanned unavailability	Could	0.50%

Table 54: Solar PV production unit – investment data

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4.3.2.1.3. Future cost development

With the rapid improvement in the competitiveness of photovoltaic solar energy, the very rapid growth potential of solar photovoltaic in Africa is real.

Indeed, the potential for cost reduction remains important, and with rapid growth in the deployment of Solar PV projects in the subregion, the cost of installing photovoltaic systems at utility scale could fall from about 1500 USD/KW In 2018 to 800 USD/kW in 2025, a 57% reduction in 10 years (IRENA, 2016b).

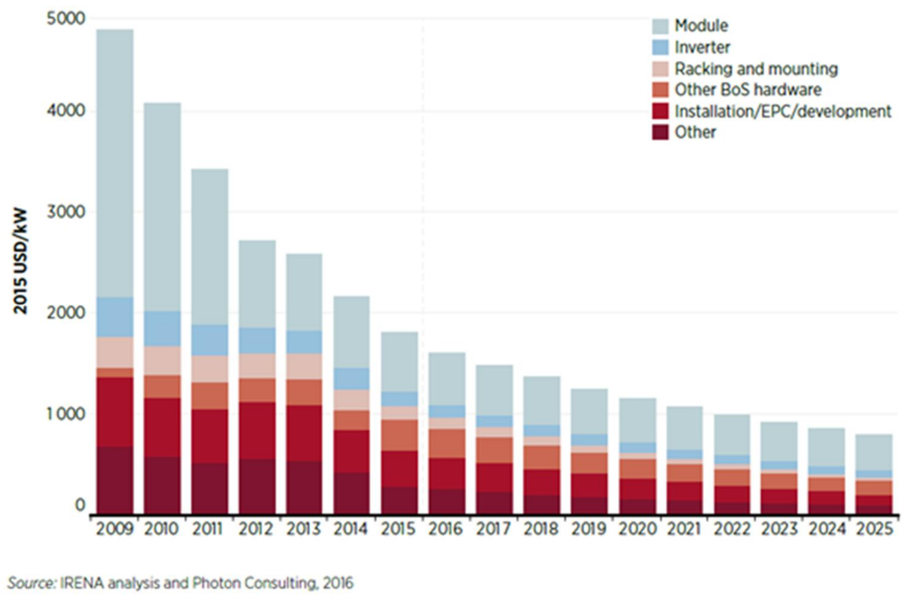


Figure 57: Expected future development of investment costs for PV projects (Source: IRENA)

4.3.2.2. SOLAR POWER PLANTS CSP

The potential for CSP development in Western Africa is quite limited given the average DNI in the sub-region. Nevertheless, it cannot be completely excluded and therefore the next paragraphs are intended to present this technology.

4.3.2.2.1. Brief Presentation of technology

A solar thermal or concentrated solar power plant (CSP) is essentially a conventional power plant using solar energy as a primary source of heat (with a back-up fossil fuel) in the boiler to convert water to steam to power a conventional steam turbine (Rankine cycle).

In order to reach the necessary temperature level in the power supply, a concentration of the solar rays is necessary. In the absence of sunshine, power generation can be maintained using a conventional fossil fuel.

However, the exclusive use of solar energy without any fuel input is also possible with units of cylindrical-parabolic solar mirrors.

With the increase in fuel prices, the installation of thermal energy storage systems is an attractive substitute for back-up fossil fuels. The cylindrical-parabolic or solar farm collection system consists of long rows of identical concentration modules placed in parallel. These modules are typically composed of trough-shaped glass mirrors following the sun from east to west by rotating on an axis and whose collector concentrates the solar radiation directly on an absorbing pipe located along its focal line. A heat transfer fluid, typically oil is distributed through the pipes at temperatures up to 400 °c. The hot oil converts the water into steam to power a steam turbine.

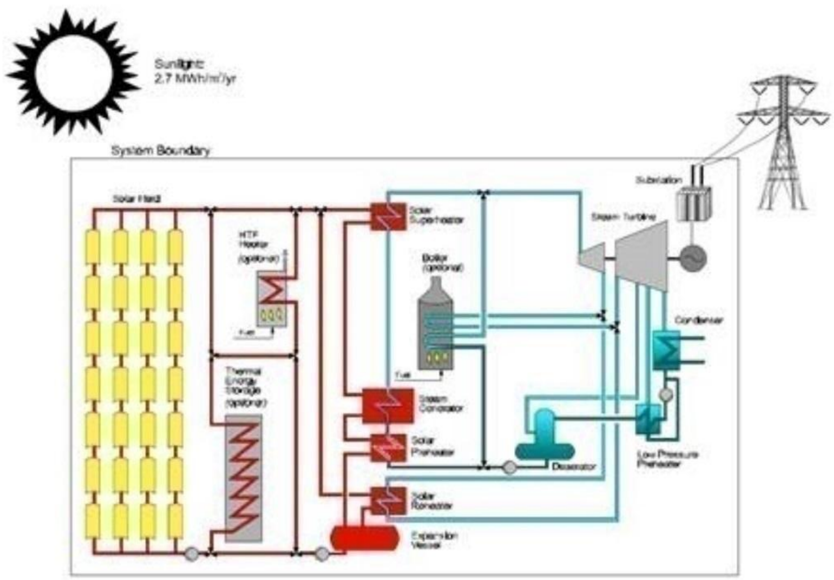


Figure 58: Operating diagram of a concentrated solar power plant with thermal storage

4.3.2.2.2. Investment data

The total installation costs for CSP plants that include thermal energy storage tend to be higher than those that do not include it, but storage also allows for higher capacity factors.

For example, for cylindrical-parabolic systems (technology with the largest share of projects installed so far), the total costs of the installed installation can range from 2550 USD to 11 265 USD/kW for systems without storage. However, by adding four to eight hours of storage, this range can be between 6050 USD and 13 150 USD/kW (Source: Renewable cost database for the period 1984-2016 IRENA).

Final version

Figure 59: Evolution of the cost of CSP technologies (Source: IRENA)

Given the most recent costs and technologies, for the summary table below, an installation cost of 7000 USD/KW and a storage time of 4 hours are assumed. Other storage times up to 8h will nevertheless also be considered as generation options if relevant.

Using ANDASOL3 as a typical unit (50 MW with 7.5 h of storage in Spain), we obtain the following data for a DNI of 2400 kWh/m2/A and a latitude of 20 ° north.

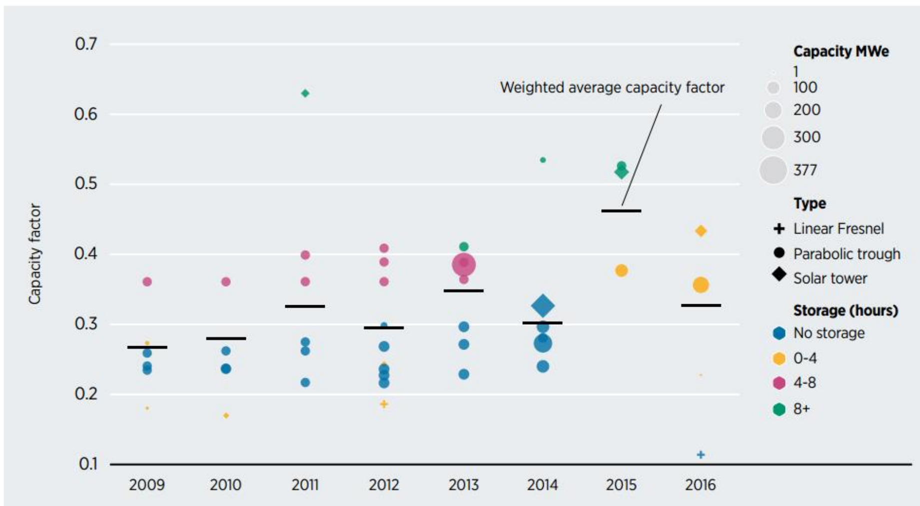
Characteristics of the plants	Units	Solar Thermal (CSP)
Nominal power (local conditions)	MW	50
Average Energy available	GWh	140
Terms of payment	%/an	70% Y0-1 30% Y0
Investment cost	MUSD	400
Investment cost/KW	USD/kW	8000
Lifetime	an	25
Fixe Operating and maintenance cost	USD/kW/an	
Variable Operating and Maintenance cost	USD/MWh	30 to 40
Efficiency	%	17%
Planned unavailability (Maintenance)	Could	2%
Unplanned unavailability	Could	-
Features		

Final version

Characteristics of the plants	Units	Solar Thermal (CSP)
-Storage	h	4
-Days	kWh/m²/y	2400
-Number of loops	-	152
-Surface of Mirrors	m²	497000

Table 55: Solar production unit CSP – investment data

The table above also takes into account the evolution of the capacity factor over time. This evolution of the capacity factor is only partly explained by the choice of sites with greater irradiation, while the remainder of the increase is induced by changes to new technologies and greater storage capacities.



Source: IRENA Renewable Cost Database.

Figure 60: Evolution of the CSP Technology capacity factor (source: IRENA)

4.3.2.2.3. Future cost development

The total average cost of electricity generation (LCOE) of CSP plants remained relatively stable between 2009 and 2012. A downward trend in LCOE began in 2012. Indeed, in 2013 and 2014, the LCOE estimates averaged about one-fifth lower than the 2009-2012 period. However, higher levels of direct normal irradiation (DNI) were probably the main factor causing lower costs during this period. Thus, learning effects and technological improvements have not yet been the main driver of cost reduction, leaving significant cost-reduction potentials, as has already been pointed out (IRENA, 2016).

Recent announcements and analysis of planned projects seem to predict a sharp downward trend from 2017 onwards. Indeed, recently, very low bids for CSP projects have been announced. Although these tenders must be taken with caution as they concern commissioning in the vicinity of 2022 and because they are positioned in a competitive environment (and therefore can deviate significantly from the LCOE), they announce however a downward trend for this technology.

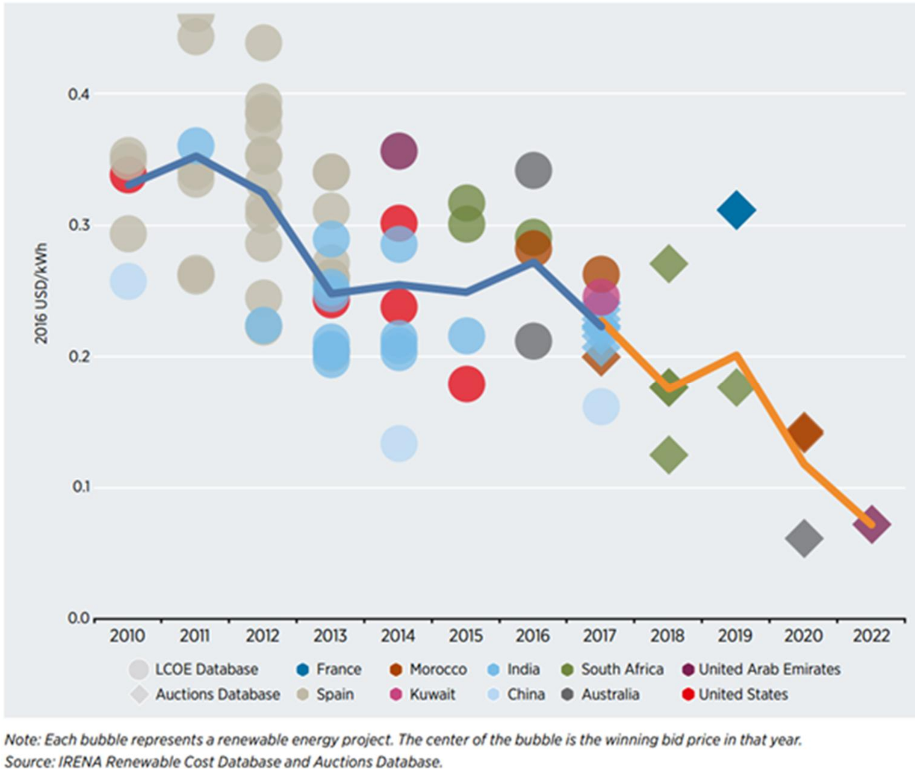


Figure 61: Evolution of the LCOE of CSP Technologies (Source: IRENA)

4.3.2.3. WIND ENERGY

4.3.2.3.1. Brief Presentation of technology

As part of this study, wind technologies allowing the development of industrial-scale projects are taken into account (several dozen MW site). In any case, the cut-in speed of a large-scale wind turbine (> 2 MW) is about 3 m/s. Below this speed, it does not produce (on the contrary it consumes).

Small wind turbines allow to operate at significantly lower wind speeds but these technologies are financially less attractive and are generally sized for rural electrification.

4.3.2.3.2. Investment data

Over the past 30 years, wind technologies have experienced a sharp decrease in average installation costs, from 3000 USD/kW in 1989 to around 1600 USD/kW today. However, there is a wide variety of installation costs, depending on the size of the sites and the technologies used.

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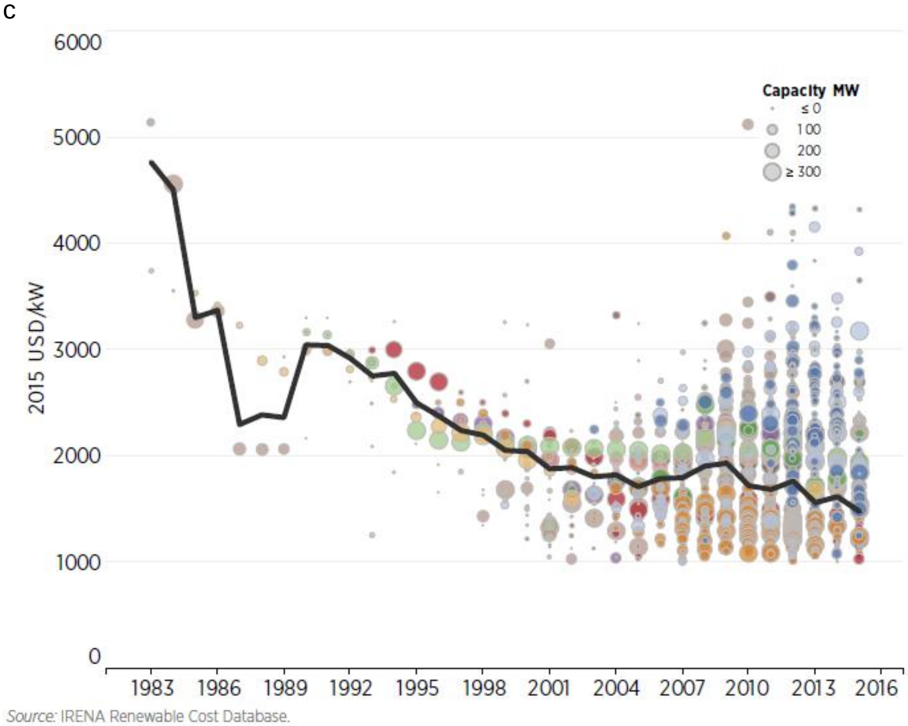

Figure 62: Investment costs for projects Wind For commissioning between 1983 and 2015 (Source: IRENA)

Given these figures, the current cost trend is shown in the table below. The installation prices include not only the price of the machine, but also the civil and electrical works.

Characteristics of the plants	Units	by wind
Nominal power (local conditions)	MW	100MMW (28*3.6 MW)
Average Energy available	GWh	200
Terms of payment	%/an	70% Y0-1 30% Y0
Investment cost	MUSD	162
Investment cost/KW	USD/kW	1620
Lifetime	an	25
Fixe Operating and maintenance cost	USD/kW/an	13
Variable Operating and Maintenance cost	USD/MWh	7
Planned unavailability (Maintenance)	Could	1%
Unplanned unavailability	Could	4%

Table 56: Wind turbines-investment data

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4.3.2.3.3. Future cost development

In the future, the price will be pushed down by technological advances at the level of towers, blades and generators. The less windy sites will benefit from the evolution to larger rotors and towers to achieve higher capacity factors.

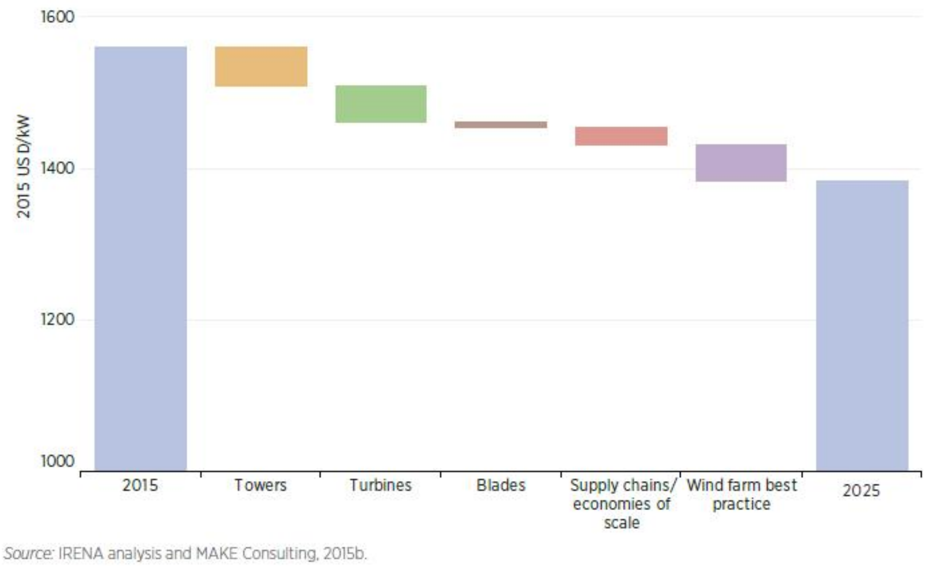

Figure 63: Expected future development of investment costs for projects Wind (Source: IRENA)

Africa will benefit from a market increase which will also reduce costs. According to IRENA, the installation cost is projected to decrease by about 1.27% annually by 2025 (excluding inflation). This reduction could even be higher than the average for Africa. Therefore, the following forecasts are considered to be relatively conservative.

4.3.2.4. BIOMASS RESOURCES

In order to provide a general overview of the impact of a biomass plant, the characteristic parameters of the following three plant sizes are presented Below: *Medium Unit-40 MW* and *Small units-5 & 20 MW.*

The investment data is based on pure biomass combustion technologies. In addition to this technology, there are several other methods of biomass combustion. These technologies are exposed briefly to provide a general overview of the different energy production possibilities offered by this fuel.

Combustion of Pure Biomass

Different combustion technologies where the biomass is directly introduced in the boiler are available depending of the biomass particle size.

Three main biomass firing technologies:

- Pulverized fuel boilers (PF): applicable for large scale power plants up to 200 MWe
- Circulating Fluidizing Bed boilers (CFB): applicable for a plant's installed power range of 20-200 MWe

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- Grate Furnace (GF): applicable for small scale power plants up to 20 MWe.

These technologies can be used for co-combustion processes too.

In order to assure a complete combustion of the biomass and to limit the presence of unburned particles in the ashes, in case of PF boilers, the milling of the wood biomass is necessary. Hammer mills are used to get a particle size of 100% smaller than 1.5 mm and of 80% smaller than 1 mm. These particle sizes are suitable for pulverized fuel boilers.

CFB boilers are more flexible than the pulverized fuel boilers. CFB boilers suspend solid fuels on upward-blowing jets of air during the combustion process. The result is a turbulent mixing of gas and solids. The tumbling action, much like a bubbling fluid, provides more effective chemical reactions and heat transfer.

CFB boilers are characterized by higher efficiencies and availability, combined with low emission values.

Co-combustion with Direct Injection

Co-combustion consists of burning a mixture of fossil fuel and biomass. In most cases co- firing identifies the combustion of wood biomass with coal. The advantages of this technology are that the coal consumption cost and the SOx, NOx, particulates, and other emissions of pollutants are reduced. Direct co-firing consists of feeding the boiler directly with the biomass-coal mixture after a pre-treatment process (cleaning, drying, milling...).

Indirect firing and gasification

In the indirect firing the biomass passes through a gasification process before being burned. The obtained syngas can be burned in a furnace or it can be used to fuel modified gas engines. The syngas is obtained via a partial oxidation of the biomass. The main advantages of this process are the feedstock flexibility (even low quality biomass as waste can be gasified). The produced gas has a LHV of around 4 MJ/Nm^3. It can be used as an alternative fuel in existing power plants.

Parallel Combustion

A new biomass fired unit that produces steam can be coupled to existing fossil fuelled facilities.

Combined heat and power generation (CHP)

CHP consists of the simultaneous production of heat and electricity.

In conventional solid biomass fuelled electricity generation units around 37% of the energy potential contained in the fuel is converted on average into electricity, whilst the rest is lost as waste heat. Even the most advanced technologies do not convert more than 55% of fuel into useful energy. CHP plants produce both electricity and heat and therefore can achieve an efficiency of up to 90%, giving energy savings between 15-40% when compared with the separate production of electricity from conventional power stations and of heat from boilers. It is the most efficient way to use fuel.

The heat produced by cogeneration can be delivered through various mediums, including hot water (e.g., for space heating and hot water systems), steam or hot air (e.g., for industrial uses).

Tri-generation

In warmer climates the need for heating is limited to a few winter months. There is, however, significant need for among other in “cooling houses” during the whole year. Tri-generation is the simultaneous production of electrical power, heat and cooling. Biomass can be used as fuel. Heat produced in CHP plants is, in this case, used to produce cooling via absorption cycles.

Characteristics of plants	Units	Biomass Plant (20MWe)	Biomass Plant (40MWe)	Biomass Plant (5MWe)
Manufacturer + Model	-	Grate Furnace	CFB boiler / Grate Furnace	Grate Furnace
Number of ST	-	1	1	1
Brutto Power ST (local conditions)	MW	20	40	5
Total Nominal Power (brutto)	MW	20	40	5
Investment Cost (note 1)	MUSD	37 à 50	60 à 90	10 à 15
Investment Cost / kW (note 1)	USD/kW	1750 à 2500 à 2500	1500 à 2250	2000 à 3000
Lifetime	an	25	25	25
O&M Cost – fixed	USD/kW/an	204	136	272
O&M Cost – variable	USD/MWh	included	included	inclued
Fuel 1		Wood shavings / agricultural waste	Wood shavings / agricultural waste	Wood shavings / agricultural waste
Specific Consumption - Fuel 1	kJ/kWh	9600	9600	15000
Emission CO2	mg/Nm3	0	0	0
Emission S02 (for distillats)	mg/Nm3	-	-	-
Emission NOx without SCR (on yearly basis)	mg/Nm3	250	250	250
Emission NOx with SCR	mg/Nm3	125	125	125
Planned Unavailability (maintenance)	pu	0.07	0.07	0.07
Unplanned Unavailability	pu	0.1	0.1	0.1
Specificitities				
- Average Available Energy	GWh	150	300	37
- Netto Energy Efficiency	%	24	27	20
- Average LHV	GJ/t	12	12	12
- Consommation de biomasse	t/an	190000	331 000	56 000

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Characteristics of plants	Units	Biomass Plant (20MWe)	Biomass Plant (40MWe)	Biomass Plant (5MWe)
- Prix du combustible sans transport	USD/GJ	<2	<2	<2
- Prix du combustible avec transport (500km)	USD/GJ	2 à 3.5	2 à 3.5	2 à 3.5

Table 57 : Biomass Plant – Investment data

Note 1 : orders of magnitude of CAPEX investments strongly dependent on technologies and equipment sources. Estimated prices with technologies and equipment produced in Asia

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4.3.2.5. NUCLEAR ENERGY

The option of developing nuclear power plants has not been considered as a credible alternative for power supply in the West Africa region for the following reasons

- The region's important energy resources in hydropower, gas and renewables are largely sufficient to meet the needs of the region by providing a sufficiently diversified and affordable energy mix;
- The discounted electricity cost (LCOE) of nuclear power plants is over $ 105 / MWh, which is 40% more expensive than the gas option (combined cycle) and almost double of solar option in the medium term;
- The unit size of the nuclear power plants (more than 1000MW per unit) would lead to severe operating constraints for low-meshed electrical systems such as those in West Africa and additional costs in terms of strengthening the electrical system.
- The development of nuclear power can only be envisaged in the long term, beyond the horizon of the study, because it requires the establishment of specific expertise, competent supervisory authorities, the achievement of more advanced and longer feasibility and impact studies than those required for other types of production.

4.3.3. Synthesis of supply analysis - Levelized Cost Of Energy

The choice for generation technologies is partly driven from their underlying costs. These costs typically cover investment costs, operation and maintenance costs (fixed and variable), and fuel costs. A suitable metric to compare these costs amongst generation technologies is the Levelized Costs Of Energy (LCOE).This metric is used to assess the competitiveness of generation technologies and expresses all cost components in USD per MWh. Moreover, it takes into account the lifetime and utilization rate of the technologies. Note however that while an LCOE assessment provides a valuable first insight, a complete assessment requires a more detailed economic model as it will be developed in the generation master plan.

Based on the technology assumptions as discussed above in this section, the LCOE values for the different future technology options are listed in Figure 64. Distinction is made between the LCOE values in 2017 (left bars) and 2030 (right bars). Note that the values are based on a 10% discount rate and an 80% utilization rate (baseload) for thermal units. LCOE values are shown under the baseline fuel costs projections.

The figure shows that the big hydroelectric plants are among the plants having the lowest LCOE. Note however that the picture presents an average value for a big dam but that each project should be considered individually as they all have different investment costs and producible.

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Regarding thermal plants, it is interesting to note that, with the current fuel prices considered, combined cycles firing Natural Gas are characterized by a LCOE slightly lower than the coal plants but the trend is inverted in 2030 due to the expected decrease of coal price. However, it is important to mention that the LCOE do not take into account the cost of CO2 emissions nor the technical constraints inherent in steam turbine technology (limited flexibility) which are two obstacles to the future development of coal. All other thermal units show significantly higher levelized costs.

Towards 2030 the LCOE values are expected to change driven by the changing fuel cost and the decreasing CAPEX costs for renewable energy sources. The solar PV LCOE is expected to drop significantly towards 2030. This brings solar PV down in the merit order below every thermal power plant. Note however that LCOE for solar plants are very dependant on local irradiation conditions. Therefore the selection of the site will need to be done carefully.

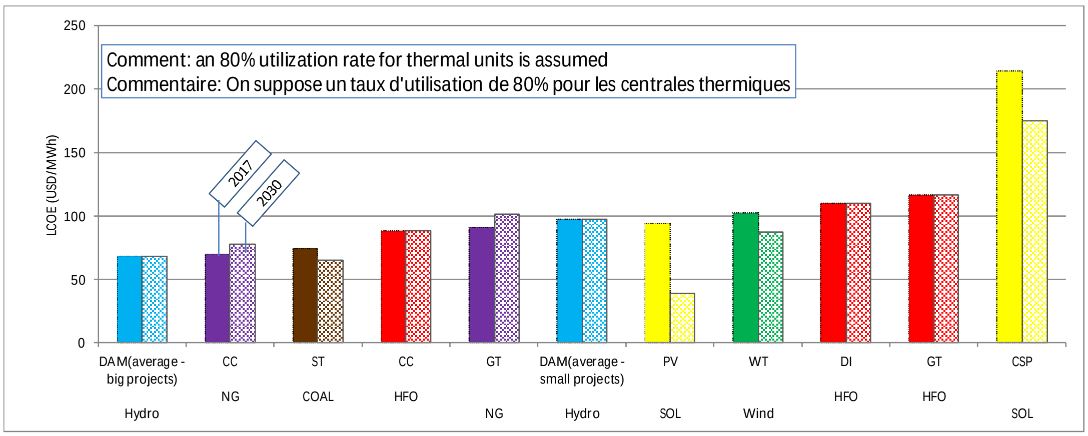

Figure 64: Levelized costs of energy for different generation technologies and fuels assuming baseload operation for thermal units.

While the above figure assumed that the thermal units could be operated as baseload units (80% utilization rate), the technology LCOE-values will change in case the units are operated as mid-peak or peaking plants. This is illustrated in Figure 65, assuming a 35% utilization rate. The figure shows that the change in utilization rate largely changes the LCOE order as gas turbines now becomes cheaper than steam power plants. This is due to the capital intensity of the latter plants compared to turbines. Note that the LCOEs of renewable technologies are omitted from this figure as comparison with part-loaded thermal units is not enriching.

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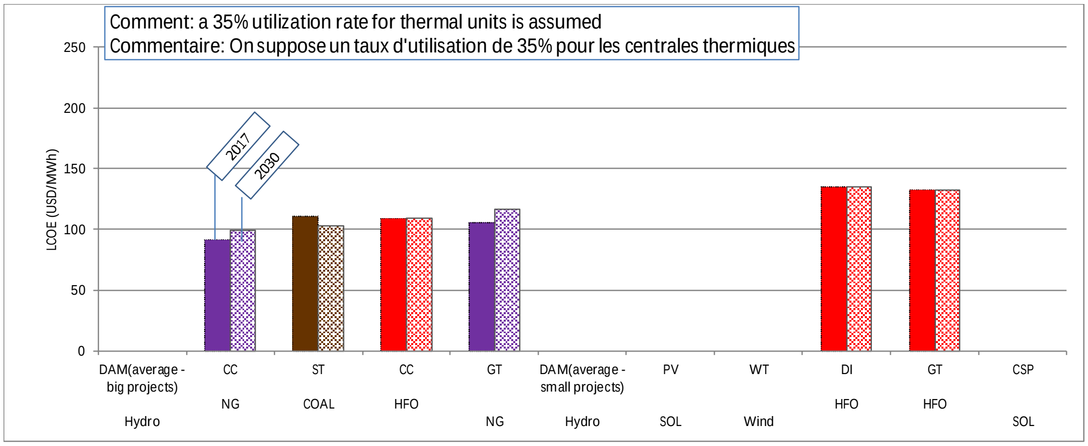

Figure 65: Levelized costs of energy for different generation technologies and fuels assuming mid-peak operation for thermal units.

4.4. Identification of storage options

Considering the expected development of renewable energies in West Africa and the constraints related to this development (flexibility requirements, operational limits), the development of storage capacity in the sub-region cannot be excluded from the scope of this study.

Given the specificities of the subregion, hydroelectric storage has great potential and complementarity between solar and hydro resources is essential for the development of affordable, reliable, sustainable and modern energy for all. In addition, thermal storage opportunities coupled with concentrated solar power plants can not be ruled out. Finally, and given the current technological advances, storage by industrial batteries appears as a feasible and potentially competitive solution for the installation of large-scale storage in the networks, especially for countries without major hydroelectric resources.

Nevertheless, in view of the objectives of the study and the time horizon considered, we will focus on the role that batteries can play to offset the intermittency of renewable energy sources in general, and solar photovoltaic plants in particular , de facto excluding the development of storage solutions for operational constraints.

Different battery models are present on the market and their investment costs (2014 data) are shown in Figure 66. EOS Aurora batteries are currently emerging as the most competitive solution. Indeed the EOS Aurora differs from other batteries by the use of air as an essential element of its cathode. Thanks to this and to the use of zinc as the first component of its anode, the design of batteries that are both inexpensive and environmentally friendly is possible, while maintaining an overall efficiency (over a charge-discharge cycle) of 75%. Nevertheless, there is still very little feedback on the actual performance of this type of battery and basing the development of an optimal action plan on these assumptions for storage could be risky.

The development of the optimal action plan will therefore be based on the cost and performance characteristics of the second most economical type of battery, which have also benefited from a sharp reduction in costs in recent years: Li-ion batteries, technology benefiting from sufficient feedback. According to BNEF, these batteries currently have an installation cost of less than 300 $/ kWh.

It should be noted that this does not bind the optimal action plan to a particular commercial technology, but that it can be based on a realistic set of assumptions. In practice, calls for tenders for the development of installations will allow the selection of the most competitive batteries for a given capacity and possibly to accelerate the storage implementation if the anticipated rapid technological evolution is materialized in fact.

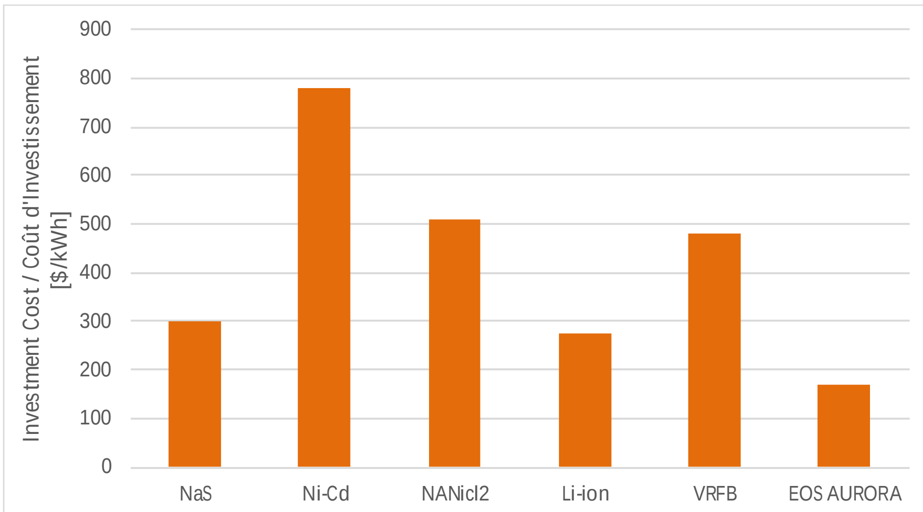

Figure 66: Investment costs for different technologies of batteries[5]

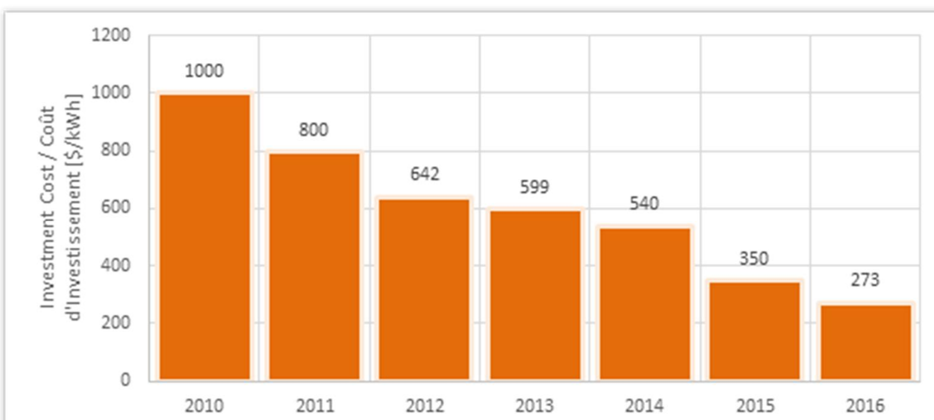

Figure 67: Evolution of LI-ion technologies investment costs between 2010 and 2016 (source : BNEF)

[5] Source: Behnam Zakeri, Sanna Syri. “Electrical Energy Storage Systems: A comparative life cycle cost Analysis.” In: Elsevier Journal (2014) , EOS ENERGY STORAGE© , BNEF and Lazard

The different characteristics of the Tesla PowerPack (example of LI-ion battery) are summarized in Table 58.

Characteristics	Tesla PowerPack
Installed Capacity	1 MW
Energy	4 MWh
Output Voltage	380-480 Vca, triphased
Energy for one cycle	8280 kWh/cycle
Global efficiency of the battery	>90% à 25°C
Lifetime	5000 cycles or abut 15 years
Operating Temperature	-20 to 50°C
Fixed O&M costs	0.05% of the investment cost

Table 58: Characteristics of the Tesla PowerPack (Source: TESLA)

Given that the expected main justification for storage is to compensate for the variability of renewable resources (mainly solar), it is considered that the storage units could be connected with the photovoltaic solar panels on the same DC circuit and connected to the grid with the help of inverters of nominal power equal to the peak demand of the system and not the sum of this peak demand and the storage capacity. On the other hand, low-cost rectifiers will be needed to ensure, where necessary, storage from existing thermal units, the capacity of which must be the minimum of thermal capacity and storage.

The cost assumptions used for storage in the development of the optimal development plan are therefore as follows:

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- **Investment cost**: the investment cost used for the LI-ion battery is $ 273 / kWh - 179,000 FCFA / kWh. A devrease in investment costs will be considered based on the assumptions presented by IRENA in its report Electricity Storage cost and market up to 2030 (2017). In this report, a decrease in the total installation cost between 54% and 61% by 2030 is estimated (57.5% considered here). It should be noted that these values assume that the batteries will use the inverters already installed for the use of solar power plants. A sensitivity study will evaluate the impact of the chosen decay model.

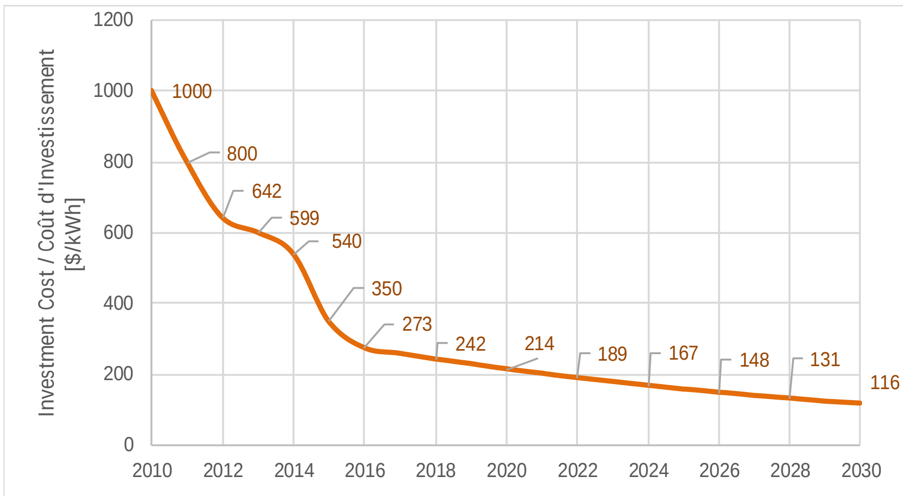

Figure 68: decay model of investment costs of TESLA batteries $/kWh

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5. TRANSMISSION ANALYSIS

5.1. Current situation of the infrastructure per country

This section presents the existing network for the different countries, including transmission lines, transformers and the shunt reactive power compensation devices (capacitive and inductive). The collected data were synthesized in tables per country. Symbol N/A (*not available)* replaces the missing data. These values should be validated and N/A values should be filled by the concerned countries.

In this section, the sign convention which is used for reactive power compensation devices is the following: Reactors are represented by a negative value while capacitors are represented by a positive value. In addition, the type of compensation device is presented, in terms of fixed shunt (*fixed*), switchable shunt (*switch*) or Static Var Compensator (*SVC*). If present, series compensation is highlighted as well.

In the following tables, it is also specified if transformers are equipped with on-load tap changer (OLTC).

5.1.1. Benin

The current electrical network of Benin is shown on the following tables (lines, transformers, shunt reactive compensation).

Only transmission lines with operating voltage equal or higher than 90 kV are considered. The system has 13 transmission lines (10 single circuits and 3 double circuits), 11 transformers and 1 shunt reactive compensation devices[6].

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Maria Gleta 2_161	Avakpa_161	161	N/A	128	1.940	6.240	1.350
Sakete_161	Cotonou_161	161	N/A	178	2.750	8.450	1.980
Sakete_161	Cotonou_161	161	N/A	178	2.750	8.450	1.980
Bohicon_161	Onigbolo_161	161	N/A	178	4.290	13.220	2.830
Djougou_161	Parakou_161	161	N/A	178	6.670	20.310	9.600
Maria Gleta 2_161	Cotonou_161	161	N/A	128	0.560	1.710	0.810
Parakou_161	Bembereke_161	161	N/A	178	4.900	15.100	3.500
Djougou_161	Natitingou_161	161	N/A	178	4.200	12.800	3.000
Onigbolo_161	Sakete_161	161	N/A	178	2.310	7.090	1.660

[6] This one capacitor in Benin is modelled as two capacitors (1 step of 7.2 MVAr and 25 steps of 0.4 MVAr)

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Maria Gleta 2_161	Cotonou_161	161	N/A	128	0.560	1.710	0.810
Tanzoun_161	Sakete_161	161	28	178	1.740	4.537	0.109
Tanzoun_161	Sakete_161	161	28	178	1.740	4.537	0.109
Maria Gleta 1_161	Maria Gleta 2_161	161	5	128	0.300	0.822	0.215
Maria Gleta 1_161	Maria Gleta 2_161	161	5	128	0.300	0.822	0.215

Table 59: Existing transmission lines (Nominal voltage higher than or equal to 90 kV) - Benin

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Cotonou_161	Akpakpa_15	37.5	No
Cotonou_161	Porto-Novo_15	15.0	No
Cotonou_161	Gbegamey Aggreko_15	37.5	No
Cotonou_161	Vedoko_15	15.0	No
Maria Gleta 2_161	Aggreko Maria Gleta_15.8	100.0	No
Maria Gleta 2_161	Maria Gleta TAG CEB_15.8	50.0	No
Maria Gleta 2_161	TB TAG BID_15.8	100.0	No
Natitingou_161	Natitingou SBEE Diesel_15	20.0	No
Parakou_161	Parakou Thermal_15	60.0	No
Sakete_161	Sakete_330	200.0	No
Sakete_161	Sakete_330	200.0	No

Table 60: Existing 2W transformers – Benin

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Parakou_161	-7.2	1	Switch
Parakou_161	-0.4	25	Switch

Table 61: Existing reactive power compensation - Benin

5.1.2. Burkina Faso

The current electrical network of Burkina Faso is shown on the following tables (lines, transformers, shunt reactive compensation).

Only transmission lines with operating voltage equal or higher than 90 kV are considered. The system has 12 transmission lines (11 single circuits and 1 double circuits), 64 transformers and 22 shunt reactive compensation devices.

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Pa_225	Kodeni_225	225	N/A	327	1.701	10.509	9.458
Pa_225	Zagtouli_225	225	N/A	327	2.588	15.995	14.466
Bagre_132	Zano_132	132	N/A	110	3.030	7.438	0.766
Kompienga_132	Zano_132	132	N/A	110	13.258	32.541	3.365
Zano_132	Patte D'Oie_132	132	N/A	110	13.545	33.242	3.447
Ouaga 1_90	Ouaga 2_90	90	N/A	75	0.272	0.728	1.386
Ouaga 1_90	Ouaga 1_90	90	N/A	75	0.210	0.568	1.081
Ouaga 1_90	Kossodo_90	90	N/A	75	0.741	2.173	0.051
Zagtouli_90	Ouaga 2_90	90	N/A	72	2.667	7.802	0.180
Zagtouli_90	Ouaga 2_90	90	N/A	72	2.667	7.802	0.180
Pa_90	Wona_90	90	N/A	72	2.644	7.735	0.178
Komsilga_90	Patte D'Oie_90	90	25	65	4.567	12.522	0.280
Komsilga_90	Zagtouli_90	90	12	65	2.162	5.929	0.133

Table 62: Existing transmission lines (Nominal voltage higher than or equal to 90 kV) – Burkina Faso

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Bagre_132	Bagre G1_6.6	10.0	No
Bagre_132	Bagre G1_6.6	10.0	No
Bobo 1_33	Bobo 1_15	10.0	Yes
Bobo 1_33	Bobo 1_15	10.0	Yes
Bobo 2_15	BOBO II G1_5.5	6.9	No
Bobo 2_15	BOBO II G2_5.5	6.9	No
Bobo 2_33	Bobo 2_15	10.0	Yes
Bobo 2_33	Bobo 2_15	10.0	Yes
Bobo 2_33	BOBO II G3_5.5	6.9	No
Bobo 2_33	BOBO II G4_5.5	6.9	No
Bobo 2_33	BOBO II G5_5.5	6.9	No
BOBO II G6_11	Bobo 2_33	25.0	No
BOBO II G7_11	Bobo 2_33	25.0	No
BOBO II G8_11	Bobo 2_33	25.0	No

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
BOBO II G9_11	Bobo 2_33	25.0	No
Kodeni_225	Kodeni_33	40.0	No
Kodeni_225	Kodeni_33	40.0	No
Kompienga_132	Fada Extension _6.6	10.0	No
Kompienga_132	Kompienga G1_6.6	10.0	No
Kompienga_132	Kompienga G1_6.6	10.0	No
Komsilga G1_11	Komsilga_33	25.0	No
Komsilga G2_11	Komsilga_33	25.0	No
Komsilga G3_11	Komsilga_33	25.0	No
Komsilga G4_11	Komsilga_33	25.0	No
Komsilga G5_11	Komsilga_33	25.0	No
Komsilga G6_11	Komsilga_33	25.0	No
Komsilga G7_11	Komsilga_33	25.0	No
Komsilga_90	Komsilga_33	40.0	No
Komsilga_90	Komsilga_33	40.0	No
Kossodo G7_11	Kossodo_33	10.0	No
Kossodo G8_11	Kossodo_33	10.0	No
Kossodo_33	Kossodo_15	15.0	No
Kossodo_33	Kossodo_15	15.0	No
Kossodo_33	Kossodo G1_11	5.0	No
Kossodo_33	Kossodo G2_11	10.0	No
Kossodo_33	Kossodo G3_11	10.0	No
Kossodo_33	Kossodo G4_11	12.0	No
Kossodo_33	Kossodo G5_11	12.0	No
Kossodo_33	Kossodo G6_11	25.0	No
Kossodo_90	Kossodo_33	40.0	No
Kossodo_90	Kossodo_15	40.0	No
Niofila G1_0.4	Bobo 2_33	4.0	No
Ouaga 1_15	Ouaga 1 G1_6.3	4.0	No
Ouaga 1_15	Ouaga 1 G2_6.3	4.0	No

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Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Ouaga 1_33	Ouaga 1_15	15.0	No
Ouaga 1_33	Ouaga 1_15	15.0	No
Ouaga 1_90	Ouaga 1_15	40.0	No
Ouaga 2 G6_15	Ouaga 2 G1_5.5	6.6	No
Ouaga 2 G6_15	Ouaga 2 G2_5.5	6.6	No
Ouaga 2 G6_15	Ouaga 2 G3_5.5	6.6	No
Ouaga 2 G6_15	Ouaga 2 G4_5.5	10.0	No
Ouaga 2 G6_15	Ouaga 2 G5_5.5	10.0	No
Ouaga 2_33	Ouaga 2 G6_15	15.0	No
Ouaga 2_33	Ouaga 2 G6_15	15.0	No
Ouaga 2_90	Ouaga 2 G6_15	40.0	Yes
Pa_225	Pa_90	40.0	No
Patte D'Oie_132	Patte D'Oie_33	10.0	No
Patte D'Oie_132	Patte D'Oie_33	10.0	No
Patte D'Oie_132	Patte D'Oie_90	40.0	No
Wona_90	Wona_33	40.0	No
Zagtouli_225	Zagtouli_90	70.0	No
Zagtouli_225	Zagtouli_90	70.0	No

Table 63: Existing 2W transformers - Burkina Faso

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Substation Side 3 [Name_Voltage]	Rated Power Side 1 [MVA]	Rated Power Side 2 [MVA]	Rated Power Side 3 [MVA]	Regulating (OLTC)
Zagtouli_90	Zagtouli_33	Zagtouli 1_34.5	20.0	15.0	5.0	N/A
Zagtouli_90	Zagtouli_33	Zagtouli 2_34.5	20.0	15.0	5.0	N/A

Table 64: Existing 3W transformers - Burkina Faso

Final version

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Kodeni RE_225	-28.0	1	Fixed
Kodeni_225	-13.0	1	Switch
Kodeni_225	-1.4	12	Switch
Kodeni_33	5.0	2	Switch
Kompienga_132	-4.5	1	Switch
Kossodo_15	4.8	1	Switch
Kossodo_15	0.9	1	Switch
Kossodo_15	0.7	2	Switch
Ouaga 1_15	4.8	1	Switch
Ouaga 1_15	1.2	5	Switch
Ouaga 1_15	7.0	1	Switch
Ouaga 1_90	14.4	1	Switch
Ouaga 2 G6_15	4.8	4	Switch
Ouaga 2 G6_15	3.0	1	Switch
Ouaga 2 G6_15	1.5	2	Switch
Ouaga 2000_33	4.8	1	Switch
Pa_225	-30.0	1	N/A
Patte D'Oie_132	-4.5	1	Switch
Patte D'Oie_33	5.0	2	Switch
Patte D'Oie_33	4.8	1	Switch
Patte D'Oie_33	-3.5	1	Switch
Zagtouli_225	-15.0	2	Switch

Table 65: Existing reactive power compensation - Burkina Faso

5.1.3. Côte d’Ivoire

The current electrical network of Côte d’Ivoire is shown on the following tables (lines, transformers, shunt reactive compensation).

Only transmission lines with operating voltage equal or higher than 90 kV are considered. The system has 77 transmission lines (74 single circuits and 3 double circuits), 197 transformers and 39 shunt reactive compensation devices.

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Kossou_225	Bouake_225	225.000	109.9	327.4	1.276	8.770	7.850
Azito 2_225	Yopougon 2 _225	225.000	16.0	327.4	0.185	1.270	1.144
Akoupé_225	Abobo 2_225	225.000	20.8	327.4	0.380	1.720	1.530
Taabo 1_225	Akoupé_225	225.000	150.0	327.4	1.740	11.970	10.720
Bingerville_225	Riviera_225	225.000	21.0	327.4	0.244	1.676	1.502
Ferkéssédougou 2_225	Sikasso RE_225	225.000	237.0	327.4	2.752	18.912	16.950
Abobo 1_225	Azito 2_225	225.000	16.7	327.4	0.193	1.332	1.194
Abobo 1_225	Azito 2_225	225.000	16.7	327.4	0.193	1.332	1.194
Abobo 1_225	Djibi 2_225	225.000	8.7	327.4	0.101	0.695	0.623
Abobo 1_225	Yopougon 2_225	225.000	12.0	327.4	0.139	0.957	0.858
Azito 1_225	Vridi 2_225	225.000	12.2	327.4	0.141	0.973	0.872
Buyo 1_225	Soubre 2_225	225.000	82.2	327.4	0.955	6.560	5.870
Taabo 1_225	Soubre 2_225	225.000	195.8	327.4	2.276	15.641	13.990
Buyo 2_225	Man_225	225.000	193.2	327.4	2.244	15.418	13.810
Riviera_225	Djibi 2_225	225.000	6.3	327.4	0.073	0.502	0.450
Kossou_225	Taabo 2_225	225.000	124.0	245.5	2.295	10.287	9.130
Bouake_225	Ferkéssédougou 1_225	225.000	233.8	327.4	2.716	18.658	16.720
Ferkéssédougou 1_225	Kodeni RE_225	225.000	221.9	327.4	2.576	17.699	15.860
Man_225	Laboa_225	225.000	152.0	327.4	1.765	12.130	10.860
Taabo 1_225	Abobo 2_225	225.000	170.8	246.0	3.161	14.170	12.564
Soubre 2_225	Taabo 2_225	225.000	195.8	327.4	2.276	15.641	13.990
Soubre 1_225	San Pedro 1_225	225.000	117.0	327.0	1.359	9.337	8.369
Yopougon 2_225	Taabo 1_225	225.000	162.0	327.0	1.882	12.928	11.588
Vridi 2_225	Riviera_225	225.000	18.3	327.0	0.213	1.460	1.309
Bingerville_225	Prestea_225	225.000	189.0	327.0	2.195	15.083	13.520
San Pedro_33	Faye_33	33.000	38.2	24.9	50.512	147.328	0.059
Yopougon 2 -1_90	Yopougon 1 -1_90	90.000	7.8	109.0	0.481	1.156	2.261
Laboa_90	Seguela_90	90.000	82.0	74.8	14.578	42.518	0.941
Laboa_90	Odienne_90	90.000	122.2	74.8	21.724	63.362	1.402
Tongon_90	Korhogo_90	90.000	56.2	74.8	10.000	29.167	0.644
Taabo_90	Hire_90	90.000	22.0	74.8	3.911	11.407	0.252
Korhogo_90	Ferkéssédougou_90	90.000	48.3	71.7	10.197	25.044	0.554
Gagnoa_90	Divo_90	90.000	81.2	74.8	14.400	42.000	0.929
Hire_90	Divo_90	90.000	41.9	74.8	7.450	21.730	0.480
Dimbokro_90	Taabo_90	90.000	72.2	74.8	12.836	37.437	0.828
Yamoussoukro_90	Dimbokro_90	90.000	67.4	72.0	11.982	34.948	0.773
Danane_90	Man_90	90.000	76.8	74.8	13.653	39.822	0.881
Daloa_90	Buyo_90	90.000	112.1	74.8	19.927	58.120	1.286

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From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Boundia_90	Korhogo_90	90.000	103.5	74.8	18.406	53.684	1.188
Odienne_90	Boundia_90	90.000	123.1	74.8	21.884	63.829	1.412
Bouake 2_90	Serebou_90	90.000	131.1	74.8	23.303	67.767	1.504
Bouake 2_90	Marabadiassa_90	90.000	81.4	74.8	14.471	42.207	0.934
Bouake 2_90	Bouake 1_90	90.000	26.4	74.8	4.701	13.713	0.303
Ayame 1_90	Ayame 2_90	90.000	4.0	71.7	0.844	2.074	0.046
Bongo_90	Ayame 1_90	90.000	65.7	71.7	13.870	34.067	0.754
Dimbokro_90	Attakro_90	90.000	103.9	74.8	18.471	53.874	1.192
Koumassi_90	Anoumabo 2_90	90.000	2.8	109.0	0.173	0.415	0.812
Abobo 1_90	Yopougon 2_90	90.000	16.6	75.0	2.951	8.607	0.190
Abobo 1_90	Yopougon 1 -1_90	90.000	13.2	71.7	2.787	6.844	0.151
Bia Nord 1_90	Plateau_90	90.000	2.8	109.0	0.173	0.415	0.812
Bia Sud 2_90	Anoumabo 2_90	90.000	6.3	109.0	0.389	0.933	1.826
Daloa_90	Kossou 1_90	90.000	110.6	74.8	19.662	57.350	1.269
Gagnoa_90	Kossou 1_90	90.000	120.9	72.0	25.523	62.688	1.387
Riviera 1_90	Bia Nord 2_90	90.000	10.4	71.7	2.195	5.392	0.119
Vridi 2_90	Treichville 1_90	90.000	6.5	98.2	0.752	3.370	0.077
Treichville 1_90	Vridi 2_90	90.000	6.5	98.2	0.752	3.370	0.077
Vridi 1_90	Sir_90	90.000	3.0	71.7	0.633	1.556	0.034
Vridi 2_90	Yopougon 1 -2_90	90.000	15.7	71.7	3.314	8.141	0.180
Abobo 2_90	Bia Nord 2_90	90.000	4.9	71.7	1.034	2.540	0.056
Abobo 2_90	Bia Nord 2_90	90.000	4.9	71.7	1.034	2.540	0.056
Abobo 2_90	Adjame_90	90.000	4.7	74.8	0.836	2.437	0.054
Abobo 2_90	Bongo_90	90.000	58.1	71.7	12.266	30.126	0.666
Riviera 2_90	Bia Sud 1_90	90.000	11.2	75.0	2.322	5.704	0.126
Zuenoula_90	Kossou 2_90	90.000	92.7	74.8	16.480	48.067	1.060
Bouake 1_90	Kossou 2_90	90.000	115.3	71.7	24.343	59.790	1.323
Kossou 2_90	Yamoussoukro_90	90.000	53.3	72.0	9.474	27.630	0.611
Grand Bassam_90	Riviera 2_90	90.000	28.6	71.7	6.038	14.830	0.328
Agnibilekrou_90	Abengourou_90	90.000	53.0	74.8	9.422	27.481	0.608
Abengourou_90	Attakro_90	90.000	40.1	74.8	7.111	20.740	0.459
Grand Bassam_90	Abrobakro_90	90.000	25.0	71.7	5.278	12.963	0.287
Abrobakro_90	Ayame 2_90	90.000	59.0	71.7	12.402	30.463	0.674
Adjame_90	Plateau_90	90.000	3.7	109.0	0.228	0.548	1.073
Hire_90	Agbaou_90	90.000	14.6	74.8	2.595	7.570	0.167
Plateau_90	Treichville 2_90	90.000	3.8	109.0	0.235	0.563	1.102
Treichville 2_90	Plateau_90	90.000	3.8	109.0	0.235	0.563	1.102
Bia Sud 1_90	Vridi 2_90	90.000	7.8	72.0	1.386	4.044	0.089
Vridi 1_90	Bia Sud 2_90	90.000	8.0	72.0	1.422	4.148	0.092

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From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Dabou_90	Abobo 1_90	90.000	57.7	74.8	10.260	29.926	0.662
Yopougon_90	Agboville_90	90.000	51.7	74.8	9.191	26.807	0.592
Taabo_90	Agboville_90	90.000	118.2	75.0	21.013	61.289	1.353
Koumassi_90	Riviera 1_90	90.000	8.0	75.0	1.422	4.148	0.092
Yopougon 2_90	Yopougon 2 -1_90	90.000	5.2	109.0	0.321	0.770	1.508
Yopougon 2_90	Yopougon 2 -2_90	90.000	5.2	109.0	0.321	0.770	1.508

Table 66: Existing transmission lines (Nominal voltage higher than or equal to 90 kV) – Côte d'Ivoire

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Abengourou_90	Abengourou_33	10	Yes
Abobo 1_225	Abobo 2_90	70	Yes
Abobo 1_225	Abobo 2_90	70	Yes
Abobo 1_225	Abobo 2_90	70	Yes
Abobo 1_225	Abobo 2_90	70	Yes
Abobo 2_90	Abobo_15	50	Yes
Abobo 2_90	Abobo_15	50	Yes
Abobo 2_90	Abobo_15	36	Yes
Abobo 2_90	Abobo_15	36	Yes
Abrobakro_90	Abrobakro_33	24	No
Agbaou_90	Agbaou_11	25	Yes
Agboville_90	Agboville_33	24	Yes
Agboville_90	Agboville_15	20	Yes
Aggreko 1&2-1 Vridi_15	Aggreko 1 CI_0.4	112.5	No
Aggreko 3-1 Vridi_15	Aggreko 3 CI_0.4	105	No
Aggreko 4-1 Vridi_11	Aggreko 4 CI_0.4	75	No
Aggreko 5-1 Vridi_11	Aggreko 5 CI_0.4	75	No
Aggreko CI 1_90	Aggreko 1&2-2 Vridi_15	85	Yes
Aggreko CI 2_90	Aggreko 3-2 Vridi_15	85	Yes
Aggreko CI_225	Aggreko 4-2 Vridi_11	70	No
Aggreko CI_225	Aggreko 5-2 Vridi_11	70	No
Agnibilekrou_90	Agnibilekrou_33	20	Yes

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Akoupé_225	Akoupé_33	60	Yes
Akoupé_225	Akoupé_33	60	Yes
Akoupé_225	Akoupé_33	60	Yes
Anoumabo 1_90	Anoumabo_15	50	Yes
Anoumabo 1_90	Anoumabo_15	50	Yes
Attakro_90	Attakro_33	40	Yes
Ayame 1_90	Ayame1 G1_5.5	15	No
Ayame 1_90	Ayame1 G2_5.5	15	No
Ayame 2_90	Ayame_33	24	Yes
Ayame 2_90	Ayame2 G1_5.5	19	No
Ayame 2_90	Ayame2 G2_5.5	19	No
Azito 1_225	Azito_15	50	Yes
Azito 1_225	Azito_15	50	Yes
Azito 1_225	Azito_15	50	Yes
Azito 1_225	Azito Tag 1_15.8	190	No
Azito 1_225	Azito Tag 2_15.8	190	No
Azito 1_225	Azito TAV_15.8	190	No
Bia Nord 1_90	Bia Nord_15	36	Yes
Bia Nord 1_90	Bia Nord_15	36	Yes
Bia Nord 1_90	Bia Nord_15	36	Yes
Bia Sud 1_90	Bia Sud_15	50	Yes
Bia Sud 1_90	Bia Sud_15	50	Yes
Bia Sud 1_90	Bia Sud_15	50	Yes
Bia Sud 1_90	Bia Sud_15	50	Yes
Bongo_90	Bongo_33	10	Yes
Bouake 1_90	Bouake_33	10	Yes
Bouake 1_90	Bouake 1_15	36	Yes
Bouake 1_90	Bouake 1_15	36	Yes
Bouake 2_90	Bouake 2_15	36	Yes
Bouake 2_90	Bouake 2_15	36	No

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Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Bouake_225	Bouake 2_90	70	Yes
Boundia_90	Boundia_33	24	Yes
Boundia_90	Boudiali_15	24	Yes
Buyo 1_225	Buyo_90	70	Yes
Buyo 2_225	Buyo G1_10.5	85	No
Buyo 2_225	Buyo G2_10.5	61	No
Buyo_90	Buyo_33	7.5	Yes
Dabou_90	Dabou_33	40	Yes
Daloa_90	Daloa_33	16	Yes
Daloa_90	Daloa_15	20	Yes
Daloa_90	Daloa_15	24	Yes
Danane_90	Danane_33	20	Yes
Dimbokro_90	Dimbroko_33	24	Yes
Dimbokro_90	Dimbokro_15	15	No
Dimbokro_90	Dimbokro_15	16	No
Divo_90	Divo_33	24	No
Divo_90	Divo_15	10	Yes
Djibi 1_225	Djibi 2_15	50	Yes
Djibi 1_225	Djibi 2_15	50	Yes
Djibi 1_225	Djibi 2_15	50	Yes
Djibi 1_225	Djibi 2_15	50	Yes
Faye_33	Faye G1_5.5	15	No
Ferkéssédougou 1_225	Ferkéssédougou_90	65	Yes
Ferkéssédougou_90	Ferkéssédougou_33	36	No
Ferkéssédougou_90	Ferkéssédougou_33	36	No
Ferkéssédougou_90	Ferkéssédougou_15	20	Yes
Ferkéssédougou_90	Ferkéssédougou_15	20	Yes
Gagnoa_90	Gagnoa_33	36	Yes
Gagnoa_90	Gagnoa_15	20	Yes
Gagnoa_90	Gagnoa_15	36	Yes

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Grand Bassam_90	Grand Bassam_15	20	Yes
Hire_90	Hire_33	18	Yes
Korhogo_90	Korhogo_33	7.5	No
Korhogo_90	Korhogo_15	20	No
Korhogo_90	Korhogo_15	20	No
Kossou 1_90	Kossou_33	24	Yes
Kossou 1_90	Kossou_33	24	Yes
Kossou 2_90	Kossou G1_17	72	No
Kossou_225	Kossou G2_17	72	No
Kossou_225	Kossou G3_17	72	No
Kossou_225	Kossou 2_90	65	Yes
Laboa_225	Laboa_90	70	Yes
Laboa_90	Laboa_33	16	Yes
Man_225	Man_90	70	Yes
Man_90	Man_33	24	Yes
Man_90	Man_15	24	Yes
Man_90	Man_15	20	Yes
Marabadiassa_90	Marabadiassa_33	10	Yes
Odienne_90	Odienne_33	10	Yes
Odienne_90	Odienne_15	7.5	Yes
Plateau_90	Plateau_15	36	No
Plateau_90	Plateau_15	36	No
Riviera 2_90	Riviera_15	36	Yes
Riviera 2_90	Riviera_15	36	Yes
Riviera 2_90	Riviera_15	36	Yes
Riviera_225	Riviera 1_90	100	Yes
Riviera_225	Riviera 1_90	100	Yes
San Pedro 1_225	San Pedro_90	70	Yes
San Pedro_90	San Pedro_33	24	Yes
San Pedro_90	San Pedro_15	20	Yes

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
San Pedro_90	San Pedro_15	40	Yes
Seguela_90	Seguela_33	7.5	Yes
Seguela_90	Seguela_15	16	Yes
Serebou_90	Serebou_33	20	Yes
Soubre 1_225	Soubre_90	70	Yes
Soubre 1_225	Soubre_90	70	Yes
Soubre 2_225	Soubre G1_10.5	120	No
Soubre 2_225	Soubre G2_10.5	120	No
Soubre 2_225	Soubre G3_10.5	120	No
Soubre G4_6.6	Soubre_33	7	No
Soubre_90	Soubre_33	36	Yes
Taabo 1_225	Taabo_90	70	Yes
Taabo 1_225	Taabo_90	70	Yes
Taabo 2_225	Taabo G1_13.8	82.5	No
Taabo 2_225	Taabo G2_13.8	82.5	No
Taabo 2_225	Taabo G3_13.8	82.5	No
Taabo_90	Taabo_33	20	Yes
Tongon_90	Tongon_11	20	Yes
Tongon_90	Tongon_11	20	Yes
Treichville 1_90	Treichville_15	50	Yes
Treichville 1_90	Treichville_15	50	Yes
Treichville 1_90	Treichville_15	50	Yes
Vridi 1_225	Vridi1 Tag 1_11	61	No
Vridi 1_225	Vridi 2_90	70	Yes
Vridi 1_225	Vridi 2_90	70	Yes
Vridi 1_225	Vridi 2_90	70	Yes
Vridi 1_225	Vridi1 Tag 3_11	61	No
Vridi 1_225	Ciprel Tag 1_11	151	No
Vridi 1_90	Vridi 2_15	36	Yes
Vridi 1_90	Vridi 1_15	40	Yes

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Vridi 1_90	Vridi 1_15	40	Yes
Vridi 2_225	Ciprel TAV_15	151	No
Vridi 2_225	Ciprel Tag 9_11	151	No
Vridi 2_90	Ciprel Tag 5_11	47	No
Vridi 2_90	Ciprel Tag 8_11	151	No
Vridi 2_90	Ciprel Tag 6_11	47	No
Vridi 2_90	Ciprel Tag 7_11	47	No
Yamoussoukro_90	Yamoussoukro_33	24	Yes
Yamoussoukro_90	Yamoussoukro_15	40	Yes
Yamoussoukro_90	Yamoussoukro_15	40	Yes
Yopougon 1 -2_90	Yopougon 1_33	40	Yes
Yopougon 1 -2_90	Yopougon 1_15	50	Yes
Yopougon 1 -2_90	Yopougon 1_15	50	Yes
Yopougon 1 -2_90	Yopougon 1_15	50	Yes
Yopougon 1 -2_90	Yopougon 1_15	50	Yes
Yopougon 2 _225	Yopougon 2 -1_90	100	Yes
Yopougon 2 _225	Yopougon 2 -1_90	100	Yes
Yopougon 2 -1_90	Yopougon 2_15	50	Yes
Yopougon 2 -1_90	Yopougon 2_15	50	Yes
Yopougon 2 -1_90	Yopougon 2_15	50	Yes
Zuenoula_90	Zuenoula_33	24	Yes

Table 67: Existing 2W transformers - Côte d'Ivoire

Final version

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Abengourou_33	2.4	3	Switch
Abobo_15	2.4	3	Switch
Abobo_15	2.4	3	Switch
Agnibilekrou_33	2.4	3	Switch
Anoumabo_15	2.4	3	Switch
Anoumabo_15	2.4	3	Switch
Attakro_33	2.4	3	Switch
Attakro_33	2.4	3	Switch
Bia Nord_15	2.4	3	Switch
Bia Nord_15	2.4	3	Switch
Bia Nord_15	2.4	3	Switch
Bia Sud_15	2.4	3	Switch
Bia Sud_15	2.4	3	Switch
Bia Sud_15	2.4	3	Switch
Bia Sud_15	2.4	3	Switch
Bouake 2_15	2.4	3	Switch
Bouake 2_90	-20	1	Switch
Boundia_33	2.4	3	Switch
Djibi 2_15	2.4	3	Switch
Djibi 2_15	2.4	3	Switch
Djibi 2_15	2.4	3	Switch
Djibi 2_15	2.4	3	Switch
Ferkéssédougou 1_225	-40	1	Switch
Ferkéssédougou 2_225	-20	1	Fixed
Ferkéssédougou_15	2.4	3	Switch
Ferkéssédougou_33	2.4	3	Switch
Korhogo_90	3.3	3	Switch
Laboa_225	-20	1	Switch
Man_225	-20	1	Switch
Plateau_15	2.4	3	Switch
Plateau_15	2.4	3	Switch

Final version

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Riviera_15	2.4	3	Switch
Riviera_15	2.4	3	Switch
Soubre 2_225	-20	2	Switch
Tongon_11	2.4	3	Switch
Tongon_11	2.4	3	Switch
Tongon_11	2.4	3	Switch
Treichville_15	2.4	3	Switch
Treichville_15	2.4	3	Switch
Treichville_15	2.4	3	Switch
Yopougon 1_15	2.4	3	Switch
Yopougon 1_15	2.4	3	Switch
Yopougon 1_15	2.4	3	Switch
Yopougon 1_33	2.4	3	Switch
Yopougon 2_15	2.4	3	Switch
Yopougon 2_15	2.4	3	Switch

Table 68: Existing reactive power compensation - Côte d'Ivoire

5.1.4. Gambia

The current electrical network of the Gambia is not represented in the model as it does not feature high voltage transmission infrastructures interconnected with the neighbouring countries.

The national projects planned for the upcoming years are presented in Appendix J.

5.1.5. Ghana

The current electrical network of Ghana is shown on the following tables (lines, transformers, shunt reactive compensation).

Only transmission lines with operating voltage equal or higher than 90 kV are considered. The system has 100 transmission lines (91 single circuits and 9 double circuits), 170 transformers and 43 shunt reactive compensation devices.

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Pokuase_330	Aboadze_330	330	185	1000	0.9	5.67	43.5
Pokuase_330	Volta_330	330	30	1000	0.023	0.148	1.13
Prestea_225	Elubo_225	225	74.3	327	0.85	5.94	5.325
Volta_161	Kpong GS_161	161	13.1	273	1.14	8.43	1.946
Bui_161	Sunyani_161	161	137.6	364	4.24	18.68	8.577
Volta_161	Achimota_161	161	25.7	213	0.72	3.8	0.975
Akosombo _161	Volta_161	161	67.6	213	2.12	10.29	2.563
Akosombo _161	Volta_161	161	67.6	213	2.12	10.29	2.563
Akosombo _161	Volta_161	161	67.6	213	2.12	10.29	2.563
Akosombo _161	Nkawkaw_161	161	121.7	364	3.24	13.61	6.16
Anwomaso_161	Nkawkaw_161	161	93.4	170	4.15	14.877	3.373
Anwomaso_161	Kumasi_161	161	11	488	0.075	0.471	0.109
Akosombo _161	Tafo_161	161	61.2	170	2.72	9.74	2.205
Akosombo _161	Tafo_161	161	61.2	364	1.57	6.84	3.09
Akosombo _161	Old Kpong_161	161	16.1	213	0.51	2.45	0.61
Akosombo _161	Old Kpong_161	161	16.1	213	0.51	2.45	0.61
Akosombo _161	Kpong GS_161	161	24.6	213	0.77	3.81	0.915
Akosombo _161	Asiekpe_161	161	54.7	128	3.94	8.89	1.935
Akosombo _161	Aflao Ghana_161	161	70.1	128	8.837	20.254	4.413
Volta_161	Tema_161	161	3.2	364	0.085	0.357	0.162
Volta_161	Tema_161	161	3.2	364	0.085	0.357	0.162
Volta_161	Old Kpong_161	161	51.5	213	1.62	7.84	1.952
Volta_161	Old Kpong_161	161	51.5	213	1.62	7.84	1.952
Achimota_161	Mallam_161	161	15	170	0.535	1.877	0.442
Mallam_161	Winneba_161	161	42.9	488	0.293	1.839	0.426
Achimota_161	Mallam_161	161	15	170	0.535	1.877	0.442
Winneba_161	Aboadze_161	161	132	150	4.216	16.24	3.827
Cape Coast_161	Aboadze_161	161	58	150	2.35	9.06	2.132
Cape Coast_161	Mallam_161	161	116.9	488	0.818	5.133	1.188
Takoradi_161	Tarkwa_161	161	51.4	150	2.28	8.2	1.85

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Takoradi_161	Aboadze_161	161	15	170	0.67	2.39	0.54
Takoradi_161	Aboadze_161	161	15	170	0.67	2.39	0.54
Takoradi_161	Essiama_161	161	70.54	182	3.74	11.16	2.522
New Tarkwa_161	Prestea_161	161	20.9	150	0.94	3.27	0.77
Tarkwa_161	New Tarkwa_161	161	8.3	150	0.37	1.29	0.305
Prestea_161	Obuasi_161	161	112.2	364	2.974	12.52	5.676
Prestea_161	Bogoso_161	161	13	364	0.347	1.462	0.663
Tarkwa_161	Aboadze_161	161	73.8	364	1.763	7.424	3.364
Tarkwa_161	Prestea_161	161	29.2	364	0.437	1.842	0.835
Dunkwa_161	New Obuasi_161	161	24.9	170	1.11	3.97	0.895
Dunkwa_161	Bogoso_161	161	66	170	2.94	10.51	2.375
Obuasi_161	New Obuasi_161	161	7.1	170	0.32	1.13	0.255
Kumasi_161	Konogo_161	161	51.5	170	2.29	8.2	1.855
Kumasi_161	Tower 26-2_161	161	10	364	0.27	1.12	0.505
Kumasi_161	Techiman_161	161	115	364	2.94	12.84	5.815
Nkawkaw_161	Tafo_161	161	59.5	170	2.65	9.47	2.14
Nkawkaw_161	Konogo_161	161	51.5	170	2.36	8.46	1.91
Tafo_161	Akwatia_161	161	56.4	170	2.43	8.71	1.97
Akwatia_161	New Obuasi_161	161	110	244	3.6	16.73	4.13
Tamale_161	Bolgatanga_161	161	158.1	244	5.15	23.99	5.945
Tamale_161	Yendi_161	161	100	182	5.3	15.81	3.621
Bogoso_161	Akyempin_161	161	51	182	2.65	7.9	1.795
Diacem_161	Aflao Ghana_161	161	N/A	180	0.1	0.21	0.05
Techiman_161	Sunyani_161	161	54.1	244	1.8	8.36	2.06
Sunyani_161	Ahafo_161	161	40	364	0.935	5.049	1.783
Obuasi_161	Tower 26-1_161	161	43.1	170	1.92	6.87	1.55
Tower 26-1_161	Ahafo_161	161	104	170	1.84	11.53	2.67
Tower 26-2_161	Ahafo_161	161	104	364	1.84	11.53	2.67
Kumasi_161	New Obuasi_161	161	60	364	1.595	6.721	3.046
Bolgatanga_161	Zebila_161	161	45	244	1.792	8.345	2.068

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Zebila_161	Bawku_161	161	35	182	2.919	8.7	2.025
Bui_161	Sawla_161	161	18	364	0.424	1.85	0.837
Bui_161	Techiman_161	161	18	364	0.423	1.85	0.837
Bui_161	Kintampo_161	161	68	364	1.81	7.6	3.44
Kintampo_161	Buipe_161	161	85	364	2.226	9.377	4.256
Buipe_161	Tamale_161	161	98	364	2.598	10.941	4.958
Kintampo_161	Techiman_161	161	65	364	1.749	7.368	3.344
Volta_161	Accra Est_161	161	7.5	213	0.47	2.32	0.55
Accra Est_161	Achimota_161	161	18.2	213	0.34	1.66	0.405
Volta_161	Accra Est_161	161	7.5	213	0.47	2.32	0.55
Accra Est_161	Achimota_161	161	18.2	213	0.34	1.66	0.405
Achimota_161	Volta_161	161	7.5	213	0.81	3.91	0.975
Sunyani_161	Mim_161	161	60	364	3.981	9.571	1.844
Nkawkaw_161	New Aberim_161	161	50	170	1.907	6.834	1.549
Essiama_161	Effasu_161	161	52	182	1.378	5.805	2.631
Asawinso_161	Ayanfuri_161	161	34.6	142	2.535	5.6	1.218
Ayanfuri_161	Dunkwa_161	161	34.6	142	2.535	5.6	1.218
Bolgatanga_161	Tumu_161	161	139	182	7.367	21.976	5.033
Tumu_161	Wa_161	161	150	182	7.95	23.72	5.5
Wa_161	Sawla_161	161	95	182	4.7	14.06	3.17
Juabeso_161	Asawinso_161	161	70	182	3.418	10.196	2.317
Juabeso_161	Mim_161	161	80	364	3.98	9.57	4.32
Asogli_161	Kpone_161	161	N/A	600	0.038	0.476	0.215
Kpone_161	Asogli_161	161	N/A	600	0.038	0.476	0.215
Volta_161	Smelteri_161	161	2.5	213	0.127	0.646	0.155
Volta_161	Smelteri_161	161	2.5	213	0.127	0.646	0.155
Volta_161	Smelteri_161	161	2.5	213	0.127	0.646	0.155
Volta_161	Smelteri_161	161	2.5	213	0.127	0.646	0.155
Volta_161	Smelteri_161	161	2.5	213	0.127	0.646	0.155
Volta_161	Smelteri_161	161	2.5	213	0.127	0.646	0.155

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Smelteri_161	Smelteri 2_161	161	0.5	213	0.032	0.164	0.04
Smelteri_161	Smelteri 3_161	161	0.5	213	0.032	0.164	0.04
Smelteri_161	Smelteri 4_161	161	0.5	213	0.032	0.164	0.04
Smelteri_161	Smelteri 5_161	161	0.5	213	0.032	0.164	0.04
Smelteri_161	Smelteri 6_161	161	0.5	213	0.032	0.164	0.04
Smelteri_161	Smelteri 1_161	161	0.5	213	0.032	0.164	0.04
Smelteri_161	TT1PP Generation_161	161	5	364	0.133	0.558	0.253
Aflao Ghana_161	Diacem_161	161	137	180	0.1	0.21	0.05
TT1PP Generation_161	Smelter _161	161	5	364	0.133	0.558	0.253
Akosombo _161	Volta_161	161	67.6	213	2.12	10.29	2.563
Volta_161	Kpone_161	161	13.1	644	0.06	0.74	0.334
Prestea_161	Bogoso_161	161	13.1	364	0.347	1.462	0.663
Elubo_161	Effasu_161	161	79	238	2.022	8.824	3.99
Kpone_161	Volta_161	161	13.1	644	0.06	0.74	0.334
Obotan_161	Asawinso_161	161	30	182	1.56	4.65	1.055
Smelteri_161	Aksa_161	161	4.5	488	0.035	0.44	0.19
Smelteri_161	Aksa_161	161	4.5	488	0.035	0.44	0.19
Smelteri_161	Karpower 1_161	161	10	364	0.27	1.12	0.505
Smelteri_161	Karpower 2_161	161	10	364	0.27	1.12	0.505

Table 69 Existing transmission lines (Nominal voltage higher than or equal to 90 kV) – Ghana

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Aboadze PST_161	Aboadze _330	200.0	No
Aboadze PST_161	Aboadze _330	200.0	No
Aboadze PST_161	Aboadze _161	400.0	No
Aboadze _161	TAPCo 1_13.8	165.0	No
Aboadze _161	TAPCo 2_13.8	165.0	No
Aboadze _161	TAPCo 3_13.8	165.0	No
Aboadze _161	TICo 1_13.8	165.0	No
Aboadze _161	TICo 2_13.8	165.0	No
Aboadze _161	Aboadze _34.5	13.3	Yes
Aboadze _161	TICo_13.8	165.0	No
Aboadze _161	AMERI_13.8	300.0	No
Accra Est_161	Accra Est 1_34.5	66.0	Yes
Accra Est_161	Accra Est 2_34.5	66.0	Yes
Accra Est_161	Accra Est 1_34.5	66.0	Yes
Accra Est_161	Accra Est 2_34.5	66.0	Yes
Achimota_161	Achimota 1_34.5	66.0	No
Achimota_161	Achimota 2_34.5	66.0	No
Achimota_161	Achimota 3_34.5	66.0	No
Achimota_161	Achimota 4_34.5	66.0	No
Achimota_161	Achimota 5_34.5	66.0	No
Achimota_161	Achimota 1_34.5	66.0	No
Ahafo_161	Ahafo 1_11	53.0	No
Ahafo_161	Ahafo 1_11	53.0	No
Akosombo _161	Akosombo 1_14.4	200.0	No
Akosombo _161	Akosombo 2_14.4	200.0	No
Akosombo _161	Akosombo 3_14.4	200.0	No
Akosombo _161	Akosombo 4_14.4	200.0	No
Akosombo _161	Akosombo 5_14.4	200.0	No
Akosombo _161	Akosombo 6_14.4	200.0	No
Akosombo _161	Akosombo_11.5	33.0	Yes

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Akosombo _161	Akosombo_11.5	33.0	Yes
Aksa_161	AKSA G1_13.8	200.0	No
Aksa_161	AKSA G2_13.8	200.0	No
Aksa_161	AKSA G3_13.8	200.0	No
Aksa_161	AKSA G4_13.8	200.0	No
Aksa_161	AKSA_13.8	200.0	No
Akyempin_161	Akyempim_34.5	33.0	Yes
Anwomaso_161	Anwomaso 1_34.5	66.0	Yes
Anwomaso_161	Anwomaso 2_34.5	66.0	Yes
Asawinso_161	Asawinso 1_34.5	33.0	Yes
Asawinso_161	Asawinso 2_34.5	33.0	Yes
Asiekpe_161	Asiekpe PST_161	200.0	No
Asogli 2_330	Sunon Asogli 2 G3_13.8	145.0	No
Asogli 2_330	Sunon Asogli 2 G2_13.8	145.0	No
Asogli 2_330	Sunon Asogli 2 G1_13.8	145.0	No
Asogli_161	Sunon Asogli 1-5_13.8	50.0	No
Asogli_161	Sunon Asogli 1-1_13.8	50.0	No
Asogli_161	Sunon Asogli 1-2_13.8	50.0	No
Asogli_161	Sunon Asogli 1-3_13.8	50.0	No
Asogli_161	Sunon Asogli 1-4_13.8	50.0	No
Asogli_161	Sunon Asogli 1-6_13.8	50.0	No
Ayanfuri_161	Ayanfuri 2_11.5	25.0	No
Bogoso_161	Bogoso_34.5	33.0	Yes
Bogoso_161	Bogoso_34.5	33.0	Yes
Bolgatanga_161	Bolgatanga_330	200.0	No
Bolgatanga_225	Bolgatanga_330	200.0	No
Bolgatanga_225	Navrongo_34.5	60.0	No
Bui 1_14.4	Bui_161	160.0	No
Bui 2_14.4	Bui_161	160.0	No
Bui 3_14.4	Bui_161	160.0	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Buipe_161	Buipe_34.5	33.0	Yes
Cape Coast_161	Cape Coast_34.5	33.0	Yes
CENIT_13.8	Tema_161	145.0	No
Diacem_161	Aflao Ghana_34.5	25.0	Yes
Dunkwa_161	Dunkwa_34.5	5.0	Yes
Elubo_225	Elubo_161	200.0	No
Essiama_161	Essiama_34.5	33.0	Yes
Ho _69	Ho_11.5	33.0	Yes
Juabeso_161	Juabeso_34.5	33.0	No
Karpower 1_161	Karpower ship I -1_13.8	150.0	No
Karpower 1_161	Karpower ship I -2_13.8	150.0	No
Karpower 1_161	Karpower ship I -3_13.8	150.0	No
Karpower 1_161	Karpower ship I -4_13.8	150.0	No
Karpower 2_161	Karpower ship II -1_13.8	150.0	No
Karpower 2_161	Karpower ship II -2_13.8	150.0	No
Kintampo_161	Kintampo_34.5	33.0	Yes
Kintampo_161	Kintampo_34.5	33.0	Yes
Konogo_161	Konogo A_34.5	33.0	Yes
Konogo_161	Konogo B_34.5	33.0	Yes
Kpandu_69	Kpandu_34.5	10.0	Yes
Kpeve_69	Kpeve_34.5	7.0	Yes
Kpong GS_161	Kpong 1_13.8	51.0	No
Kpong GS_161	Kpong 2_13.8	51.0	No
Kpong GS_161	Kpong 3_13.8	51.0	No
Kpong GS_161	Kpong 4_13.8	51.0	No
Kpong GS_161	Kpone TPP1_13.8	150.0	No
Kpong GS_161	Kpone TPP2_13.8	150.0	No
Kumasi_161	Kumasi A1_34.5	66.0	Yes
Kumasi_161	Kumasi 1_34.5	66.0	Yes
Kumasi_161	Kumasi 2_34.5	66.0	Yes

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Kumasi_161	Kumasi A2_34.5	66.0	Yes
Mallam_161	Mallam 1_34.5	66.0	Yes
Mallam_161	Mallam 1_34.5	66.0	Yes
Mallam_161	Mallam 2_34.5	66.0	Yes
Mallam_161	Mallam 2_34.5	66.0	Yes
Mim_161	Mim_34.5	33.0	No
New Aberim_161	New Aberim_11	53.0	No
New Aberim_161	New Aberim_11	53.0	No
New Obuasi_161	New Obuasi_34.5	33.0	Yes
New Obuasi_161	New Obuasi_34.5	33.0	Yes
New Obuasi_161	New Obuasi_34.5	33.0	Yes
New Tema_161	New Tarkwa_11.5	25.0	No
New Tema_161	New Tarkwa_11.5	25.0	No
Nkawkaw_161	Nkawkaw_34.5	33.0	Yes
Nkawkaw_161	Nkawkaw_34.5	33.0	Yes
Obotan_161	Obotan_34.5	33.0	Yes
Obuasi_161	Obuasi_34.5	15.0	Yes
Obuasi_161	Obuasi_34.5	15.0	Yes
Obuasi_161	Obuasi_34.5	15.0	Yes
Old Kpong_161	Afienya_34.5	66.0	Yes
Old Kpong_161	Afienya_34.5	66.0	Yes
Sawla_161	Sawla_34.5	13.3	Yes
Sawla_161	Sawla_34.5	13.3	Yes
Smelteri 1_161	Valco 1_13.8	85.0	No
Smelteri 2_161	Valco 8_13.8	85.0	No
Smelteri 3_161	Valco 3_13.8	85.0	No
Smelteri 4_161	Valco 4_13.8	85.0	No
Smelteri 5_161	Valco 5_13.8	85.0	No
Smelteri 6_161	Valco 6_13.8	85.0	No
Smelteri_161	Smelteri_34.5	66.0	Yes

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Smelteri_161	Smelteri_34.5	66.0	Yes
Sogakope_69	Sogakope_34.5	15.0	Yes
Tafo_161	Tafo 1_11.5	13.3	Yes
Tafo_161	Tafo 2_34.5	33.0	Yes
Takoradi_161	Takoradi 1_34.5	33.0	No
Takoradi_161	Takoradi 2_34.5	66.0	Yes
Takoradi_161	Takoradi 1_34.5	33.0	No
Tamale_161	Tamale A_34.5	66.0	No
Tamale_161	Tamale B_34.5	66.0	No
Tarkwa_161	Tarkwa B_34.5	33.0	Yes
Tarkwa_161	Tarkwa A_34.5	33.0	Yes
Techiman_161	Techiman_34.5	33.0	Yes
Techiman_161	Techiman_34.5	33.0	Yes
Tema_161	New Tema 1_34.5	66.0	Yes
Tema_161	New Tema 1_34.5	66.0	Yes
Tema_161	New Tema 1_34.5	33.0	Yes
Tema_161	New Tema 2_34.5	20.0	Yes
Tema_161	New Tema 1_34.5	66.0	Yes
Tema_161	New Tema 1_34.5	66.0	Yes
TT1PP Generation_161	Enclave 1_34.5	25.0	Yes
TT1PP Generation_161	Enclave 2_34.5	25.0	Yes
TT1PP Generation_161	Enclave 3_34.5	25.0	Yes
TT1PP Generation_161	Enclave 4_34.5	50.0	Yes
Tumu_161	Tumu_34.5	33.0	Yes
Tumu_161	Tumu_34.5	33.0	Yes
Volta PST_161	Volta_330	200.0	No
Volta PST_161	Volta_330	200.0	No
Volta_161	Volta PST_161	400.0	No
Wa_161	Wa_34.5	33.0	Yes
Wa_161	Wa_34.5	33.0	Yes

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Winneba_161	Winneba B_34.5	33.0	Yes
Winneba_161	Winneba A_34.5	33.0	Yes
Yendi_161	Yendi_34.5	33.0	Yes
Yendi_161	Yendi_34.5	33.0	Yes
Zebila_161	Zebila_34.5	33.0	No
Zebila_161	Zebila_34.5	33.0	No

Table 70: Existing 2W transformers – Ghana

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Substation Side 3 [Name_Voltage]	Rated Power Side 1 [MVA]	Rated Power Side 2 [MVA]	Rated Power Side 3 [MVA]	Regulating
Akwatia_161	Akwatia 2_34.5	Akwatia 3_11.5	33.0	33.0	20.0	No
Akwatia_161	Akwatia 1_34.5	Akwatia 4_11.5	33.0	33.0	20.0	No
Asiekpe_161	Asiekpe_69	Asiekpe A_11.5	25.0	25.0	25.0	No
Asiekpe_161	Asiekpe_69	Asiekpe B_11.5	25.0	25.0	25.0	No
Bolgatanga_161	Bolgatanga 1_34.5	Bolgatanga 1_11.5	20.0	12.5	12.5	No
Bolgatanga_161	Bolgatanga 2_34.5	Bolgatanga 2_11.5	20.0	12.5	12.5	No
New Cape Coast_161	New Cape Coast C1_34.5	New Cape Coast A_11.5	33.0	33.0	20.0	No
New Cape Coast_161	New Cape Coast C1_34.5	New Cape Coast C2_11.5	33.0	33.0	20.0	No
Prestea_161	Prestea A_55	Prestea A_6.6	13.3	13.3	4.7	No
Prestea_161	Prestea B_55	Prestea B_6.6	20.0	20.0	7.0	No
Prestea_225	Prestea_161	Prestea B_13.2	200.0	200.0	70.0	No
Prestea_225	Prestea_161	Prestea C_13.2	200.0	200.0	70.0	No
Sunyani_161	Sunyani 1_34.5	Sunyani 1_11.5	33.0	33.0	20.0	No
Sunyani_161	Sunyani 2_34.5	Sunyani 2_11.5	33.0	33.0	20.0	No

Table 71: Existing 3W transformers – Ghana

Final version

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Accra Est 1_34.5	22.4	1	Switch
Accra Est 2_34.5	22.4	1	Switch
Achimota 1_34.5	21.6	1	Switch
Achimota 2_34.5	21.6	1	Switch
Achimota 3_34.5	21.6	1	Switch
Achimota 4_34.5	21.6	1	Switch
Achimota 5_34.5	21.6	1	Switch
Kenyase/Ahafo 1_11	40	-	SVC
Anwomaso 1_34.5	21.6	1	Switch
Anwomaso 2_34.5	21.6	1	Switch
Asawinso 2_34.5	10.8	1	Switch
Asawinso 2_34.5	10.8	1	Switch
Asawinso 2_34.5	10.8	1	Switch
Bogoso_34.5	10.8	1	Switch
Bogoso_34.5	10.8	1	Switch
Bolgatanga_161	-17.0	1	Switch
Cape Coast_34.5	10.8	1	Switch
Ho_11.5	5.4	1	Switch
Kadjebi_69	2.4	1	Switch
Kpandu_34.5	10.8	1	Switch
Kumasi 1_34.5	21.6	1	Switch
Kumasi 2_34.5	10.8	1	Switch
Kumasi A1_34.5	21.6	1	Switch
Kumasi A2_34.5	21.6	1	Switch
Kumasi_161	15	1	Switch
Mallam 1_34.5	21.6	1	Switch
Mallam 2_34.5	21.6	1	Switch
Mim_34.5	10.8	1	Switch
New Aberim_11	40.0	-	SVC
New Cape Coast C1_34.5	10.8	1	Switch
New Obuasi_161	10.8	1	Switch

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Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Obotan_34.5	10.8	1	Switch
Obuasi_34.5	10.8	1	Switch
Sunyani_161	5.4	1	Switch
Sunyani_161	5.4	1	Switch
Takoradi 1_34.5	10.8	1	Switch
Takoradi 2_34.5	10.8	1	Switch
Takoradi 2_34.5	10.8	1	Switch
Tamale_34.5	40.0	-	SVC
Techiman_161	10.8	1	Switch
Winneba A_34.5	10.8	1	Switch
Winneba B_34.5	10.8	1	Switch

Table 72: Existing reactive power compensation - Ghana

5.1.6. Guinea

The current electrical network of Guinea is shown on the following tables (lines, transformers, shunt reactive compensation).

Only transmission lines with operating voltage equal or higher than 60 kV are considered. The system has 16 transmission lines (10 single circuits and 6 double circuits), 53 transformers and 6 shunt reactive compensation devices.

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Kaleta_225	Maneah_225	225	114.5	260	2.57	9.27	17.33
Kaleta_225	Maneah_225	225	114.5	260	2.57	9.27	17.33
Grandes Chutes_110	Kindia_110	110	30.4	76	3.668	10.552	0.502
Kindia_110	Grandes Chutes_110	110	30.4	76	3.668	10.552	0.502
Linsan_110	Kindia_110	110	64.6	76	7.795	22.423	1.067
Linsan_110	Kindia_110	110	64.6	76	7.795	22.423	1.067
Grandes Chutes_110	Garafiri_110	110	143.0	76	17.255	49.636	2.361
Matoto_110	Grandes Chutes_110	110	68.5	76	10.566	21.785	1.088
Grandes Chutes_110	Matoto_110	110	68.5	76	8.265	23.777	1.131

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Grandes Chutes_110	Donkeah_110	110	13.0	59	2.084	4.298	0.215
Linsan_110	Garafiri_110	110	48.0	76	5.792	16.661	0.793
Linsan_110	Garafiri_110	110	48.0	76	5.792	16.661	0.793
Linsan_110	Mamou_110	110	43	76	5.188	14.926	0.710
Maneah_110	Matoto_110	110	25.0	128	1.560	8.260	0.413
Matoto_110	Maneah_110	110	25.0	128	1.560	8.260	0.413
Maneah_110	Grandes Chutes_110	110	42.5	59	6.817	14.050	0.702
Kaloum_110	Matoto_110	110	14.9	107	0.932	4.925	0.246
Matoto_110	Kaloum_110	110	14.9	107	0.932	4.925	0.246
Yessoulou_60	Grandes Chutes_60	60	36.8	32	19.830	40.890	0.200
Matoto_60	Sonfonio_60	60	10.3	32	5.550	11.440	0.057
Sonfonio_60	Yessoulou_60	60	18.51	32	9.970	20.560	0.101
Kipé_60	Matoto_60	60	4.47	32	2.400	4.960	0.025
Kipé_60	Hamdallaye_60	60	4.35	32	2.340	4.830	0.024
Hamdallaye_60	Kaloum_60	60	6.03	32	3.740	7.210	0.317

Table 73: Existing transmission lines (Nominal voltage higher than or equal to 60 kV) – Guinea

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Baneah G1_3.2	Baneah_15	2.8	No
Baneah G2_3.2	Baneah_15	2.8	No
Baneah G1_3.2	Baneah_15	2.8	No
Baneah G2_3.2	Baneah_15	2.8	No
Donkea G1_6.3	Donkeah_110	8.5	No
Donkea G2_6.3	Donkeah_110	8.5	No
Donkeah_110	Donkea_15	15.0	Yes (110 kV ±10x1.25%)
Garafiri_110	Garafiri G1_5.65	31.5	No
Garafiri_110	Garafiri G2_5.65	31.5	No
Garafiri_110	Garafiri G3_5.65	31.5	No
G-Energie G1_11.5	Kaloum_20	35.0	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
G-Energie G2_11.5	Kaloum_20	35.0	No
Grandes Chutes G1_3.3	Grandes Chutes_60	6.3	No
Grandes Chutes G2_3.3	Grandes Chutes_60	6.3	No
Grandes Chutes G3_5.5	Grandes Chutes_60	11.0	No
Grandes Chutes G4_5.5	Grandes Chutes_60	11.0	No
Grandes Chutes_60	Grandes Chutes_110	35.0	Yes (110 kV±10x1.25%)
Hamdallaye_20	Hamdallaye_60	25.0	Yes (60±8x1.25%/20kV)
Kaleta_225	Kaleta G1_10.5	92.0	No
Kaleta_225	Kaleta G2_10.5	92.0	No
Kaleta_225	Kaleta G3_10.5	92.0	No
Kaleta_225	Kaleta_30	20.0	Yes (225±8x1.25%/30kV)
Kaleta_225	Kaleta_30	20.0	Yes (225±8x1.25%/30kV)
Kaloum 1 G1_11	Kaloum_20	34.0	No
Kaloum 2 G1_11	Kaloum_20	34.0	No
Kaloum 3 G1_6.3	Kaloum_20	16.0	No
Kaloum 3 G2_6.3	Kaloum_20	16.0	No
Kaloum 3 G3_6.3	Kaloum_20	16.0	No
Kaloum 3 G4_6.3	Kaloum_20	16.0	No
Kaloum 5 G1_11	Kaloum_20	15.0	No
Kaloum 5 G2_11	Kaloum_20	15.0	No
Kaloum 5 G3_11	Kaloum_20	15.0	No
Kindia_110	Kindia_15	15.0	Yes (110 kV±10x1.25%/15kV)
Kinkon_30	Kinkon_6.3	2.4	No
Kinkon_30	Kinkon_6.3	2.4	No
Kipé G1_11	Kipé_20	34.0	No
Kipé G2_11	Kipé_20	34.0	No
Kipé_20	Kipé_60	25.0	Yes (60 kV±10x1.25%)

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Kipé_20	Kipé_60	25.0	Yes (60 kV±10x1.25%)
Mamou_110	Mamou_30	15.0	Yes (110 kV±10x1.25%/30kV)
Maneah_110	Maneah_20	75.0	No
Maneah_110	Maneah_20	75.0	No
Maneah_110	Maneah_20	75.0	No
Maneah_225	Maneah_110	150.0	Yes (225±8x1.25%/110/20 kV)
Maneah_225	Maneah_110	150.0	Yes (225±8x1.25%/110/20 kV)
Maneah_225	Maneah_110	150.0	Yes (225±8x1.25%/110/20 kV)
Matoto_110	Matoto_20	63.0	Yes (110±8x1.25%/20 kV)
Matoto_110	Matoto_20	63.0	Yes (110±8x1.25%/20 kV)
Matoto_110	Matoto_20	63.0	Yes (110±8x1.25%/20 kV)
Matoto_60	Matoto_110	35.0	Yes (110±8x1.25%/60 kV)
Kaloum_20	Kaloum_110	63.0	Yes (110±8x1.25%/60 kV)
Tombo_20	Kaloum_110	63.0	Yes (110±8x1.25%/60 kV)
Tombo_20	Kaloum_60	50.0	Yes (60+16%-20%kV)

Table 74: Existing 2W transformers – Guinea

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Hamdallaye_20	8.0	1	Switch
Hamdallaye_20	8.0	1	Switch
Maneah_20	10.0	2	Switch
Matoto_20	8.0	3	Switch
Sonfonio_60	3.84	1	Switch
Kaloum_20	8.0	2	Switch
Kaloum_20	3.84	4	Switch

Table 75: Existing reactive power compensation - Guinea

Final version

5.1.7. Guinea Bissau

The current electrical network of Guinea Bissau is not represented in the model as it does not feature high voltage transmission infrastructures interconnected with the neighbouring countries.

The national projects planned for the upcoming years are presented in Appendix J.

5.1.8. Liberia

The current electrical network of Liberia is not represented in the model as it does not feature high voltage transmission infrastructures interconnected with the neighbouring countries. The following step up transformers will be modelled to connect the generating units of Liberia once this one will be interconnected to neighbouring countries.

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Monrovia_66	Monrovia_33	20.0	No
Monrovia_66	Monrovia_33	20.0	No
Monrovia_66	Monrovia_33	20.0	No
Monrovia_66	Mont Coffee G1_10.5	20.6	No
Monrovia_66	Mont Coffee G2_10.5	20.6	No
Monrovia_66	Mont Coffee G3_10.5	20.6	No
Monrovia_66	Mont Coffee G4_10.5	20.6	No

Table 76: Existing 2W transformers - Liberia

The national projects planned for the upcoming years are presented in Appendix J.

5.1.9. Mali

The current electrical network of Mali is shown on the following tables (lines, transformers, shunt reactive compensation).

Only transmission lines with operating voltage equal or higher than 90 kV are considered. The system has 12 transmission lines (12 single circuits and no double circuits), 25 transformers and 22 shunt reactive compensation devices.

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Kayes_225	Manantali_225	225	184	283	1.850	11.920	17.120
Manantali_225	Kita_225	225	119	250	1.990	12.040	18.260
Kita_225	Kodialali_225	225	181.7	250	1.100	6.660	10.100
Sikasso_225	Koutiala_225	225	133	327	1.590	10.890	9.870
Koutiala_225	Segou_225	225	146	327	1.748	11.970	10.850
Fana_150	Segou_150	150	109	100	7.850	21.010	3.320
Kalabankoro_150	Sirakoro_150	150	17	100	1.220	3.290	0.520
Kodialali_150	Lafia_150	150	6.5	100	0.580	1.550	0.240
Kodialali_150	Kalabankoro_150	150	5	100	0.360	0.970	0.150
Sirakoro_150	Selingue_150	150	115	100	8.600	20.450	3.640
Sirakoro_150	Balingue_150	150	12	100	0.900	2.130	0.380
Sirakoro_150	Fana_150	150	112	100	8.600	21.650	3.400

Table 77: Existing transmission lines (Nominal voltage higher than or equal to 90 kV) – Mali

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
AGGREKO Balingue_11	Balingue_30	40.0	No
AGGREKO Kati_11	Kati_225	40.0	No
Balingue BID G1_15	Balingue_150	80.0	No
Balingue BID G1_15	Balingue_150	54.0	No
Balingue BID G1_15	Balingue_30	15.0	No
Balingue BID G1_15	Balingue_30	15.0	No
Balingue BID G1_15	Balingue_30	15.0	No
Balingue BID G1_15	Balingue_30	15.0	No
Dar Salam TAC_11	Lafia_150	30.0	No
Felou G1_11	Kayes_225	25.0	No
Felou G2_11	Kayes_225	25.0	No
Felou G3_11	Kayes_225	25.0	No
GPS Darsalam_11	Lafia_150	15.0	No
Kodialali_225	Kodialali_150	75.0	No
Kodialali_225	Kodialali_150	75.0	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Manantali G1_11	Manantali_225	47.0	No
Manantali G2_11	Manantali_225	47.0	No
Manantali G3_11	Manantali_225	47.0	No
Manantali G4_11	Manantali_225	47.0	No
Manantali G5_11	Manantali_225	47.0	No
Segou_225	Segou_150	60.0	No
Selingue G1_8.7	Selingue_150	54.0	No
SES Koutiala_11	Koutiala_225	12.5	No
SES Sikasso_11	Sikasso_225	12.5	No
Sotuba 1 G1_2	Balingue_30	14.5	No

Table 78: Existing 2W transformers – Mali

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Balingue_150	9.0	1	Switch
Balingue_150	17.0	1	Switch
Balingue_30	5.0	1	Switch
Fana_150	20.0	1	Switch
Fana_150	-5.0	1	Switch
Fana_150	-5.0	1	Switch
Kayes_225	-25.0	1	N/A
Kayes_225	-20.0	1	N/A
Kodialali_225	-25.0	1	N/A
Kodialali_225	-10.0	1	N/A
Koutiala_225	-50.0	1	N/A
Lafia_150	3.0	1	Switch
Lafia_150	5.0	1	Switch
Lafia_150	10.0	1	Switch
Manantali_225	-25.0	1	N/A
Segou_150	-5.0	1	Switch
Selingue_150	-7.5	1	Switch

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Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Sikasso RE_225	-12.0	1	Fixed
Sikasso_225	-30.0	1	N/A
Sikasso_225	-20.0	1	N/A
Sikasso_225	50.0	1	Switch
Sirakoro_150	-5.0	1	Switch

Table 79 Existing reactive power compensation - Mali

5.1.10. Niger

The current electrical network of Niger is shown on the following tables (lines, transformers, shunt reactive compensation).

Only transmission lines with operating voltage equal or higher than 90 kV are considered. The system has 7 transmission lines (7 single circuits and no double circuits), 14 transformers and 17 shunt reactive compensation devices.

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Maradi_132	Gazaou_132	132	N/A	82	9.850	21.310	1.980
Gazaou_132	Zinder_132	132	N/A	82	14.300	30.900	2.880
Dosso_132	Niamey 2CS_132	132	132	108	13.409	31.364	3.369
Dosso_132	Dosso/Birnin Kebbi_132	132	78	108	7.920	18.533	1.991
Malbaza_132	Maradi_132	132	199	110	12.940	45.190	5.090
Niamey 2_132	Gorou Banda-Niamey_132	132	10	99	0.797	2.303	0.250
Soraz_132	Zinder_132	132	N/A	110	3.560	12.730	1.370

Table 80: Existing transmission lines (Nominal voltage higher than or equal to 90 kV) – Niger

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Dosso_132	Dosso_20	20.0	No
Gorou Banda-Niamey_132	Goroubanda_11	30.0	No
Gorou Banda-Niamey_132	Goroubanda_11	30.0	No
Malbaza_132	Malbaza_20	10.0	No
Maradi_132	Maradi_20	10.0	No
Maradi_132	Maradi_20	10.0	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Niamey 2_132	Niamey 2D-2_20	40.0	No
Niamey 2_132	Niamey 2D-2_20	40.0	No
Niamey 2_132	Goudel G1_20	7.5	No
Niamey 2_132	Goudel G2_20	7.5	No
Niamey 2_132	Aggreko 1A_20	30.0	No
Niamey 2_132	Aggreko 1A_20	30.0	No
Niamey 2CS_132	Niamey 2CD_20	30.0	No
Zinder_132	Zinder_20	20.0	No

Table 81: Existing 2W transformers – Niger

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Dosso_20	4.0	1	Switch
Dosso_20	8.0	1	Switch
Dosso_20	8.0	1	Switch
Malbaza_20	0.9	1	Switch
Malbaza_20	4.0	1	Switch
Malbaza_20	0.9	1	Switch
Maradi_20	4.0	1	Switch
Maradi_20	4.0	1	Switch
Maradi_20	4.0	1	Switch
Niamey 2CD_20	4.0	1	Switch
Niamey 2CD_20	8.0	1	Switch
Niamey 2CD_20	8.0	1	Switch
Niamey 2CS_132	50.0	-	SVC
Niamey 2D-2_20	5.0	2	Switch
Zinder_20	2.0	1	Switch
Zinder_20	4.0	1	Switch
Zinder_20	4.0	1	Switch

Table 82: Existing reactive power compensation - Niger

Final version

5.1.11. Nigeria

The current electrical network of Nigeria is shown on the following tables (lines, transformers, shunt reactive compensation).

Only transmission lines with operating voltage equal or higher than 90 kV are considered. The system has 208 transmission lines (139 single circuits and 69 double circuits), 460 transformers and 78 reactive compensation devices.

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	Resistance (% p.u.)	Reactance (% p.u.)	Half susceptance (% p.u.)
ADIABOR 3	ODUKPANI 3_330	330	N/A	777	0.064	0.541	3.385
ADIABOR 3	ODUKPANI 3_330	330	N/A	777	0.064	0.541	3.385
AFAM IV 3	ALAOJI 3_330	330	N/A	777	0.090	0.760	4.747
AFAM IV 3	ALAOJI 3_330	330	N/A	777	0.089	0.760	4.747
AJA 3	EGBIN 3_330	330	N/A	777	0.050	0.426	2.658
AJA 3	EGBIN 3_330	330	N/A	777	0.050	0.426	2.658
AJA 3	LEKKI 3_330	330	N/A	777	0.650	0.547	3.418
AJA 3	LEKKI 3_330	330	N/A	777	0.650	0.547	3.418
AJAOKUTA 3	BENIN 3_330	330	N/A	777	0.698	5.927	37.025
AJAOKUTA 3	BENIN 3_330	330	N/A	777	0.698	5.927	37.025
AJAOKUTA 3	GEREGU_330	330	N/A	777	0.005	0.046	0.285
AJAOKUTA 3	GEREGU_330	330	N/A	777	0.005	0.046	0.285
AJAOKUTA 3	LOKOJA_3_330	330	N/A	777	0.170	1.441	9.000
AKANGBA 3	IKEJA W 3_330	330	N/A	777	0.061	0.517	3.227
AKANGBA 3	IKEJA W 3_330	330	N/A	777	0.061	0.517	3.227
AKURE 3	IHOVBOR_3_330	330	N/A	777	0.501	4.255	26.600
ALADJA 3	DELTA IV 3_330	330	N/A	777	0.115	0.973	6.076
ALADJA 3	SAPELE 3_330	330	N/A	777	0.226	1.915	11.962
ALAOJI 3	IKOTEKPENE 3_330	330	N/A	777	0.358	3.040	19.000
ALAOJI 3	IKOTEKPENE 3_330	330	N/A	777	0.358	3.040	19.000
AYEDE 3	OSOGBO 3_330	330	N/A	777	0.412	3.495	21.836
BENIN 3	DELTA IV 3_330	330	N/A	777	0.147	1.246	7.785
BENIN 3	SAPELE 3_330	330	N/A	777	0.179	1.520	9.493
BENIN 3	SAPELE 3_330	330	N/A	777	0.179	1.520	9.493
BENIN 3	SAPELE 3_330	330	N/A	777	0.179	1.520	9.493

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	Resistance (% p.u.)	Reactance (% p.u.)	Half susceptance (% p.u.)
BENIN 3	IHOVBOR_3_330	330	N/A	777	0.090	0.763	4.766
BENIN 3	ONITSHA 3_330	330	N/A	777	0.491	4.164	26.013
BENIN 3	ONITSHA 3_330	330	N/A	777	0.491	4.164	26.013
BKEBBI 3	KAINJI G.S.3_330	330	N/A	777	1.110	9.422	58.861
EGBIN 3	IKEJA W 3_330	330	N/A	777	0.065	0.547	3.418
EGBIN 3	OKE_ARO_ 3_330	330	N/A	777	0.065	0.547	3.418
EGBIN 3	OKE_ARO_ 3_330	330	N/A	777	0.065	0.547	3.418
EGBIN 3	BENIN 3_330	330	N/A	777	0.716	6.079	37.975
GANMO 3	JEBBA T.S.3_330	330	N/A	777	0.394	3.344	20.886
GOMBE 3	JOS 3_330	330	N/A	777	0.945	8.024	50.127
GOMBE 3	YOLA 3_330	330	N/A	777	0.860	7.295	45.570
GOMBE 3	DAMATURU 3_330	330	N/A	777	0.573	4.863	30.360
GWAGWALADA_3	LOKOJA_3_330	330	N/A	777	0.625	5.307	33.152
IKEJA W 3	OLORUNSOGO3_330	330	N/A	777	0.276	2.340	14.620
IKEJA W 3	OKE_ARO_ 3_330	330	N/A	777	0.065	0.547	3.418
IKEJA W 3	OKE_ARO_ 3_330	330	N/A	777	0.065	0.547	3.418
IKEJA W 3	OSOGBO 3_330	330	N/A	777	0.895	7.599	47.469
IKEJA W 3	OMOTOSHO3_330	330	N/A	777	0.286	2.432	15.189
IKOTEKPENE 3	ODUKPANI 3_330	330	N/A	777	0.251	2.128	13.300
IKOTEKPENE 3	ODUKPANI 3_330	330	N/A	777	0.251	2.128	13.300
JEBBA T.S.3	JEBBA G.S.3_330	330	N/A	777	0.029	0.243	1.519
JEBBA T.S.3	JEBBA G.S.3_330	330	N/A	777	0.029	0.243	1.519
JEBBA T.S.3	KAINJI T.S.3_330	330	N/A	777	0.290	2.462	15.380
JEBBA T.S.3	KAINJI T.S.3_330	330	N/A	777	0.290	2.462	15.380
JEBBA T.S.3	_330	330	N/A	777	0.437	3.708	23.160
JEBBA T.S.3	ZUNGERU_330	330	N/A	777	0.437	3.708	23.160
JOS 3	MAKURDI 3_330	330	N/A	777	0.824	6.991	43.700
JOS 3	MAKURDI 3_330	330	N/A	777	0.824	6.991	43.700
KADUNA 3	KANO 3_330	330	N/A	600	0.824	6.991	43.672
KADUNA 3	JOS 3_330	330	N/A	777	0.702	5.957	37.216

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	Resistance (% p.u.)	Reactance (% p.u.)	Half susceptance (% p.u.)
KADUNA 3	JOS 3_330	330	N/A	777	0.702	5.957	37.216
KADUNA 3	JOS 3_330	330	N/A	777	0.702	5.957	37.216
KAINJI G.S.3	KAINJI T.S.3_330	330	N/A	777	0.005	0.046	0.285
KAINJI G.S.3	KAINJI T.S.3_330	330	N/A	777	0.005	0.046	0.285
KAINJIB	KAINJI G.S.3_330	330	1.0	777	0.004	0.028	0.246
KATAMPE 3	SHIRORO 3_330	330	N/A	777	0.781	6.626	41.392
KATAMPE 3	GWAGWALADA_3_330	330	N/A	777	0.258	2.188	13.671
LEKKI 3	ALAGBON 3_330	330	N/A	777	0.650	0.547	3.418
LEKKI 3	ALAGBON 3_330	330	N/A	777	0.650	0.547	3.418
MAKURDI 3	UGWUAJI 3_330	330	N/A	777	0.537	4.559	28.504
MAKURDI 3	UGWUAJI 3_330	330	N/A	777	0.537	4.559	28.504
NHAVEN 3	ONITSHA 3_330	330	N/A	777	0.344	2.918	18.228
NHAVEN 3	UGWUAJI 3_330	330	N/A	777	0.018	0.152	0.950
NHAVEN 3	UGWUAJI 3_330	330	N/A	777	0.018	0.152	0.950
OLORUNSOGO3	AYEDE 3_330	330	N/A	777	0.215	1.824	11.392
OMOTOSHO3	BENIN 3_330	330	N/A	777	0.183	1.550	9.684
ONITSHA 3	OKPAI 3_330	330	N/A	777	0.215	1.824	11.392
ONITSHA 3	OKPAI 3_330	330	N/A	777	0.215	1.824	11.392
ONITSHA 3	ASABA 3_330	330	N/A	777	0.065	0.547	3.418
ONITSHA 3	ALAOJI 3_330	330	N/A	700	0.494	4.194	26.203
OSOGBO 3	GANMO 3_330	330	N/A	777	0.168	1.429	8.924
OSOGBO 3	AKURE 3_330	330	N/A	777	0.358	3.040	19.000
OSOGBO 3	JEBBA T.S.3_330	330	N/A	777	0.562	4.772	29.810
OSOGBO 3	JEBBA T.S.3_330	330	N/A	777	0.562	4.772	29.810
OSOGBO 3	IHOVBOR_3_330	330	N/A	777	0.505	4.286	26.772
OSOGBO 3	IHOVBOR_3_330	330	N/A	777	0.505	4.286	26.772
SHIRORO 3	GWAGWALADA_3_330	330	N/A	777	0.523	4.438	27.722
SHIRORO 3	KADUNA 3_330	330	N/A	300	0.344	2.918	18.228
SHIRORO 3	KADUNA 3_330	330	N/A	300	0.344	2.918	18.228
UGWUAJI 3	IKOTEKPENE 3_330	330	N/A	777	0.512	4.346	27.150

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	Resistance (% p.u.)	Reactance (% p.u.)	Half susceptance (% p.u.)
UGWUAJI 3	IKOTEKPENE 3_330	330	N/A	777	0.512	4.346	27.150
ZUNGERU	SHIRORO 3_330	330	N/A	777	0.437	3.708	23.160
ZUNGERU	SHIRORO 3_330	330	N/A	777	0.437	3.708	23.160
9TH MILE 1	NSUKKA 1_132	132	N/A	126	2.612	8.324	0.942
ADO EKITI 1	AKURE 1_132	132	N/A	126	3.318	10.574	1.196
ADO EKITI 1	AKURE 1_132	132	N/A	126	3.318	10.574	1.196
AFAM 1	ALAOJI 1_132	132	N/A	126	3.247	10.349	1.171
AFAM 1	PHCT MAIN1_132	132	N/A	126	2.668	8.504	0.962
AFAM 1	RIVERS_IPP_132	132	N/A	126	1.334	4.252	0.481
AGBARA 1	OJO 1_132	132	N/A	126	1.156	3.683	0.417
AGBARA 1	OJO 1_132	132	N/A	126	1.156	3.683	0.417
AHOADA 1	OMOKU 1_132	132	N/A	126	1.059	3.375	0.382
AHOADA 1	OMOKU 1_132	132	N/A	126	1.059	3.375	0.382
AHOADA 1	OWERRI 1_132	132	N/A	126	5.153	16.423	1.859
AHOADA 1	OWERRI 1_132	132	N/A	126	5.153	16.423	1.859
AJAOKUTA 1	OKENE 1_132	132	N/A	126	4.236	13.499	1.528
AKANGBA 1	ITIRE 1_132	132	N/A	126	0.212	0.675	0.079
AKANGBA 1	ITIRE 1_132	132	N/A	126	0.212	0.675	0.079
AKANGBA 1	AMUWO ODOFIN_132	132	N/A	126	0.706	2.250	0.255
AKANGBA 1	APAPA RD 1_132	132	N/A	126	0.318	1.012	0.115
AKANGBA 1	IJORA 1_132	132	N/A	126	0.586	1.867	0.212
AKANGBA 1	IJORA 1_132	132	N/A	126	0.586	1.867	0.212
AKANGBA 1	ISOLO 1_132	132	N/A	126	0.318	1.012	0.115
AKANGBA 1	ISOLO 1_132	132	N/A	126	0.318	1.012	0.115
AKOKA 1	ALAGBON 1_132	132	N/A	126	0.847	2.700	0.306
AKOKA 1	IJORA 1_132	132	N/A	126	0.565	1.800	0.204
AKOKA 1	OWOROSOKI 1_132	132	N/A	126	0.314	1.001	0.113
AKOKA 1	OWOROSOKI 1_132	132	N/A	126	0.314	1.001	0.113
AKWANGA 1	KEFFI 1_132	132	N/A	126	4.377	13.949	1.579
ALAGBON 1	IJORA 1_132	132	N/A	126	0.282	0.900	0.102

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	Resistance (% p.u.)	Reactance (% p.u.)	Half susceptance (% p.u.)
ALAOJI 1	ABA 1_132	132	N/A	126	0.706	2.250	0.255
ALAOJI 1	ABA 1_132	132	N/A	126	0.706	2.250	0.255
ALAOJI 1	UMUAHIA 1_132	132	N/A	126	4.659	14.849	1.680
ALAOJI 1	UMUAHIA 1_132	132	N/A	126	4.659	14.849	1.680
ALAOJI 1	OWERRI 1_132	132	N/A	126	4.226	13.467	1.523
ALAOJI 1	OWERRI 1_132	132	N/A	126	4.226	13.467	1.523
ALAUSA 1	OGBA 1_132	132	N/A	126	0.141	0.450	0.051
ALAUSA 1	OGBA 1_132	132	N/A	126	0.141	0.450	0.051
ALIMOSHO 1	OGBA 1_132	132	N/A	126	0.671	2.137	0.242
ALIMOSHO 1	OGBA 1_132	132	N/A	126	0.671	2.137	0.242
AMUKPE 1	OGHARA 1_132	132	N/A	126	3.459	11.024	1.247
AMUWO ODOFIN	APAPA RD 1_132	132	N/A	126	0.141	0.450	0.051
AMUWO ODOFIN	OJO 1_132	132	N/A	126	0.628	2.002	0.227
AMUWO ODOFIN	OJO 1_132	132	N/A	126	0.628	2.002	0.227
APO 1	KARU 1_132	132	N/A	126	0.706	2.250	0.255
ASABA 1	AGBOR 1_132	132	N/A	126	4.236	13.499	1.528
ASABA 1	AGBOR 1_132	132	N/A	126	4.236	13.499	1.528
ASHAKA 1	ASHAKA RNDAB_132	132	N/A	126	0.706	2.250	0.255
ASHAKA RNDAB	POTISKUM 1_132	132	N/A	126	7.483	23.848	2.698
AWKA 1	OJI RIVER 1_132	132	N/A	126	2.354	7.503	0.849
AYEDE 1	IBADAN NORTH_132	132	N/A	126	0.424	1.350	0.153
AYEDE 1	JERICHO 1_132	132	N/A	126	0.141	0.450	0.051
AZARE 1	DUTSE 1_132	132	N/A	126	3.035	9.674	1.094
BENIN 1	IRRUA 1_132	132	N/A	126	6.269	19.978	2.260
BENIN 1	AMUKPE 1_132	132	N/A	126	0.847	2.700	0.306
BIDA 1	MINNA 1_132	132	N/A	126	6.353	20.248	2.291
BIU 1	DAMBOA 1_132	132	N/A	70	10.024	31.946	3.614
BKEBBI 1	SOKOTO 1_132	132	N/A	126	9.177	29.247	3.309
CALABAR 1	ADIABOR 1_132	132	N/A	126	3.035	9.674	1.094
CALABAR 1	ADIABOR 1_132	132	N/A	126	3.035	9.674	1.094

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	Resistance (% p.u.)	Reactance (% p.u.)	Half susceptance (% p.u.)
CENTRAL AREA	GARKI NODE 1_132	132	N/A	154	0.124	0.241	4.029
CENTRAL AREA	GARKI NODE 1_132	132	N/A	154	0.124	0.241	4.029
DAKATA 1	WALALAMBE 1_132	132	N/A	126	0.565	1.800	0.204
DAKATA 1	HADEJIA 1_132	132	N/A	70	26.200	40.000	3.500
DAMBOA 1	MAIDUGURI 1_132	132	N/A	70	5.012	15.973	1.807
DELTA 1	BENIN 1_132	132	N/A	126	7.553	24.072	2.724
DELTA 1	EFFURUN 1_132	132	N/A	90	4.277	8.533	0.867
DELTA 1	EFFURUN 1_132	132	N/A	90	4.277	8.533	0.867
DELTA 1	AMUKPE 1_132	132	N/A	126	6.353	20.248	2.291
DOSSO	NIAMEY 1_132	132	N/A	126	9.530	30.372	3.437
DUTSE 1	WUDIL 1_132	132	N/A	126	3.586	11.429	1.293
EDE_1	OSOGBO 1_132	132	N/A	550	1.059	3.375	0.382
EDE_1	OSOGBO 1_132	132	N/A	550	1.059	3.375	0.382
EGBIN 1	IKORODU_132	132	N/A	126	1.412	4.500	0.509
EGBIN 1	IKORODU_132	132	N/A	126	1.412	4.499	0.509
EKET 1	UYO 1_132	132	N/A	126	3.247	10.349	1.171
EKET 1	UYO 1_132	132	N/A	126	3.247	10.349	1.171
GANMO 1	ILORIN 1_132	132	N/A	126	0.353	1.125	0.127
GOMBE 1	ASHAKA RNDAB_132	132	N/A	126	5.365	17.098	1.934
GOMBE 1	BAUCHI 1_132	132	N/A	126	10.306	32.847	3.716
GOMBE 1	BIU 1_132	132	N/A	126	10.023	31.947	3.614
GOMBE 1	T-JUNCTION 1_132	132	N/A	70	7.101	10.652	0.930
GUSAU 1	FUNTUA 1_132	132	N/A	90	13.068	26.073	2.649
IBADAN NORTH	IWO 1_132	132	N/A	126	1.271	4.050	0.458
IFE 1	ILESHA 1_132	132	N/A	126	1.377	4.387	0.496
IFE 1	ONDO2 1_132	132	N/A	126	4.095	13.051	1.477
IKEJA W 1	AGBARA 1_132	132	N/A	126	2.262	7.208	0.816
IKEJA W 1	AGBARA 1_132	132	N/A	126	2.262	7.208	0.816
IKEJA W 1	ALIMOSHO 1_132	132	N/A	126	0.247	0.787	0.089
IKEJA W 1	ALIMOSHO 1_132	132	N/A	126	0.247	0.787	0.089

Final version

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	Resistance (% p.u.)	Reactance (% p.u.)	Half susceptance (% p.u.)
IKEJA W 1	EJIGBO 1_132	132	N/A	126	0.940	2.997	0.339
IKEJA W 1	EJIGBO 1_132	132	N/A	126	0.940	2.997	0.339
IKEJA W 1	ILLUPEJU 1_132	132	N/A	126	1.412	4.500	0.509
IKEJA W 1	ILLUPEJU 1_132	132	N/A	126	1.412	4.500	0.509
IKEJA W 1	OTTA 1_132	132	N/A	126	0.847	2.700	0.306
IKEJA W 1	OTTA 1_132	132	N/A	126	0.847	2.700	0.306
IKEJA W 1	OWOROSOKI 1_132	132	N/A	126	3.459	11.024	1.247
IKEJA W 1	OWOROSOKI 1_132	132	N/A	126	3.459	11.024	1.247
IKEJA W 1	AYOBO 1_132	132	N/A	126	0.706	2.250	0.255
IKEJA W 1	AYOBO 1_132	132	N/A	126	0.706	2.250	0.255
IKORODU	SHAGAMU 1_132	132	N/A	126	2.534	8.077	0.914
ILESHA 1	ILESHA TEE1_132	132	N/A	126	1.412	4.502	0.510
ILLUPEJU 1	MARYLAND1_132	132	N/A	126	0.402	1.282	0.145
ILLUPEJU 1	MARYLAND1_132	132	N/A	126	0.402	1.282	0.145
IRRUA 1	UKPILLA 1_132	132	N/A	126	3.035	9.674	1.094
ITIRE 1	EJIGBO 1_132	132	N/A	126	0.565	1.800	0.204
ITIRE 1	EJIGBO 1_132	132	N/A	126	0.565	1.800	0.204
ITU 1	UYO 1_132	132	N/A	126	1.271	4.050	0.458
ITU 1	UYO 1_132	132	N/A	126	1.271	4.050	0.458
ITU 1	ABA 1_132	132	N/A	126	6.029	19.213	2.174
ITU 1	ADIABOR 1_132	132	N/A	126	3.343	10.655	1.206
IWO 1	ISEYIN 1_132	132	N/A	126	5.012	15.973	1.807
JOS 1	BAUCHI 1_132	132	N/A	126	8.330	26.547	3.003
JOS 1	MAKERI 1_132	132	N/A	126	3.530	11.249	1.273
JOS 1	MAKERI 1_132	132	N/A	126	3.530	11.249	1.273
JOS 1	KAFANCHAN 1_132	132	N/A	126	5.436	17.323	1.960
JOS 1	KAFANCHAN 1_132	132	N/A	126	5.436	17.323	1.960
KADUNA 1	KADUNA TOWN_132	132	N/A	126	1.412	4.500	0.509
KADUNA 1	KADUNA TOWN_132	132	N/A	126	1.412	4.500	0.509
KADUNA 1	ZARIA 1_132	132	N/A	90	7.366	14.696	1.493

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From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	Resistance (% p.u.)	Reactance (% p.u.)	Half susceptance (% p.u.)
KAIN	NEWBUSSA_132	132	11.4	85	1.354	2.702	0.275
KANKIA 1	KATSINA 1_132	132	N/A	126	4.871	15.523	1.757
KANO 1	KANKIA 1_132	132	N/A	126	7.977	25.422	2.876
KANO 1	DAKATA 1_132	132	N/A	70	1.540	3.200	0.300
KANO 1	DAKATA 1_132	132	N/A	70	1.540	3.200	0.300
KANO 1	DAN AGUNDI 1_132	132	N/A	90	1.000	1.900	0.200
KANO 1	AZARE 1_132	132	N/A	126	14.963	47.690	5.386
KANO 1	DUTSE 1_132	132	N/A	126	7.659	24.410	2.762
KANO 1	KATSINA 1_132	132	N/A	126	10.236	32.622	3.691
KANO 1	TAMBURAWA 1_132	132	N/A	90	2.376	4.741	0.481
KANO 1	WUDIL 1_132	132	N/A	126	3.530	11.249	1.273
KARU 1	KEFFI 1_132	132	N/A	126	2.894	9.224	1.043
KATAMPE 1	KUBWA_132	132	N/A	126	0.494	1.575	0.178
KATAMPE 1	APO 1_132	132	N/A	126	1.059	3.375	0.382
KATAMPE 1	APO 1_132	132	N/A	126	1.059	3.375	0.382
KATAMPE 1	GARKI NODE 1_132	132	N/A	126	0.424	1.350	0.153
KATAMPE 1	GARKI NODE 1_132	132	N/A	126	0.424	1.350	0.153
KATAMPE 1	NAT STADIUM_132	132	N/A	550	0.565	1.800	2.036
KATAMPE 1	NAT STADIUM_132	132	N/A	550	0.565	1.800	2.036
KATSINA 1	DAURA 1_132	132	N/A	126	5.647	17.998	2.036
KATSINA 1	DAURA 1_132	132	N/A	126	5.647	17.998	2.036
KONTAGORA 1	TEGINA 1_132	132	N/A	126	6.353	20.248	2.291
KONTAGORA 1	YELWA 1_132	132	N/A	126	6.212	19.798	2.240
KWANAR DANGO	ZARIA 1_132	132	N/A	90	10.074	20.100	2.043
MAIDUGURI 1	DAMATURU 1_132	132	N/A	126	5.820	49.391	7.899
MAKURDI 1	ALIADE 1_132	132	N/A	126	1.765	5.624	0.637
MINNA 1	SULEJA 1_132	132	N/A	126	6.989	22.273	2.520
MINNA 1	SULEJA 1_132	132	N/A	126	6.989	22.273	2.520
NEWBUSSA	KAIN132_132	132	11.4	85	1.354	2.702	0.275
NHAVEN 1	9TH MILE 1_132	132	N/A	126	0.706	2.250	0.255

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	Resistance (% p.u.)	Reactance (% p.u.)	Half susceptance (% p.u.)
NHAVEN 1	NKALAGU 1_132	132	N/A	126	2.753	8.774	0.993
NHAVEN 1	NKALAGU 1_132	132	N/A	126	2.753	8.774	0.993
NHAVEN 1	OJI RIVER 1_132	132	N/A	126	3.113	9.921	1.122
NHAVEN 1	OTURKPO 1_132	132	N/A	126	11.019	35.119	3.971
NKALAGU 1	ABAKALIKI 1_132	132	N/A	126	3.830	12.205	1.381
OFFA 1	OMUARAN 1_132	132	N/A	126	3.355	10.693	1.210
OGBA 1	OTTA 1_132	132	N/A	126	3.127	9.966	1.128
OKADA 1	IHOVBOR 1_132	132	N/A	126	2.471	7.874	0.891
OKADA 1	IHOVBOR 1_132	132	N/A	126	2.471	7.874	0.891
OKENE 1	UKPILLA 1_132	132	N/A	126	2.330	7.424	0.840
ONDO1 1	ONDO2 1_132	132	N/A	126	4.130	13.161	1.489
ONITSHA 1	AWKA 1_132	132	N/A	126	2.118	6.749	0.763
ONITSHA 1	GCM 1_132	132	N/A	126	1.306	4.165	0.472
OSOGBO 1	AKURE 1_132	132	N/A	126	6.565	20.923	2.365
OSOGBO 1	IWO 1_132	132	N/A	126	5.647	17.998	2.036
OSOGBO 1	OFFA 1_132	132	N/A	126	3.706	11.811	1.337
OSOGBO 1	ILESHA TEE1_132	132	N/A	126	1.023	3.260	0.369
OTURKPO 1	ALIADE 1_132	132	N/A	126	2.767	8.819	0.998
OWO 1	OSOGBO 1_132	132	N/A	126	5.647	17.998	2.037
PANKSHIN 1	MAKERI 1_132	132	N/A	126	6.353	20.248	2.291
PANKSHIN 1	MAKERI 1_132	132	N/A	126	6.353	20.248	2.291
PAPALANTO 1	OTTA 1_132	132	N/A	126	2.118	6.749	0.763
PAPALANTO 1	OLD ABEOKUTA_132	132	N/A	126	3.883	12.374	1.400
PHCT MAIN1	PHCT TOWN1 1_132	132	N/A	126	0.212	0.675	0.076
PHCT MAIN1	PHCT TOWN2 1_132	132	N/A	126	0.212	0.675	0.076
PHCT MAIN1	RIVERS_IPP_132	132	N/A	126	1.334	4.252	0.481
SAVANNAH 1	T-JUNCTION 1_132	132	N/A	70	9.231	13.848	1.210
SHAGAMU 1	IJEBU ODE 1_132	132	N/A	126	2.894	9.224	1.043
SHAGAMU 1	AYEDE 1_132	132	N/A	126	6.494	20.698	2.342
SHIRORO 1	TEGINA 1_132	132	N/A	126	4.589	14.624	1.655

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From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	Resistance (% p.u.)	Reactance (% p.u.)	Half susceptance (% p.u.)
SHIRORO 1	MINNA 1_132	132	N/A	126	4.800	15.298	1.731
SHIRORO 1	MINNA 1_132	132	N/A	126	4.800	15.298	1.731
SOKOTO 1	TMAFARA 1_132	132	N/A	126	8.824	28.122	3.182
TAMBURAWA 1	KWANAR DANGO_132	132	N/A	90	4.752	9.481	0.964
TMAFARA 1	GUSAU 1_132	132	N/A	126	6.000	19.123	2.164
YANDEV 1	ALIADE 1_132	132	N/A	126	2.767	8.819	0.998
YENAGOA 1	AHOADA 1_132	132	N/A	126	3.247	10.349	1.171
YENAGOA 1	GBARAIN UBIE_132	132	N/A	126	0.353	1.125	0.127
YOLA 1	T-JUNCTION 1_132	132	N/A	70	33.199	49.798	4.351
YOLA 1	JALINGO 1_132	132	N/A	126	11.301	36.019	0.920
ZARIA 1	FUNTUA 1_132	132	N/A	90	8.316	16.592	1.686

Table 83: Existing transmission lines (Nominal voltage higher than or equal to 90 kV) – Nigeria

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
AJA_132	AJA	46	No
AJA_132	AJA	46	No
AJA_132	AJA	46	No
AKANGBA 1_132	AKANGBA 33	60	No
AKANGBA 1_132	AKANGBA 33	60	No
AKANGBA 1_132	AKANGBA 33	60	No
AKANGBA 1_132	AKANGBA 33	60	No
AKANGBA 1_132	AKANGBA 33	60	No
EGBIN 1_132	AES BERG202	315	No
EGBIN 1_132	AES BERG203	315	No
EGBIN 1_132	AES BERG204	315	No
EGBIN 1_132	AES BERG205	315	No
EGBIN 1_132	AES BERG206	315	No
EGBIN 1_132	AES BERG207	315	No
EGBIN 1_132	AES BERG208	315	No
EGBIN 1_132	AES BERG209	315	No

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Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
EGBIN 1_132	AES BERG210	315	No
EGBIN 1_132	AES BERG211	315	No
PAPALANTO 1_132	PAPALANTO 33	30	No
PAPALANTO 1_132	PAPALANTO 33	15	No
PAPALANTO 1_132	PAPALANTO 33	15	No
AGBARA 1_132	AGBARA 33	40	No
AGBARA 1_132	AGBARA 33	40	No
AGBARA 1_132	AGBARA 33	40	No
AKOKA 1_132	AKOKA T3	35	No
AKOKA 1_132	AKOKA T3	35	No
ALAGBON 1_132	ALAGBON 33	66	No
ALAGBON 1_132	ALAGBON 33	66	No
ALAGBON 1_132	ALAGBON 33	66	No
ALAGBON 1_132	ALAGBON 33	66	No
ALAUSA 1_132	ALAUSA 33	40	No
ALAUSA 1_132	ALAUSA 33	40	No
ALAUSA 1_132	ALAUSA 33	40	No
ALIMOSHO 1_132	ALIMOSHO 33	40	No
ALIMOSHO 1_132	ALIMOSHO 33	40	No
ALIMOSHO 1_132	ALIMOSHO 33	40	No
ITIRE 1_132	ITIRE 33	43	No
ITIRE 1_132	ITIRE 33	43	No
ITIRE 1_132	ITIRE 33	43	No
AMUWO ODOFIN_132	AMUWO ODOFIN	43	No
AMUWO ODOFIN_132	AMUWO ODOFIN	43	No
AMUWO ODOFIN_132	AMUWO ODOFIN	43	No
APAPA RD 1_132	APAPA RD 33	30	No
APAPA RD 1_132	APAPA RD 33	30	No
EJIGBO 1_132	EJIGBO 33	48	No
EJIGBO 1_132	EJIGBO 33	48	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
EJIGBO 1_132	EJIGBO 33	48	No
IJORA 1_132	IJORA 33	30	No
IJORA 1_132	IJORA 33	30	No
IJORA 1_132	IJORA 33	30	No
IJORA 1_132	IJORA 33	30	No
IKORODU_132	IKORODU 33	60	No
IKORODU_132	IKORODU 33	60	No
IKORODU_132	IKORODU 33	60	No
ILLUPEJU 1_132	ILUPEJU 33	30	No
ILLUPEJU 1_132	ILUPEJU 11	20	No
ILLUPEJU 1_132	ILUPEJU 11	20	No
ILLUPEJU 1_132	ILUPEJU 11	20	No
ISOLO 1_132	ISOLO 33	50	No
ISOLO 1_132	ISOLO 33	50	No
ISOLO 1_132	ISOLO 33	50	No
ISOLO 1_132	ISOLO 11	15	No
OJO 1_132	OJO 33	45	No
OJO 1_132	OJO 33	45	No
OJO 1_132	OJO 33	45	No
OJO 1_132	OJO 33	45	No
LEKKI 1_132	LEKKI 33_TR1	60	No
LEKKI 1_132	LEKKI 33_TR1	60	No
MARYLAND1_132	MARYLAND 33	40	No
MARYLAND1_132	MARYLAND 33	40	No
MARYLAND1_132	MARYLAND 33	40	No
OGBA 1_132	OGBA 33	48	No
OGBA 1_132	OGBA 33	48	No
OGBA 1_132	OGBA 33	48	No
OGBA 1_132	OGBA 33	48	No
OGBA 1_132	OGBA 11	20	No

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Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
OTTA 1_132	OTTA 33	48	No
OTTA 1_132	OTTA 33	48	No
OTTA 1_132	OTTA 33	48	No
OTTA 1_132	OTTA 33	48	No
OWOROSOKI 1_132	OWOROSOKI 33	60	No
OWOROSOKI 1_132	OWOROSOKI 33	60	No
AYOBO 1_132	AYOBO 33	60	No
AYOBO 1_132	AYOBO 33	60	No
SHAGAMU 1_132	SHAGAMU 33	30	No
SHAGAMU 1_132	SHAGAMU 33	30	No
SHAGAMU 1_132	SHAGAMU_CEME	15	No
SHAGAMU 1_132	SHAGAMU_CEME	15	No
SHAGAMU 1_132	PARAS_GT1	100	No
SHAGAMU 1_132	PARAS_GT2	100	No
OLD ABEOKUTA_132	ABEOKUTA OLD	30	No
OLD ABEOKUTA_132	ABEOKUTA OLD	30	No
OLD ABEOKUTA_132	ABEOKUTA OLD	30	No
OKE_ARO_1_132	OKE_ARO 33	60	No
OKE_ARO_1_132	OKE_ARO 33	60	No
IJEBU ODE 1_132	IJEBU ODE 33	30	No
IJEBU ODE 1_132	IJEBU ODE 33	30	No
EDE_1_132	EDE 33	60	No
EGBIN 3_330	EGBIN ST 1	200	No
EGBIN 3_330	EGBIN ST 2	1350	No
EGBIN 3_330	EGBIN ST 3	1350	No
EGBIN 3_330	EGBIN ST 4	1350	No
EGBIN 3_330	EGBIN ST 5	1350	No
EGBIN 3_330	EGBIN ST 6	1350	No
OLORUNSOGO3_330	OLORUNSO GT1	380	No
OLORUNSOGO3_330	OLORUNSO GT2	380	No

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
OLORUNSOGO3_330	OLORUNSO GT3	380	No
OLORUNSOGO3_330	OLORUNSO GT4	380	No
OLORUNSOGO3_330	OLORUNSO GT5	380	No
OLORUNSOGO3_330	OLORUNSO GT6	380	No
OLORUNSOGO3_330	OLORUNSO GT7	380	No
OLORUNSOGO3_330	OLORUNSO GT8	380	No
OLORUNSOGO3_330	OLORNIPPGT11	380	No
OLORUNSOGO3_330	OLORNIPPGT12	380	No
OLORUNSOGO3_330	OLORNIPPGT21	380	No
OLORUNSOGO3_330	OLORNIPPGT22	380	No
OLORUNSOGO3_330	OLOR NIPPST1	380	No
OLORUNSOGO3_330	OLOR NIPPST2	380	No
AYEDE 1_132	AYEDE 33	73	No
AYEDE 1_132	AYEDE 33	73	No
AYEDE 1_132	AYEDE 33	73	No
OSOGBO 1_132	OSOGBO 33	50	No
OSOGBO 1_132	OSOGBO 33	50	No
OSOGBO 1_132	OSOGBO 33	50	No
GANMO 1_132	GANMO 33	60	No
GANMO 1_132	GANMO 33	60	No
ADO EKITI 1_132	ADO EKITI 33	40	No
ADO EKITI 1_132	ADO EKITI 33	40	No
AKURE 1_132	AKURE 33	40	No
AKURE 1_132	AKURE 33	40	No
AKURE 1_132	AKURE 33	60	No
AKURE 1_132	AKURE 33	30	No
AKURE 1_132	AKURE 33	40	No
IBADAN NORTH_132	IBADAN NORTH	60	No
IBADAN NORTH_132	IBADAN NORTH	60	No
IBADAN NORTH_132	MCFERSON 33	40	No

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Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
IFE 1_132	IFE 33	30	No
IFE 1_132	IFE 33	30	No
IWO 1_132	IWO 33	40	No
ILESHA 1_132	ILESHA 33	40	No
ILESHA 1_132	ILESHA 33	40	No
ILORIN 1_132	ILORIN 33	45	No
ILORIN 1_132	ILORIN 33	45	No
ISEYIN 1_132	ISEYIN 33	30	No
ISEYIN 1_132	ISEYIN 33	30	No
JERICHO 1_132	JERICHO 33	35	No
JERICHO 1_132	JERICHO 33	35	No
OFFA 1_132	OFFA 33	30	No
OMUARAN 1_132	OMUARAN 33	30	No
OMUARAN 1_132	OMUARAN 33	30	No
ONDO1 1_132	ONDO1 33	30	No
ONDO1 1_132	ONDO1 33	30	No
OMOTOSHO3_330	OMOTOSO GT1	380	No
OMOTOSHO3_330	OMOTOSO GT2	380	No
OMOTOSHO3_330	OMOTOSO GT3	380	No
OMOTOSHO3_330	OMOTOSO GT4	380	No
OMOTOSHO3_330	OMOTOSO GT5	380	No
OMOTOSHO3_330	OMOTOSO GT6	380	No
OMOTOSHO3_330	OMOTOSO GT7	380	No
OMOTOSHO3_330	OMOTOSO GT8	380	No
OMOTOSHO3_330	OMOTNIPP GT1	380	No
OMOTOSHO3_330	OMOTNIPP GT2	380	No
JEBBA 1_132	JEBBA 33	30	No
SHIRORO 1_132	SHIRORO 33	30	No
KATAMPE 1_132	KATAMPE 33	60	No
KATAMPE 1_132	KATAMPE 33	60	No

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Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
BKEBBI 1_132	BKEBBI 33	35	No
BKEBBI 1_132	BKEBBI 33	35	No
BKEBBI 1_132	BKEBBI 33	35	No
KUBWA_132	KUBWA 33	60	No
KUBWA_132	KUBWA 33	60	No
AKWANGA 1_132	AKWANGA 33	40	No
AKWANGA 1_132	AKWANGA 33	40	No
APO 1_132	APO 33	50	No
APO 1_132	APO 33	50	No
APO 1_132	APO 33	50	No
APO 1_132	APO 33	60	No
APO 1_132	APO 33	60	No
BIDA 1_132	BIDA 33	30	No
BIDA 1_132	BIDA 33	30	No
CENTRAL AREA_132	CENTRAL AREA	60	No
CENTRAL AREA_132	CENTRAL AREA	60	No
CENTRAL AREA_132	CENTRAL AREA	60	No
KARU 1_132	KARU 33	45	No
KARU 1_132	KARU 33	45	No
KEFFI 1_132	KEFFI 33	30	No
KONTAGORA 1_132	KONTAGORA 33	30	No
KONTAGORA 1_132	KONTAGORA 33	60	No
TEGINA 1_132	TEGINA 33	30	No
MINNA 1_132	MINNA 33	50	No
MINNA 1_132	MINNA 33	50	No
MINNA 1_132	MINNA 33	50	No
SOKOTO 1_132	SOKOTO 33	37	No
SOKOTO 1_132	SOKOTO 33	37	No
SOKOTO 1_132	SOKOTO 33	37	No
SULEJA 1_132	SULEJA 33	38	No

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Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
SULEJA 1_132	SULEJA 33	38	No
SULEJA 1_132	SULEJA 11	8	No
TMAFARA 1_132	TMAFARA 33	30	No
NAT STADIUM_132	NATSTADIUM 3	60	No
NAT STADIUM_132	NATSTADIUM 3	60	No
GWAGWALADA_1_132	GWAGWALA 33	60	No
GWAGWALADA_1_132	GWAGWALA 33	60	No
GWAGWALADA_1_132	GWAGWALA 33	60	No
KAINJI TS 1_132	KAINJI 33	40	No
KAINJI TS 1_132	KAINJI 33	40	No
JEBBA G.S.3_330	JEBBA 2G1	595	No
JEBBA G.S.3_330	JEBBA 2G2	595	No
JEBBA G.S.3_330	JEBBA 2G3	595	No
JEBBA G.S.3_330	JEBBA 2G4	595	No
JEBBA G.S.3_330	JEBBA 2G5	595	No
JEBBA G.S.3_330	JEBBA 2G6	595	No
KAINJI G.S.3_330	KAINJ 1G5	184	No
KAINJI G.S.3_330	KAINJ 1G6	290	No
KAINJI G.S.3_330	KAINJ 1G7-8	290	No
KAINJI G.S.3_330	KAINJ 1G9-10	230	No
KAINJI G.S.3_330	KAINJ 1G11	184	No
KAINJI G.S.3_330	KAINJ 1G12	184	No
SHIRORO 3_330	SHIROR 411G1	150	No
SHIRORO 3_330	SHIROR 411G2	150	No
SHIRORO 3_330	SHIROR 411G3	150	No
SHIRORO 3_330	SHIROR 411G4	150	No
AJAOKUTA 1_132	AJAOKUTA 33	45	No
AJAOKUTA 1_132	AJAOKUTA 33	45	No
DELTA 1_132	DELTA 33	45	No
DELTA 1_132	DELTA 33	45	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
DELTA 1_132	DELTA2 GT3-5	720	No
DELTA 1_132	DELTA2 GT6-8	720	No
DELTA 1_132	DELT3 GT9-11	720	No
DELTA 1_132	DELT3GT12-14	720	No
BENIN 1_132	BENIN 33	60	No
BENIN 1_132	BENIN 33	60	No
BENIN 1_132	BENIN 33	60	No
BENIN 1_132	BENIN 33	60	No
IRRUA 1_132	IRRUA 33	45	No
IRRUA 1_132	IRRUA 33	45	No
IRRUA 1_132	IRRUA 33	60	No
OKENE 1_132	OKENE 33	35	No
OKENE 1_132	OKENE 33	35	No
UKPILLA 1_132	UKPILLA 33	15	No
UKPILLA 1_132	UKPILLA 33	60	No
OKADA 1_132	OKADA 33	60	No
EFFURUN 1_132	EFFURUN 33	60	No
EFFURUN 1_132	EFFURUN 33	60	No
EFFURUN 1_132	EFFURUN 33	60	No
AMUKPE 1_132	AMUKPE 33	50	No
AMUKPE 1_132	AMUKPE 33	50	No
IHOVBOR_3_330	IHOVBOR 1	60	No
IHOVBOR 1_132	IHOVBOR 33	50	No
IHOVBOR 1_132	IHOVBOR 33	50	No
LOKOJA 1_132	LOKOJA 33	60	No
OGHARA 1_132	OGHARA 33	50	No
OGHARA 1_132	OGHARA 33	50	No
DELTA IV 3_330	DELTA1 GT1	720	No
DELTA IV 3_330	DELTA1 GT2	720	No
DELTA IV 3_330	DELTA GT 15	720	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
DELTA IV 3_330	DELTA GT16	720	No
DELTA IV 3_330	DELTA GT17	720	No
DELTA IV 3_330	DELTA GT18	720	No
DELTA IV 3_330	DELTA GT19	720	No
DELTA IV 3_330	DELTA GT20	720	No
SAPELE 3_330	SAPELE GT1-2	140	No
SAPELE 3_330	SAPELE GT3-4	140	No
SAPELE 3_330	SAPELE ST1	140	No
SAPELE 3_330	SAPELE ST2	140	No
SAPELE 3_330	SAPELE ST3	140	No
SAPELE 3_330	SAPELE ST4	140	No
SAPELE 3_330	SAPELE ST5	140	No
GEREGU_330	GEREGU GT11	858	No
GEREGU_330	GEREGU GT12	858	No
GEREGU_330	GEREGU GT13	858	No
GEREGU_330	GER NIPPGT21	858	No
GEREGU_330	GER NIPPGT22	858	No
GEREGU_330	GER NIPPGT23	858	No
IHOVBOR_3_330	IHOVBOR_GTB1	140	No
IHOVBOR_3_330	IHOVBOR_GTB2	140	No
IHOVBOR_3_330	IHOVBOR_GTB3	140	No
IHOVBOR_3_330	IHOVBOR_GTB4	140	No
KANO 1_132	KANO 33	40	No
KANO 1_132	KANO 33	40	No
KANO 1_132	KANO 33	40	No
KANO 1_132	KANO 33	40	No
KADUNA 1_132	KADUNA 33	60	No
KADUNA 1_132	KADUNA 33	60	No
KADUNA 1_132	KADUNA 33	60	No
KADUNA 1_132	KADUNA 33	60	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
KADUNA TOWN_132	KADUNA TOWN	45	No
KADUNA TOWN_132	KADUNA TOWN	45	No
KADUNA TOWN_132	KADUNA TOWN	45	No
KADUNA TOWN_132	KADUNA TOWN	45	No
KADUNA TOWN_132	KADUNA TOWN	15	No
KANKIA 1_132	KANKIA 33	30	No
KANKIA 1_132	KANKIA 33	30	No
DAKATA 1_132	DAKATA 33	50	No
DAKATA 1_132	DAKATA 33	50	No
DAKATA 1_132	DAKATA 33	50	No
DAN AGUNDI 1_132	DANAGUNDI33	60	No
DAN AGUNDI 1_132	DANAGUNDI33	60	No
AZARE 1_132	AZARE 33	30	No
AZARE 1_132	AZARE 33	30	No
DUTSE 1_132	DUTSE 33	30	No
DUTSE 1_132	DUTSE 33	30	No
GUSAU 1_132	GUSAU 33	30	No
GUSAU 1_132	GUSAU 33	30	No
KATSINA 1_132	KATSINA 33	30	No
KATSINA 1_132	KATSINA 33	40	No
KATSINA 1_132	KATSINA 33	40	No
KATSINA 1_132	KATSINA 33	60	No
TAMBURAWA 1_132	TAMBURAWA 33	30	No
TAMBURAWA 1_132	TAMBURAWA 33	30	No
KWANAR DANGO_132	KWANAR DANGO	40	No
ZARIA 1_132	ZARIA 33	40	No
ZARIA 1_132	ZARIA 33	40	No
FUNTUA 1_132	FUNTUA 33	30	No
FUNTUA 1_132	FUNTUA 11	8	No
FUNTUA 1_132	FUNTUA 11	8	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
DAURA 1_132	DAURA 33	60	No
DAURA 1_132	DAURA 33	60	No
WALALAMBE 1_132	WALALAMBE 33	40	No
WALALAMBE 1_132	WALALAMBE 33	40	No
WUDIL 1_132	WUDIL 33	30	No
HADEJIA 1_132	HADEJIA 33	11	No
HADEJIA 1_132	HADEJIA 33	11	No
GOMBE 1_132	GOMBE 33	60	No
GOMBE 1_132	GOMBE 33	30	No
JOS 1_132	JOS 33	60	No
JOS 1_132	JOS 33	60	No
YOLA 1_132	YOLA 33	30	No
YOLA 1_132	YOLA 33	30	No
BAUCHI 1_132	BAUCHI 33	40	No
BAUCHI 1_132	BAUCHI 33	60	No
BIU 1_132	BIU 33	23	No
BIU 1_132	BIU 33	23	No
PANKSHIN 1_132	PANKSHIN 33	40	No
PANKSHIN 1_132	PANKSHIN 33	40	No
POTISKUM 1_132	POTISKUM 33	30	No
POTISKUM 1_132	POTISKUM 33	30	No
SAVANNAH 1_132	SAVANNAH 33	15	No
T-JUNCTION 1_132	MAYOBELWA 33	28	No
DAMBOA 1_132	DAMBOA 33	30	No
JALINGO 1_132	JALINGO 33	30	No
JALINGO 1_132	JALINGO 33	30	No
MAIDUGURI 1_132	MAIDUG 33	30	No
MAIDUGURI 1_132	MAIDUG 33	30	No
MAIDUGURI 1_132	MAIDUG 33	30	No
MAIDUGURI 1_132	MAIDUG 33	60	No

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Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
MAKERI 1_132	MAKERI 33	60	No
MAKERI 1_132	MAKERI 33	60	No
KAFANCHAN 1_132	KAFANCHAN 33	60	No
KAFANCHAN 1_132	KAFANCHAN 33	60	No
ONITSHA 1_132	ONTISHA 33	41	No
ONITSHA 1_132	ONTISHA 33	41	No
ONITSHA 1_132	ONTISHA 33	41	No
ONITSHA 1_132	ONTISHA 33	41	No
ONITSHA 1_132	ONTISHA 33	41	No
ONITSHA 1_132	ONTISHA 11	15	No
ONITSHA 1_132	ONTISHA 11	15	No
NHAVEN 1_132	NHAVEN 33	45	No
NHAVEN 1_132	NHAVEN 33	45	No
NHAVEN 1_132	NHAVEN 33	45	No
NHAVEN 1_132	NHAVEN 33	45	No
MAKURDI 1_132	MAKURDI 33	50	No
MAKURDI 1_132	MAKURDI 33	50	No
AWKA 1_132	AWKA 33	30	No
AWKA 1_132	AWKA 33	30	No
NKALAGU 1_132	NKALAGU 33	30	No
NKALAGU 1_132	NKALAGU 33	30	No
NSUKKA 1_132	NSUKKA 33NEW	60	No
NSUKKA 1_132	NSUKKA 33NEW	60	No
OJI RIVER 1_132	OJI RIVER 66	30	No
OJI RIVER 1_132	OJI RIVER 33	15	No
OJI RIVER 1_132	OJI RIVER 33	30	No
OJI RIVER 1_132	AGU-AWKA 33	40	No
OJI RIVER 1_132	AGU-AWKA 33	60	No
OJI RIVER 1_132	AGU-AWKA 33	60	No
ABAKALIKI 1_132	ABAKALIKI 33	45	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
ABAKALIKI 1_132	ABAKALIKI 33	45	No
OTURKPO 1_132	OTURKPO 33	26	No
OTURKPO 1_132	OTURKPO 33	26	No
OTURKPO 1_132	OTURKPO 33	26	No
YANDEV 1_132	YANDEV 33	25	No
YANDEV 1_132	YANDEV 33	25	No
YANDEV 1_132	YANDEV 33	25	No
ASABA 1_132	ASABA 33T	50	No
ASABA 1_132	ASABA 33T	50	No
AGBOR 1_132	AGBOR 33T	50	No
AGBOR 1_132	AGBOR 33T	50	No
GCM 1_132	GCM 33	60	No
OKPAI 3_330	OKPAI GT11	600	No
OKPAI 3_330	OKPAI GT12	600	No
OKPAI 3_330	OKPAI ST18	600	No
NSUKKA 66_66	NSUKKA 33	8	No
NSUKKA 66_66	NSUKKA 33	8	No
AFAM 1_132	AFAM 33	45	No
AFAM 1_132	AFAM 11	64	No
CALABAR 1_132	CALABAR 33	60	No
CALABAR 1_132	CALABAR 33	60	No
CALABAR 1_132	CALABAR 33	60	No
EKET 1_132	EKET 33	53	No
EKET 1_132	EKET 33	53	No
EKET 1_132	IBOM GT1	286	No
EKET 1_132	IBOM GT2	286	No
EKET 1_132	IBOM GT3	286	No
ITU 1_132	ITU 33	60	No
ITU 1_132	ITU 33	40	No
PHCT MAIN1_132	PHCT MAIN 33	60	No

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Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
PHCT MAIN1_132	PHCT MAIN 33	60	No
PHCT MAIN1_132	PHCT MAIN 33	60	No
PHCT TOWN1 1_132	PHCT TOWN1 3	35	No
PHCT TOWN1 1_132	PHCT TOWN1 3	35	No
PHCT TOWN1 1_132	PHCT TOWN1 3	35	No
PHCT TOWN2 1_132	PHCT TOWN 33	60	No
PHCT TOWN2 1_132	PHCT TOWN 33	60	No
UYO 1_132	UYO 33	60	No
UYO 1_132	UYO 33	40	No
UYO 1_132	UYO 33	60	No
RIVERS_IPP_132	RIVERS_GT1	40	No
RIVERS_IPP_132	RIVERS_GT2	40	No
YENAGOA 1_132	YENAGOA 33	40	No
YENAGOA 1_132	YENAGOA 33	40	No
AHOADA 1_132	AHOADA 33	30	No
AHOADA 1_132	AHOADA 33	30	No
OMOKU 1_132	OMOKU1 GT1	60	No
OMOKU 1_132	OMOKU1 GT2	60	No
OMOKU 1_132	OMOKU2 GT1	60	No
OMOKU 1_132	OMOKU2 GT2	60	No
GBARAIN UBIE_132	GABARIN_GTB1	100	No
GBARAIN UBIE_132	GABARIN_GTB2	100	No
ABA 1_132	ABA 33	34	No
ABA 1_132	ABA 33	34	No
ABA 1_132	ABA 33	34	No
ABA 1_132	ABA 33	34	No
ABA 1_132	ABA 11	15	No
ABA 1_132	ABA 6.6	8	No
UMUAHIA 1_132	UMUAHIA 33	40	No
UMUAHIA 1_132	UMUAHIA 33	40	No

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Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
OWERRI 1_132	OWERRI 33	53	No
OWERRI 1_132	OWERRI 33	53	No
OWERRI 1_132	OWERRI 33	53	No
AFAM IV 3_330	AFAM4GT15-16	169	No
AFAM IV 3_330	AFAMV GT 19	330	No
AFAM IV 3_330	AFAMV GT 20	330	No
AFAM IV 3_330	AFAM VI GT11	330	No
AFAM IV 3_330	AFAM VI GT12	330	No
AFAM IV 3_330	AFAM VI GT13	330	No
AFAM IV 3_330	AFAM VI ST10	330	No
ALAOJI 3_330	ALAOJIGS	140	No
ALAOJI 3_330	ALAOJIGS	140	No
ALAOJI 3_330	ALAOJIGS	140	No
ODUKPANI 3_330	ODUKPANI GT1	600	No
ODUKPANI 3_330	ODUKPANI GT2	600	No
ODUKPANI 3_330	ODUKPANI GT3	600	No
ODUKPANI 3_330	ODUKPANI GT4	600	No
ODUKPANI 3_330	ODUKPANI GT5	600	No
PHCT TOWN1 3_33	ELEELENWO 33	60	No
PHCT TOWN1 3_33	ELEELENWO 33	60	No
PHCT TOWN1 3_33	ELEELENWO 33	60	No
ZUNGERU1_330	ZUNGERU1	206	No
ZUNGERU2_330	ZUNGERU2	206	No
ZUNGERU3_330	ZUNGERU3	206	No

Table 84: Existing 2W transformers – Nigeria

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Substation Side 3 [Name_Voltage]	Rated Power Side 1 [MVA]	Rated Power Side 2 [MVA]	Rated Power Side 3 [MVA]	Regulating (OLTC)
AJA_132	AJA TR1_33	AJA_11	60	40	20	No
IJORA 1_132	IJORA_33	IJORA11_11	30	22.5	7.5	No
OGBA 1_132	OGBA 33 2_33	OGABA 11 2_11	45	33	11	No
AJA 3_330	AJA 132_132	AJA TR3 33_33	150	150	100	No
AJA 3_330	AJA 132_132	AJA TR2 33_33	150	150	100	No
AJA 3_330	AJA 132_132	AJA TR4 33_33	150	150	100	No
AKANGBA 3_330	AKANGBA 1_132	5T1A AKANGBA_13.8	90	90	100	No
AKANGBA 3_330	AKANGBA 1_132	5T1B AKANGBA_13.8	90	90	100	No
AKANGBA 3_330	AKANGBA 1_132	5T2A AKANGBA_13.8	90	90	100	No
AKANGBA 3_330	AKANGBA 1_132	5T2B AKANGBA_13.8	90	90	100	No
AKANGBA 3_330	AKANGBA 1_132	5T14A AKANGB_33	150	150	100	No
AKANGBA 3_330	AKANGBA 1_132	5T 4B AKANGB_33	150	150	100	No
EGBIN 3_330	EGBIN 1_132	IBTR1 33_33	150	150	100	No
EGBIN 3_330	EGBIN 1_132	IBTR2 33_33	150	150	150	No
IKEJA W 3_330	IKEJA W 1_132	IKW T1A 33_33	150	50	50	No
IKEJA W 3_330	IKEJA W 1_132	IKW T1B 33_33	150	150	75	No
IKEJA W 3_330	IKEJA W 1_132	IKW T2A 33_33	150	150	75	No
IKEJA W 3_330	IKEJA W 1_132	IKW T2B 33_33	150	150	75	No
IKEJA W 3_330	IKEJA W 1_132	IKEJA W T1A_33	150	150	100	No
LEKKI 3_330	LEKKI 1_132	LEKKI 33_T1_33	300	300	100	No
LEKKI 3_330	LEKKI 1_132	LEKKI 33_T2_33	300	300	100	No
ALAGBON 3_330	ALAGBON 1_132	ALAGBON TR3_33	300	300	100	No
ALAGBON 3_330	ALAGBON 1_132	ALAGBON TR2_33	300	300	100	No
OKE_ARO_ 3_330	OKE_ARO_1_132	OKE_ARO T1A_33	300	225	75	No
OKE_ARO_ 3_330	OKE_ARO_1_132	OKE_ARO T2A_33	300	300	75	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Substation Side 3 [Name_Voltage]	Rated Power Side 1 [MVA]	Rated Power Side 2 [MVA]	Rated Power Side 3 [MVA]	Regulating (OLTC)
AYEDE 3_330	AYEDE 1_132	AYEDE TR3 33_33	150	150	100	No
AYEDE 3_330	AYEDE 1_132	AYEDE TR2 33_33	150	150	75	No
AYEDE 3_330	AYEDE 1_132	AYEDE TR1 33_33	150	150	75	No
OSOGBO 3_330	OSOGBO 1_132	OSOGBO 4T1_33	150	150	100	No
OSOGBO 3_330	OSOGBO 1_132	OSOGBO 4T7_18	90	90	100	No
OSOGBO 3_330	OSOGBO 1_132	OSOGBO 4T6_33	150	150	100	No
GANMO 3_330	GANMO 1_132	GANMO TR1_33	150	150	100	No
GANMO 3_330	GANMO 1_132	GANMO TR2_33	150	100	100	No
AKURE 3_330	AKURE 1_132	AKURE TR1 33_33	150	150	100	No
AKURE 3_330	AKURE 1_132	AKURE TR2 33_33	150	150	100	No
KATAMPE 3_330	KATAMPE 1_132	KATEMPE TR2_33	150	150	100	No
KATAMPE 3_330	KATAMPE 1_132	KATEMPE TR4_33	150	150	100	No
KATAMPE 3_330	KATAMPE 1_132	KATEMPE TR5_33	150	150	100	No
BKEBBI 3_330	BKEBBI 1_132	BKB5_13.8	90	90	90	No
BKEBBI 3_330	BKEBBI 1_132	BKB6_13.8	90	90	90	No
BKEBBI 3_330	BKEBBI 1_132	BKB1_33	150	150	100	No
JEBBA T.S.3_330	KAINJI TS 1_132	KAINJI TR1_33	150	50	50	No
JEBBA T.S.3_330	JEBBA 1_132	JEBBA TR1_13.8	80	80	100	No
SHIRORO 3_330	SHIRORO 1_132	SHIRORO TR1_33	150	150	100	No
SHIRORO 3_330	SHIRORO 1_132	SHIRORO TR2_33	150	150	100	No
GWAGWALADA_3_330	GWAGWALADA_1_132	GWAGWALA TR1_33	150	150	100	No
GWAGWALADA_3_330	GWAGWALADA_1_132	GWAGWALA TR2_33	150	150	100	No
AJAOKUTA 3_330	AJAOKUTA 1_132	AJAOKUTA T1A_33	162	162	100	No
AJAOKUTA 3_330	AJAOKUTA 1_132	AJAOKUTA T2A_33	162	162	80	No
AJAOKUTA 3_330	AJAOKUTA 1_132	AJAOKUTA T3A_33	162	162	100	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Substation Side 3 [Name_Voltage]	Rated Power Side 1 [MVA]	Rated Power Side 2 [MVA]	Rated Power Side 3 [MVA]	Regulating (OLTC)
BENIN 3_330	BENIN 1_132	BENIN TR1_33	150	150	100	No
BENIN 3_330	BENIN 1_132	BENIN TR3_33	150	150	50	No
DELTA IV 3_330	DELTA 1_132	DELTAIV TR5_33	150	150	100	No
LOKOJA_3_330	LOKOJA 1_132	LOKOJA TR1_33	150	150	100	No
KADUNA 3_330	KADUNA 1_132	KADUNA T1A_33	90	90	100	No
KADUNA 3_330	KADUNA 1_132	KADUNA T2A_13.8	60	60	100	No
KADUNA 3_330	KADUNA 1_132	KADUNA T3A_33	150	150	100	No
KADUNA 3_330	KADUNA 1_132	KADUNA T4A_33	150	150	100	No
KADUNA 3_330	KADUNA 1_132	KADUNA T5A_33	150	150	100	No
KANO 3_330	KANO 1_132	KANO T1A_33	150	150	100	No
KANO 3_330	KANO 1_132	KANO T2A_33	150	150	50	No
KANO 3_330	KANO 1_132	KANO T3A_33	150	150	100	No
KANO 3_330	KANO 1_132	KANO T3A_33	150	150	100	No
GOMBE 1_132	GOMBE TR3 33_33	GOMBE T3_11	100	100	100	No
GOMBE 3_330	GOMBE 1_132	GOMBE T3A_33	150	150	100	No
GOMBE 3_330	GOMBE 1_132	GOMBE T4A_33	150	150	100	No
JOS 3_330	JOS 1_132	JOS T3A_33	150	150	100	No
YOLA 3_330	YOLA 1_132	YOLA T1 33_33	150	150	100	No
YOLA 3_330	YOLA 1_132	YOLA T2 33_33	150	150	100	No
MAIDUGURI 3_330	MAIDUGURI 1_132	MAIDUG T2A_33	150	150	100	No
MAIDUGURI 3_330	MAIDUGURI 1_132	MAIDUG T1A_33	150	50	50	No
JALINGO 3_330	JALINGO 1_132	JALINGO TR1_33	150	150	50	No
JALINGO 3_330	JALINGO 1_132	JALINGO TR2_33	150	150	50	No
DAMATURU 3_330	DAMATURU 1_132	DAMATURU T13_33	150	150	100	No
DAMATURU 3_330	DAMATURU 1_132	DAMATURU T23_33	150	150	100	No
NHAVEN 3_330	NHAVEN 1_132	NHAVEN T3_33	150	150	100	No
NHAVEN 3_330	NHAVEN 1_132	NHAVEN T4_33	150	150	75	No
ONITSHA 3_330	ONITSHA 1_132	ONITSHA T2A_33	150	150	100	No

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Substation Side 3 [Name_Voltage]	Rated Power Side 1 [MVA]	Rated Power Side 2 [MVA]	Rated Power Side 3 [MVA]	Regulating (OLTC)
ONITSHA 3_330	ONITSHA 1_132	ONITSHA T6A_13.8	90	90	30	No
ONITSHA 3_330	ONITSHA 1_132	ONITSHA T1A_13.8	90	90	100	No
ONITSHA 3_330	ONITSHA 1_132	ONITSHA T3A_33	150	150	100	No
ONITSHA 3_330	ONITSHA 1_132	ONITSHA T5A_13.8	150	150	30	No
MAKURDI 3_330	MAKURDI 1_132	MAKURDI T1 3_33	150	150	100	No
UGWUAJI 3_330	UGWUAJI 1_132	UGWUAJI T3_33	150	150	100	No
UGWUAJI 3_330	UGWUAJI 1_132	UGWUAJI T4_33	150	150	100	No
ASABA 3_330	ASABA 1_132	ASABA T1_33	150	150	75	No
ASABA 3_330	ASABA 1_132	ASABA T2_33	150	150	75	No
ABA 1_132	ABA TR1 33_33	ABA TR1_11	45	100	100	No
AFAM IV 3_330	AFAM 1_132	AFAM T1A_33	162	162	100	No
AFAM IV 3_330	AFAM 1_132	AFAM T1A_33	162	162	100	No
AFAM IV 3_330	AFAM 1_132	AFAM T1A_33	162	162	100	No
ALAOJI 3_330	ALAOJI 1_132	ALAOJI T1A_33	150	150	100	No
ALAOJI 3_330	ALAOJI 1_132	ALAOJI T2A_33	150	150	100	No
ALAOJI 3_330	ALAOJI 1_132	ALAOJI T3A_33	150	150	100	No
ADIABOR 3_330	ADIABOR 1_132	ADIABOR T133_33	150	150	100	No
ADIABOR 3_330	ADIABOR 1_132	ADIABOR T233_33	150	150	100	No
KAINJIB_330	KAIN132_132	KAIN33_33	N/A	N/A	N/A	No

Table 85: Existing 3W transformers – Nigeria

Final version

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
AGBARA_33	20	1	Fixed
IKORODU_33	20	2	Fixed
ILUPEJU_33	20	1	Fixed
OJO_33	20	1	Fixed
ABEOKUTA OLD_33	20	2	Fixed
IJEBU ODE_33	20	1	Fixed
SHAGAMU_33	20	1	Fixed
AYEDE_33	20	2	Fixed
ILORIN_33	20	1	Fixed
ISEYIN_33	20	1	Fixed
NIAMEY 1_132	10	5	Fixed
JEBBA T.S.3_330	20	1	Fixed
AKWANGA_33	20	1	Fixed
KONTAGORA_33	20	1	Fixed
MINNA_33	20	2	Fixed
IRRUA_33	20	1	Fixed
OKENE_33	20	1	Fixed
AMUKPE 1_132	20	1	Fixed
EFFURUN 1_132	20	1	Fixed
KADUNA TOWN_33	20	2	Fixed
KATSINA_33	20	1	Fixed
ZARIA_33	20	1	Fixed
WUDIL_33	20	1	Fixed
GOMBE 3_330	20	1	Fixed
JOS 3_330	20	1	Fixed
YOLA 3_330	-75	1	Fixed
MAKURDI_33	20	1	Fixed
UGWUAJI 3_330	20	1	Fixed
AWKA_33	20	1	Fixed
UYO_33	20	1	Fixed

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
KANO 3_330	-25	3	Switch.
GOMBE 3_330	-25	2	Switch.
GOMBE 3_330	-25	2	Switch.
KADUNA 3_330	-25	3	Switch.
JOS 3_330	-25	3	Switch.
JEBBA T.S.3_330	-25	3	Switch.
JEBBA T.S.3_330	-25	3	Switch.
OSOGBO 3_330	-25	3	Fixed
BENIN 3_330	-25	3	Switch.
BENIN 3_330	-25	3	Switch.
ALAOJI 3_330	-25	3	Switch.
IKEJA W 3_330	-25	3	Switch.
IKEJA W 3_330	-25	3	Switch.
KATAMPE 3_330	-25	3	Switch.
MAKURDI 3_330	-25	3	Switch.
ONITSHA 3_330	-25	3	Switch.
OKE_ARO_ 3_330	-25	3	Switch.
GOMBE T3A_33	-30	1	Switch.
GOMBE T4A_33	-30	1	Switch.
YOLA T2_33	-30	1	Switch.
YOLA T1_33	-30	1	Switch.
KANO 3_330	25	2	Fixed
KANO 3_330	25	2	Fixed
AKANGBA 1_132	12	6	Fixed
AKANGBA_33	12	2	Fixed
AKOKA T3_33	12	2	Fixed
ALAUSA_33	12	2	Fixed
ALIMOSHO_33	12	2	Fixed
EJIGBO_33	12	2	Fixed
IJORA_33	12	2	Fixed

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
ISOLO_33	12	2	Fixed
OGBA_33	12	2	Fixed
OTTA_33	12	2	Fixed
YANDEV_33	20	1	Fixed
AKURE_33	20	1	Fixed
DAKATA_33	20	1	Fixed
KANO_33	20	1	Fixed
DANAGUNDI_33	20	1	Fixed
APO_33	20	1	Fixed
AWKA 1_132	20	1	Fixed
GUSAU 1_132	25	3	Fixed
GWAGWALA_33	25	2	Fixed
ILUPEJU_33	20	1	Fixed
MAIDUG_33	10	1	Fixed
MAIDUG_33	10	1	Fixed
MAIDUGURI 1_132	10	1	Fixed
OGBA 1_132	12	6	Fixed
OJI RIVER_33	10	1	Fixed

Table 86: Existing reactive power compensation - Nigeria

5.1.12. Senegal

The current electrical network of Senegal is shown on the following tables (lines, transformers, shunt reactive compensation).

Only transmission lines with operating voltage equal or higher than 90 kV are considered. The system has 47 transmission lines (46 single circuits and 1 double circuits), 56 transformers and 20 shunt reactive compensation devices.

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Dagana_225	Matam_225	225.000	267.0	283.3	2.690	17.300	24.840
Dagana_225	Sakal_225	225.000	114.0	283.3	1.150	7.390	10.605
Tobene_225	Touba_225	225.000	105.0	312.0	1.535	4.086	15.883
Kaolack_225	Touba_225	225.000	72.0	311.8	1.022	2.720	10.589
Sakal_225	Tobene_225	225.000	124.5	226.7	1.250	8.070	11.585
Tobene_225	Kounoune_225	225.000	53.0	245.0	0.990	3.970	7.110
Kounoune_225	Diamniadio_225	225.000	8.0	348.0	0.358	1.280	2.683
Diamniadio_225	Sendou_225	225.000	2.0	348.0	0.089	0.320	0.671
Sendou_225	Diass_225	225.000	15.0	312.0	0.137	0.948	1.610
Diass_225	Mbour_225	225.000	28.5	312.0	0.287	1.312	2.513
Bakel_225	Matam_225	225.000	150.0	283.3	1.550	9.950	13.955
Bakel_225	Kayes_225	225.000	106.0	283.3	1.090	6.870	9.865
Dagana_225	Rosso_225	225.000	0.0	214.3	0.660	3.070	2.590
Thiona_90	Tobene_90	90.000	31.4	71.0	6.070	16.410	0.558
Belair_90	Hann_90	90.000	4.5	98.0	0.503	1.800	0.097
Belair_90	Hann_90	90.000	4.5	98.0	0.503	1.800	0.097
Belair_90	Hann_90	90.000	5.0	86.0	0.710	2.265	0.100
Hann_90	Mbao_90	90.000	10.9	85.7	1.560	5.137	0.472
Cape Des Biches_90	Kounoune_90	90.000	6.5	86.0	0.990	3.035	0.124
Cape Des Biches_90	Sococim_90	90.000	10.5	82.0	0.983	3.050	0.125
Kounoune_90	Sococim_90	90.000	4.7	85.7	0.716	2.196	0.090
Sococim_90	OLAM_90	90.000	8.0	82.0	1.510	4.685	0.192
Meckhe_90	Tobene_90	90.000	35.8	106.3	1.452	5.200	0.558
SOMETA_90	OLAM_90	90.000	3.0	82.0	0.556	1.757	0.072
Belair_90	Universite_90	90.000	3.5	156.0	0.130	0.735	1.042
Universite_90	Aeroport_90	90.000	10.4	156.0	0.385	2.180	3.095
Patte D'Oie_90	Cape Des Biches_90	90.000	15.0	82.0	2.170	7.131	0.292
Patte D'Oie_90	Hann_90	90.000	0.8	81.8	0.144	0.375	0.015
Taiba_90	Tobene_90	90.000	13.0	106.3	1.452	5.200	0.558
Thiona_90	SOMETA_90	90.000	17.5	82.0	3.304	10.249	0.420
Mbao_90	Cape Des Biches_90	90.000	5.8	86.0	1.028	3.378	0.154
Hann_90	Patte D'Oie_90	90.000	0.8	81.8	0.144	0.375	0.015
Cape Des Biches_90	Patte D'Oie_90	90.000	15.0	82.0	2.170	7.131	0.292
Kounoune_90	Hann_90	90.000	19.0	98.0	2.382	10.420	0.455
Patte D'Oie_90	Aeroport_90	90.000	8.0	156.0	0.296	1.679	2.381

Table 87: Existing transmission lines (Nominal voltage higher than or equal to 90 kV) – Senegal

Final version

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Bakel_30	Bakel_225	20	No
Belair_15	Belair_90	50	No
Belair_15	Belair_90	50	No
Belair_15	Belair_90	50	No
Belair_15	Belair_90	46	No
Cape Des Biches_90	Cap des Biches - IPP Contour Global G1_11	67	No
Cape Des Biches_90	Cap des Biches - IPP Contour Global G2_11	45	No
Cape Des Biches_90	Cap Des Biches Gen	36	No
Cape Des Biches_90	Cap Des Biches Gen	33	No
Cape Des Biches_90	Cap Des Biches Gen	27	No
Cap des Biches C4 G2_11.5	Cape Des Biches_90	26.5	No
Cap des Biches C4 G4_11.5	Cape Des Biches_90	40	No
Cape Des Biches_30	Cape Des Biches_90	65	Yes
Cape Des Biches_30	Cape Des Biches_90	65	Yes
Dagana_225	Dagana_30	20	No
Thiona_90	Dangote	22	No
Diass_225	Diass_30	40	No
Diass_225	Diass_30	40	No
Hann 1_30	Hann_90	80	Yes
Hann 2_30	Hann_90	80	Yes
Hann 3_30	Hann_90	80	Yes
Kaolack_33	Kahone_G1_0.4	4.4	No
Kaolack_33	Kahone_G2_0.4	4.4	No
Kaolack_33	Kahone_G3_0.4	4.4	No
Kaolack_33	Kahone_G4_0.4	4.4	No
Kaolack / Kahone 1G_15	Kaolack_225	50	No
Kaolack / Kahone 2G_15	Kaolack_225	50	No
Kaolack / Kahone 3G_15	Kaolack_225	50	No
Kaolack_225	Kaolack_33	40	No

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Kaolack_225	Kaolack_33	40	No
Kounoune_90	Kounoune_225	75	No
Kounoune_90	Kounoune_225	75	No
Kounoune_15	Kounoune_90	75	No
Kounoune_15	Kounoune_90	75	No
Matam_30	Matam_225	20	No
Matam_225	Matam_90	20	No
Mbour_225	Mbour_33	40	No
Mbour_225	Mbour_33	40	No
Meckhe_90	Meckhe 1_30	25	No
Meckhe_90	Meckhe 2_30	25	No
Sakal_30	Sakal_225	50	No
Sendou_225	Sendou_11	150	No
Sendou_225	Sendou_11	150	No
Taiba_90	Taiba	10	No
Tobene_90	Tobene_225	75	No
Tobene_90	Tobene_225	75	No
Tobene_G1	Tobene_225	90	No
Tobene_G2	Tobene_225	90	No
Touba_225	Touba_30	40	No
Touba_225	Touba_30	40	No

Table 88: Existing 2W transformers – Senegal

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Matam_225	-20	1	Switch
Matam_225	-25	1	Switch
Sakal_225	-20	1	Switch
Dagana_225	-20	1	Switch
Kaolack_225	-25	1	Switch
Touba_225	-25	1	Switch

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Dagana_225	-25	1	Switch
Tobene_225	-20	1	Switch
Koungheul_225	-20	1	Switch
Koungheul_225	-20	1	Switch
Manantali - Kayes Series compensation	-30	1	Series
Matam – Bakel Series compensation	-30	1	Series
Matam – Dagana Series compensation	-30	1	Series
Dagana – Matam Series compensation	-30	1	Series
Dagana – Sakal Series compensation	-30	1	Series

Table 89: Existing reactive compensation - Senegal

5.1.13. Sierra Leone

The current electrical network of Sierra Leone is shown on the following tables (lines, transformers, shunt reactive compensation).

Only transmission lines with operating voltage equal or higher than 90 kV are considered. The system has 1 double circuit transmission lines, 2 transformers and 1 shunt reactive compensation devices.

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Bumbuna_161	Freetown_161	161	N/A	244	6.743	31.119	7.650
Bumbuna_161	Freetown_161	161	N/A	244	6.743	31.119	7.650

Table 90: Existing transmission lines (Nominal voltage higher than or equal to 90 kV) – Sierra Leone

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Bumbuna_161	Bumbuna G1_13.8	31.3	No
Bumbuna_161	Bumbuna G2_13.8	31.3	No

Table 91: Existing 2W transformers - Sierra Leone

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Freetown_161	5.0	15	Switch

Table 92: Existing reactive compensation - Sierra Leone

The national projects planned for the upcoming years are presented in Appendix J.

5.1.14. Togo

The current electrical network of Togo is shown on the following tables (lines, transformers, shunt reactive compensation).

Only transmission lines with operating voltage equal or higher than 90 kV are considered. The system has 10 transmission lines (7 single circuits and 3 double circuits), 10 transformers and 2 shunt reactive compensation devices.

From Substation	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Davié_161	Lomé (Aflao) 1_161	161	39	132	2.343	6.411	1.675
Davié_161	Lomé (Aflao) 1_161	161	39	132	2.343	6.411	1.675
Momé Hagou_161	Davié_161	161	49	132	2.943	8.055	2.104
Momé Hagou_161	Davié_161	161	49	132	2.943	8.055	2.104
Sokodé_161	Kara_161	161	76	178	4.023	12.006	2.758
Sokodé_161	Atakpamé_161	161	194	178	10.268	30.648	7.040
Lomé (Aflao) 1_161	Lomé (Port)_161	161	0	178	0.800	2.790	0.545
Lomé (Aflao) 1_161	Lomé (Port)_161	161	0	178	0.800	2.790	0.545
Nangbéto_161	Atakpamé_161	161	0	178	1.940	6.240	1.350
Nangbéto_161	Momé Hagou_161	161	116	178	7.209	18.796	1.879

Table 93: Existing transmission lines (Nominal voltage higher than or equal to 90 kV) – Togo

Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Kara_161	Kara_15	25.0	No
Lomé (Aflao) 1_161	Contour Global Gen_15	63.0	No
Lomé (Aflao) 1_161	Contour Global Gen_15	63.0	No
Lomé (Aflao) 1_161	Contour Global Gen_15	20.0	No
Lomé (Aflao) 1_161	Lomé Port TAG CEB_15	25.0	No
Lomé (Port)_161	Lome CEET_15	15.0	No

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Substation Side 1 [Name_Voltage]	Substation Side 2 [Name_Voltage]	Rated Power [MVA]	Regulating (OLTC)
Maria Gleta 1_161	Maria Gleta TAG APR_15	57.0	No
Nangbéto 1_10.3	Nangbéto_161	35.5	No
Nangbéto 2_10.3	Nangbéto_161	35.5	No
Sokodé_161	Sokode Diesel_15	5.0	No

Table 94: Existing 2W transformers – Togo

Substation [Name_Voltage]	Capacity / step (Mvar)	Number of steps	Type (Fixed-Switch-SVC)
Kara_161	-1.0	18	Switch
Sokodé_161	-5.0	1	Switch

Table 95: Existing reactive compensation – Togo

5.1.15. Cape Verde

There is no interconnected network in the country. Given the island nature of Cape Verde, the transmission and distribution networks are decentralized. Thus, in each island transmission and distribution networks are developed according to the sources of generation. Nevertheless, access to electricity remains difficult in the Capeverdien territory due to the fragmentation of the electricity grid.

The project of development of transmission and distribution power systems in 6 islands will contribute to the improvement of the technical, commercial and financial performances of the national electricity company (ELECTRA). The project concerns 492 000 inhabitants (or 94% of the total population) of Cape Verde living in six of its islands. It will help increase the overall access rate to electricity from 88% in 2010 to 98% by 2018.

5.2. Status of interconnections

5.2.1. Existing

The table below summarizes the list of interconnection lines which are considered as existing in the 2017 model. Currently, 14 high voltage lines connect the different countries of the WAPP region together in order to allow the sharing of electricity between them. The current blocks which are operated synchronously (mainly three separate ones) as of today are presented in section 5.4.

Since the previous master plan realized in 2011, one line has been put in service: Ferkéssédougou – Sikasso 225kV (connecting Côte d'Ivoire and Mali).

Country	HV Interconnection	Voltage Level [kV]	Rated Power [MVA]	Length [km]
Benin - Nigeria	Sakete - Ikeja West	330	777.0	75
Niger - Nigeria	Dosso - Birnin Kebbi	132	107.7	132
Niger - Nigeria	Gazaoua - Katsina	132	82.3	72
Ghana - Togo	Akosombo - Aflao - Lomé	161	128.0	128
Ghana - Togo	Akosombo - Asiekpe - Lomé	161	128.0	128
Côte d'Ivoire - Mali	Ferkéssédougou - Sikasso	225	327.4	237
Côte d'Ivoire - Burkina Faso	Ferkéssédougou - Bobo	225	327.4	222
Senegal - Mali	Matam - Kayes	225	283.3	256
Côte d'Ivoire - Ghana	Riviera - Prestea	225	327.0	210
Togo-Benin	Nangbéto-Bohicon	161	178	80.3
Togo-Benin	Mome Hagou-Avakpa	161	128	54
Togo-Benin	Kara-Djougou	161	178	58
Togo-Benin	Mome-Hagou- Maria Gleta	161	128	92
Senegal - Mauritania	Dagana - Rosso	225	214.3	37

Table 96: Existing interconnections (2017)

The parameters considered for each existing interconnection are presented in Appendix H

5.2.2. Committed Projects

Table 97 lists the interconnection projects that are decided for the upcoming years. The following table lists the interconnections which are planned, yet not decided. For each line, the voltage level, the length, the commissioning year and the size of the planned interconnection is given. These values should be validated and N/A values should be filled by the concerned countries.

Country	HV Interconnection	Voltage Level [kV]	Rated Power [MVA]	Commissioning Year	Length [km]	Comment
CI-LI-SL-GU	CLSG	225	250	2020	1303	(See CLSG Table)
GH-BU	Bolgatanga-Ouagadougou	225	327	2018	198	
GH-TO	Volta-Davié (Lomé)	330	776	2019	340	
TO-BN	Davié-Sakete	330	977	2019		
BU-NR-NI-BN	Dorsale Nord	330	760	2022	832	

Country	HV Interconnection	Voltage Level [kV]	Rated Power [MVA]	Commissioning Year	Length [km]	Comment
SE-GA-GB-GU	OMVG	225	250	2020	1677	(See OMVG Table)
MA-SE	Kayes-Tambacounda	225	327	2019	288	
SE-MAU	Noukchott-Tobene	225	250	2020	425	Double circuit
MA-MAU	Kayes-Kiffa	225	250	2021	437	
TO-BN	Porga-Dapaong	161	178	2022	82	
TO-GH	Dapaong – Bawku	161	178	2022	65	
GU-MA	N'Zérékoré – Fomi – Bamako (Kodialani)	225	250	2022	1074	

Table 97: Decided interconnections (After 2017)

Country	HV Interconnection	Voltage Level [kV]	Rated Power [MVA]	Commissioning Year	Length [km]	Comment
CI-GU	Boundiali-Fomi	225	250	>2025	380	
CI-MA	Boundiali-Tengrela-Bougouni	225			330	
LI-CI	Buchanan-San Pedro	225	250	-	400	
BN-NI	Second circuit Sakete-Onigbolo	330	777	-	75	
GU-MA	Linsan-Manantali	225	250	>2020	410	Single/Double circuit?
GH-BU-MA	Bolgatanga-Bobo-Sikasso	225	250	>2021	555	Double circuit
BU-TB	Kompenga-Porga	161		>2025	-	
GH-TB-NI	Yendi-Bembereke-Kainji	330		>2025	-	

Table 98: Planned interconnections (After 2017)

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The 225kV line from Boundiali to Fomi is under study and will not be in service before 2025. The 225kV line from Ouagadougou to Bolgatanga is being put in service in the summer of 2018.The 330kV line between Ghana, Togo, Benin and Nigeria is currently under construction. The construction work on the Ghanaian and Nigerian side have been completed and the line will be commissioned in 2019. The 225kV interconnection of Mali-Burkina Faso and Ghana is planned for after 2021 and feasibility studies are currently ongoing. The Dorsale Nord 330kV connecting Burkina Faso to Niger, Benin and Nigeria is under study and will not come in service before 2020. The commissioning of the line Linsan-Manantali is linked to the Koukoutamba commissioning and is planned for after 2020. Similarly, the Kayes-Tambacounda 225kV line is planned in 2019 with the commissioning of Gouina which is currently under construction. The connection of N'Zérékoré to Fomi and Bamako is under study and is planned for 2022. On the Togo-Benin side, the commissioning of the 161kV line between Porga and Dapaong is planned for 2022. Also, the line between Dapaong and Bawku which is currently exploited under 34.5 kV will be exploited in 161kV. The line is already designed to be exploited in this voltage level.

The two planned projects of CLSG (2020) and OMVG (2020) which are composed of multiple different substations and lines are detailed in Table 99 and Table 100. From the expected commissioning dates of the different projects, it can be expected that the fourteen (14) WAPP countries will be interconnected by 2022.

Country	Name	Voltage Level [kV]	Length [km]	Commissioning Year
Guinea	Linsan - Kamakwie	225	144	2020
Guinea-Sierra Leone	Kamakwie - Yiben	225	55	2020
Sierra Leone	Yiben - Bumbuna	225	75	2020
Sierra Leone	Bumbuna - Bikongor	225	146	2020
Sierra Leone	Bikongore - Kenema	225	97	2020
Sierra Leone-Liberia	Kenema - Mano	225	116	2020
Liberia	Mano - Monrovia	225	107	2020
Liberia	Monrovia - Buchanan	225	116	2020
Liberia	Buchanan - Yekepa	225	230	2020
Liberia-Côte d'Ivoire	Yekepa - Man	225	152	2020
Liberia-Guinea	Yekepa - N'Zérékore	225	49	2020

Table 99: Planned projects of CLSG

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Country	Name	Voltage Level [kV]	Length [km]	Commissioning Year	Comment
Senegal	Kaolack - Koungheul	225	135	2020	
Senegal	Koungheul - Tambacounda	225	135	2020	
Senegal	Tambacounda – Kedougou (Sambangalou)	225	261.56	2020	
Senegal-Guinea	Kedougou (Sambangalou) - Mali	225	45	2020	
Guinea	Mali - Labé	225	82.29	2020	
Guinea	Labé - Linsan	225	137.78	2020	
Guinea	Linsan - Boké	225	110.12	2020	Connection of Kaleta
Guinea-Guinea Bissau	Boké - Saltinho	225	98.45	2020	
Guinea Bissau	Saltinho - Bambadinca	225	56.35	2020	
Guinea Bissau	Bambadinca - Mansoa	225	52.9	2020	
Guinea Bissau	Mansoa - Bissau	225	35.66	2020	
Guinea Bissau-Senegal	Mansoa - Tanaff	225	73.47	2020	
Senegal-Gambia	Tanaff - Soma	225	95.9	2020	
Senegal-Gambia	Soma - Kaolack	225	119.24	2020	
Gambia	Soma - Brikama	225	153.8	2020	

Table 100: Planned projects of OMVG

5.3. National Projects

This section presents the transmission projects which are planned on a national level and which do not connect two or more countries.

For each project, the respective commissioning year as well as the sizing of the element is given (Power [MVA] or line type, Length [km]). These values should be completed or validated by the concerned countries. These national projects are presented in Appendix J.

5.4. Synthesis of the inventory of transmission assets

The WAPP's current situation is one in which different synchronous blocks exists. Within these different blocks, power transfers are realized between countries through the high voltage interconnections. Currently, as of January 2018, these different blocks are:

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- Block A: Burkina Faso, Ghana, Côte d'Ivoire, part of Mali (up to Bamako) and part of Togo/Benin.
- Block B: Senegal, Mauritania and part of Mali (up to Bamako)
- Block C: Nigeria, Niger and part of Togo/Benin
- The other countries of the WAPP are not connected to each other through the High Voltage (HV) grid and operate in an isolated way. These countries are Guinea, Guinea Bissau, The Gambia, Liberia and Sierra Leone.

The current exchanges that are considered for the modeling of the current peak situation are depicted in the figures hereafter.

Figure 69 depicts the exchanges between the different countries of block A. In this synchronous block, Côte d'Ivoire and Ghana are both countries with a surplus of installed capacity compared to its neighbours. For economic reasons, Burkina Faso usually imports only 50 MW from Côte d'Ivoire, but it will increase to 70 MW as of 2018 with an objective of 90 MW over the short term. Burkina Faso is currently only connected to Côte d'Ivoire through the 225 kV line from Ferkéssédougou to Bobo. Higher levels of imports are foreseen for the future as the 225 kV line between Ouagadougou and Bolgatanga (Ghana) is put in service in 2018.

Mali is split between two different synchronous blocks. When exchanges from Côte d'Ivoire (Ferkéssédougou to Sikasso) are greater than 40 MW, the splitting is done in Bamako at the Kalabankoro substation. When Mali is importing less than 40 MW from Côte d'Ivoire, the grid is split by opening the 150 kV Fana-Segou line at Fana.

In the peak situation, it is supposed than Mali imports around 70 MW from Côte d'Ivoire. The countries of Togo and Benin will import around 50 MW from Ghana (through the 161 kV interconnection lines between Akosombo and Lomé) while 200 MW will be imported from Nigeria. These two countries also lie in two different synchronous blocks and it is supposed that the splitting is currently performed at the Mome-Hagou substation. It is to be noted that throughout the year, this separation point between the two networks changes according to the demand and the available imports from Ghana and Nigeria.

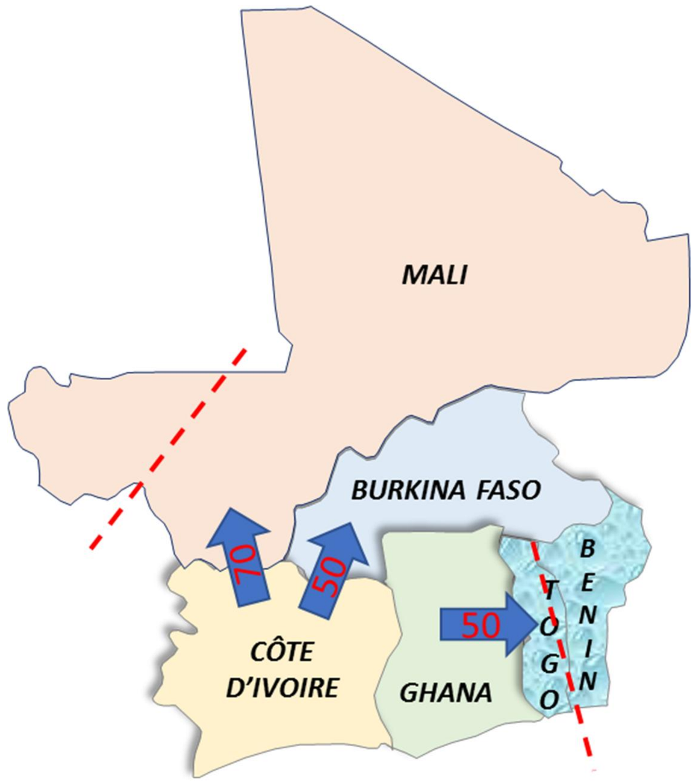

Figure 69: Current assumed exchanges at the peak in block A

The exchanges assumed between the countries of Senegal, Mauritania and Mali are shown in Figure 70. In this situation, it is assumed that the hydropower plant of Felou and Manantali will export respectively 18 MW and 30 MW to Mauritania and 18 MW (Felou) and 60 MW (Manantali) to Senegal. No other exchanges are assumed in this situation.

Figure 71 shows the exchanges assumed currently at the peak between the countries of Nigeria, Niger and Togo-Benin. 200 MW are exported from Nigeria to the part of Togo-Benin which is synchronous with this block through the 330 kV line between Ikeja West and Sakete. Niger's imports are assumed to be of a total of around 40 MW with part of this power being delivered to Niamey and another part to Gazaou through the 132 kV grid.

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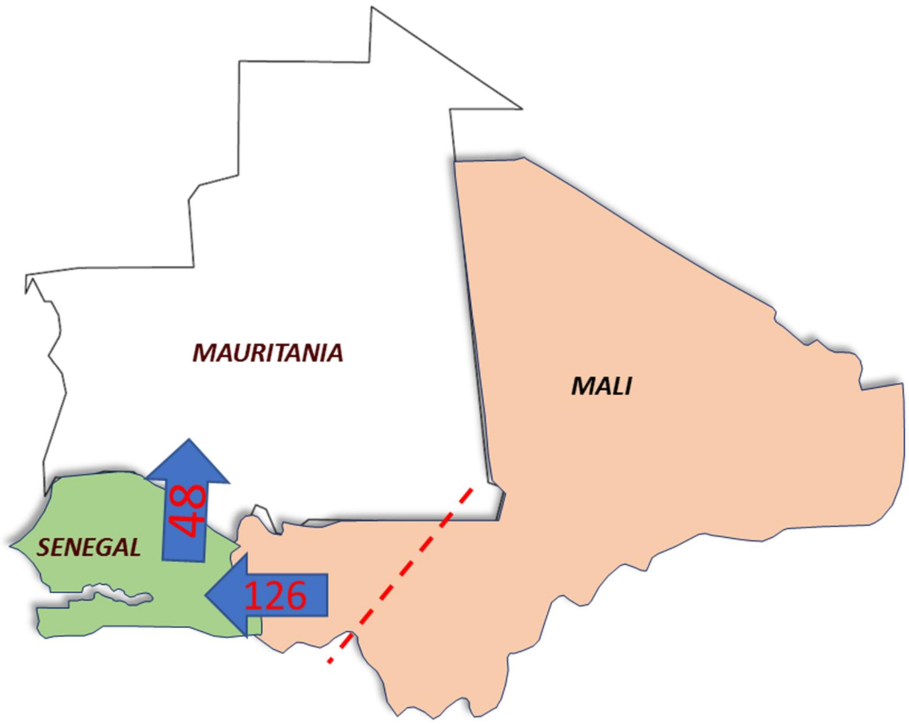

Figure 70: Current assumed exchanges at the peak in block B

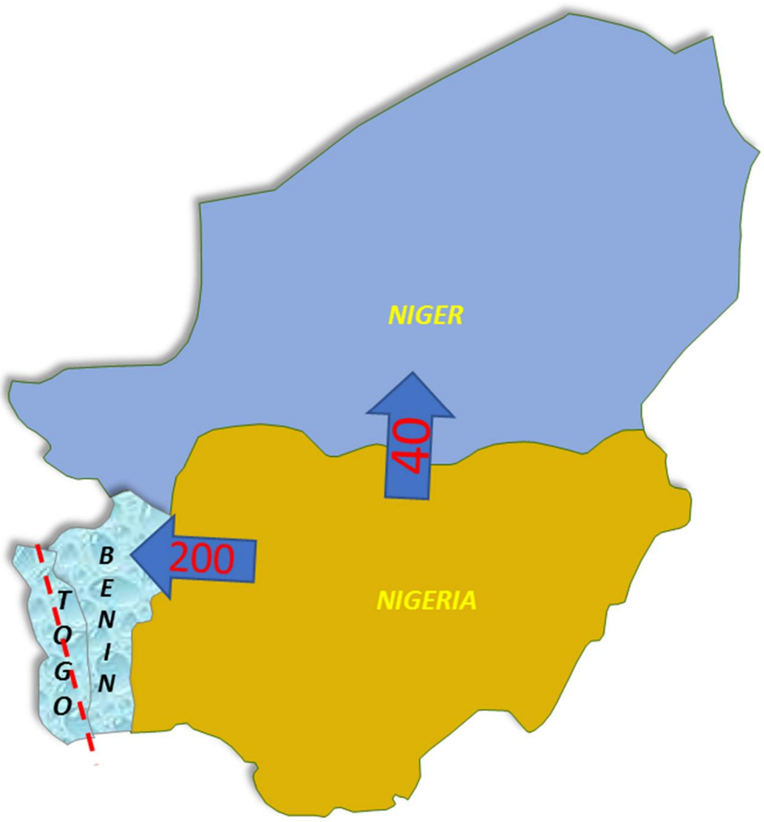

Figure 71: Current assumed exchanges at the peak in block C

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As of today, blocks A and C, connecting Ghana through Togo and Benin and to Nigeria are not synchronized due to frequency problems. More specifically, the frequency control in Nigeria is problematic and the operating limits are not satisfied. The challenge observed is that due to the size of Nigeria compared to the neighbouring countries, frequency deviations in Nigeria have a significant impact on the frequency of the system and operational limits were no longer satisfied. A specific study has been realized recently on this specific concern and on the synchronization of all WAPP countries together. Additionally, it is to be noted that Nigeria is working on the regulators of their machines providing reserves in order to improve their frequency control.

Similarly, Mali, which is connected to Côte d'Ivoire and to Senegal does not operate in a synchronous way with both countries. This way of operation is due to the observation that when Mali is connected to both synchronous blocks simultaneously and importing around 50 MW from Côte d'Ivoire, low voltages occur (especially around Koutiala), causing the protection systems of many equipment to trip. Furthermore, the 150kV grid of Bamako is currently not designed for being at the centre of the two synchronous blocks and limits the synchronization of Senegal-Mali and Côte d'Ivoire together.

Renewable integration in Senegal has proven to cause some operational problems in maintaining the frequency and voltage criteria. Frequency deviations are seen due to the lack of reserves in the system and the increasing penetration of wind and solar production in Senegal and Mauritania. The main reasons for these challenges are twofold:

- The reactive power capabilities of the Senegalese grid are limited
- The low reserve level and the absence of automatic frequency and voltage control means in the Senegalese grid.

A challenge foreseen in the region due to the high penetration of renewables which is planned will be linked to the forecast of renewable production and the capabilities of the region to satisfy the intermittence and unpredictability of these sources. Concrete measures and planification needs will be necessary to cope with the variation of renewable production and make sure that classical generation means (hydro, thermal,…) are available when needed. This aspect has proven to be of high importance to satisfy the evening peak when renewable production is decreasing, and demand is increasing. Furthermore, a specific attention will be dedicated to the specificities of the renewable technology to be implemented and the voltage control possibilities of these technologies in order to satisfy the operational limits at all times.

Due to the lack of generation capacities in many countries of the WAPP, reserve requirements are not strongly followed and operational problems as well as load shedding and possible system collapses are seen throughout the year. This current challenge in the operation of the high voltage network is accentuated with the fact that the transmission network currently does not satisfy the N-1 criteria.

Throughout the WAPP, it is observed that many countries encounter voltage problems on their grid. This observation is especially true in the north of the coastal countries (Ghana, Côte d'Ivoire, Togo, Benin,…). In these countries, most of the generation and big load centres are located along the coast and few generators exist inland to control the voltage profiles. In those zones which lack voltage control capabilities, Static Var Compensators (SVCs) have been necessary in order to satisfy operational limits.

As of today, many countries still experience load shedding needs due to insufficient generation capacities. This load shedding needs are mostly necessary at the peak demand time which is observed in the evening. In order to avoid discrepancies in the economic growth and wellness between the population, this load shedding is realized in a rotating manner between different substations. Additionally, load shedding is sometimes performed to resolve operational problems such as the lack of reserves, frequency and voltage deviations, etc.

Furthermore, it was noted by different countries that a particular challenge for the upcoming years is to make sure that the development of the distribution grid follows that of the generation and transmission plans. In fact, the distribution grids of many west African countries are relatively old and need to be maintained. The development and maintenance of these distribution grid are of importance in order to allow for the increase in demand as well as to reduce the high losses on the distribution network. These high losses on the distribution grid are of the order of around 20% and have a significant impact on the delivery of the electricity demand to the population (adequacy). This adequacy problem shows the need of reinforcing the production capabilities in the region.

5.5. Definition of Unitary Prices

This section has as objective of listing the unitary prices of the different equipment that will be used in the development of this master plan. This list was established based on the experience of the Consultant in various development studies and in particular in Africa. The costs mentioned in Table 101 are exempt from all taxes and customs duties: they include the cost of studies, infrastructures, civil engineering and assembly.

Element	Voltage Level [kV]	Capacity [MVA]	Investment cost [kUSD]	
Transformer	400/225	350	5043	kUSD
Transformer	400/225	200	3813	kUSD
Single circuit line	400 kV	1400	431	kUSD/km
Double circuit line	400 kV	2 x 1400	615	kUSD/km
AIS Bay	400 kV		2614	kUSD
GIS Bay	400 kV		4356	kUSD
AIS Coupling	400 kV		2768	kUSD
GIS Coupling	400 kV		6085	kUSD

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Element	Voltage Level [kV]	Capacity [MVA]	Investment cost [kUSD]	
Construction site opening	400 kV		4428	kUSD
Transformer	330/225	500	5252	kUSD
Transformer	330/225	200	3321	kUSD
Transformer	330/161	400	4059	kUSD
Transformer	330/161	250	3198	kUSD
Transformer	330/132	300	3444	kUSD
Transformer	330/132	150	2460	kUSD
Transformer	330/132	90	1845	kUSD
Single circuit line	330 kV	1000	357	kUSD/km
Double circuit line	330 kV	2 x 1000	507	kUSD/km
Addition of second circuit on existing tower	330 kV	1000	150	kUSD/km
AIS Bay	330 kV		2091	kUSD
GIS Bay	330 kV		3485	kUSD
AIS Coupling	330 kV		2214	kUSD
GIS Coupling	330 kV		4868	kUSD
Construction site opening	330 kV		4182	kUSD
Transformer	225/161	500	4490	kUSD
Transformer	225/161	200	2829	kUSD
Transformer	225/90	70	1523	kUSD
Transformer	225/90	100	1707	kUSD
Transformer	225/90	120	1984	kUSD
Single circuit line	225 kV	327	234	kUSD/km
Double circuit line	225 kV	2 x 327	335	kUSD/km
Addition of second circuit on existing tower	225 kV	327	101	kUSD/km
AIS Bay	225 kV		1107	kUSD
GIS Bay	225 kV		1845	kUSD
AIS Coupling	225 kV		1169	kUSD
GIS Coupling	225 kV		1947	kUSD
Construction site opening	225 kV		3690	kUSD
Transformer	161/69	90	1599	kUSD
Single circuit line	161 kV	364	209	kUSD/km

Element	Voltage Level [kV]	Capacity [MVA]	Investment cost [kUSD]	
Double circuit line	161 kV	2 x 364	296	kUSD/km
Addition of second circuit on existing tower	161 kV	364	87	kUSD/km
Single circuit line	161 kV	182	205	kUSD/km
Double circuit line	161 kV	2 x 182	292	kUSD/km
Addition of second circuit on existing tower	161 kV	182	86	kUSD/km
AIS Bay	161 kV		923	kUSD
GIS Bay	161 kV		1538	kUSD
AIS Coupling	161 kV		984	kUSD
GIS Coupling	161 kV		1658	kUSD
Construction site opening	161 kV		3075	kUSD
Transformer	132/90	40	861	kUSD
Single circuit line	132 kV	107	197	kUSD/km
Double circuit line	132 kV	2 x 107	279	kUSD/km
Addition of second circuit on existing tower	132 kV	107	82	kUSD/km
AIS Bay	132 kV		861	kUSD
GIS Bay	132 kV		1415	kUSD
AIS Coupling	132 kV		923	kUSD
GIS Coupling	132 kV		1523	kUSD
Construction site opening	132 kV		2583	kUSD
Single circuit line	90 kV	75	187	kUSD/km
Double circuit line	90 kV	2 x 75	267	kUSD/km
Addition of second circuit on existing tower	90 kV	75	80	kUSD/km
AIS Bay	90 kV		738	kUSD
GIS Bay	90 kV		1230	kUSD
AIS Coupling	90 kV		800	kUSD
GIS Coupling	90 kV		1332	kUSD
Construction site opening	90 kV		2214	kUSD
SVC	-		123	kUSD
Capacitor	-		15	kUSD
Reactance	-		15	kUSD

Table 101: Unitary cost of equipment proposed for the development of the master plan

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It is to be noted that the list of prices defined above is No-exhaustive and contains the most common equipment that will be used in the study. Other voltage levels and element sizes may be used in order to be consistent with the existing elements of the high voltage grid. The unitary price of these elements will be defined based on the same source and will be consistent with the reference prices given in Table 101.

6. DEFINITION OF PLANNING AND OPERATING CRITERIA

6.1. Planning Criteria

6.1.1. Review of existing security standards

In order to plan for security of supply, there is no single standard that is universally used. The types of criteria that have historically been used by utilities for capacity planning are:

- Specified percentage reserve margin
- Loss of largest unit
- Derated capacity margin
- Loss of Load Expectation (LOLE)
- Expected Energy Not Served (EENS)

These criteria can be classified in two different categories: Deterministic and Probabilistic Criteria.

Deterministic criteria include reserve margin percentage and loss of largest unit. These criteria can be easily calculated but they suffer from a major limitation because they do not take stochastic distribution of unforeseen events into account and hence, the potential issues linked to uncertainty that could affect the reliability of the system. The unpredictable nature of Power Systems risks is better captured with Probabilistic Criteria such as Loss of Load Expectation. Its evaluation however requires specialized and time-consuming methods to be computed.

1) Reserve Margin

The reserve margin is the difference between total installed capacity and the annual peak load and it is often expressed in percentage of peak load. This calculation can be easily performed for a long study period as load forecasts are generally made available for a long period. The need of additional generating resources is then computed by comparing the installed capacity required to reach the Reserve Margin Target and the installed capacity already contracted for the same time-period. Such a criterion is based on a Reserve Margin target is too simple and does not consider the peculiarities of the power systems (unavailability, intermittency of RES, uncertainties).

If required this process can be refined to consider seasonal characteristics of the system (different peak load, different availability of generation plants and/or hydraulicity).

2) **Loss of Largest Unit**

The Loss of Largest Unit criterion is also a deterministic measure that is easy to evaluate and interpret. It corresponds to a reserve capacity (expressed in MW) equivalent to the size of the biggest unit of the system. This criterion is therefore very close to the criterion Reserve Margin (above). However, unlike the reserve margin criteria, the Loss of Largest Unit recognizes the potential reliability issue if the largest resource fails or is otherwise unavailable to serve load. On the other hand, in most cases, the use of this criterion without any other indices will result in insufficient capacity available to meet load when one or more units are unexpectedly tripped while other generation is out for scheduled maintenance.

3) **Derated Capacity Margin**

Derated capacity margins represent the average excess of available supply at peak load demand. The available supply takes into account the statistical unavailabilities of power plants due to maintenance or outages. Unlike the reserve margin criterion this criterion tends to take into account some probabilities of unavailability. However it does not consider the intermittency of renewable energy sources and therefore cannot be considered as a measure of reliability in a system including such sources.

4) **Loss of Load Expectation**

The Loss of Load Expectation (LOLE) is a probabilistic criterion that indicates the expected number of hours in a year during which power demand exceeds the available generation capacity, resulting in the inability to supply the totality of the load without mitigation measures[7]. The Loss of Load Probability is equivalent to the Loss of Load Expectation but it is characterized in percentage [%] of the time instead of hours per year.

Loss of Load Expectation criterion leads to a perceivable and foreseeable risk of shortages independently of structural changes in the system (introduction of big thermal or hydro units, or integration of Renewable Energy Sources). It allows taking into account the different sources of uncertainty identified: Load demand profile and generating profile with their own characteristics (outages and relative sizes of plants). Depending on the characteristics of the system annual LOLE observed values can be volatile from year to year and are a No-linear parameter.

The use of this criterion for generation expansion planning is used to be applied in a large number of countries around the world, notably in Europe but also in the Middle-East, in North-America and in Africa.

Depending on the utilities, this criterion can be defined while considering or not that there are generating capacities outside the national power system that could provide support through transmission interconnections. In such a case, the utility would depend on neighbouring countries. If the criterion is defined in islanded mode (without considering generating capacity in neighbouring countries) the imports can be seen as a mitigation measure to deal with a lack of power available locally.

[7] **Mitigation Measures** may include for example import from neighbouring countries, Demand Side Management measures by the mean of interruptible loads..

5) Expected Energy Not Served

While LOLE is an excellent criterion for evaluating the reliability of a system, it provides an incomplete picture. It does not give any indication related to the number and the magnitude of shortages even if these two characteristics of shortage are important in order to develop and evaluate corrective measures.

Expected Energy Not Served (EENS) is the expected amount of energy that would be curtailed due to the lack of available generating capacity in absence of mitigation measure. This reliability criterion is also a probabilistic one but it is seldom used around the world. Consequently there is a lack of meaningful references for defining acceptable levels of EENS.

6.1.2. Definition of the optimal security standard

6.1.2.1. LOSS OF LOAD EXPECTATION CRITERIA

The use of a LOLE security standard is used in several countries of Western Africa and it is in line with international practices and it is recommended to maintain such a probabilistic approach, especially with the foreseen increase of RES in the energy mix.

However, the question remains related to the level of Loss of Load that can be accepted in the Western African system. The choice of a LOLE criterion should be economically justified. Indeed, a too stringent criterion will result in an excessive amount of reserve capacity to be built and maintained. On the other hand relaxing the criterion too much will incure outage related costs for final consumers during the shortages. The equilibrium is found when the LOLE level balances the Cost of Unserved Energy (CUE) and the Cost of Reserve capacity Margin (CRM).

The values of CUE computed all around the world showed huge disparities in function of the characteristics of the consumption and the importance of electricity in the economy. The Cost of Unserved Energy is in a range between 0 and 60 USD/kWh. The higher the CUE is the more stringent the LOLE should be for a given Cost of Reserve capacity Margin. However, estimates of CUE are not directly transferable from one economy to another because of structural differences in economic and social activities.

This section aims at presenting the criteria applied in different countries in West Africa and elsewhere in the world. These criteria were proposed by national planning teams or by consultants based on the characteristics of the country and the international practice

It is worth mentioning that the criterion used depends not only from economic situation of the country but also the mode of operating their system. As such, some countries do consider a planning criterion in islanded mode while other countries do apply their criterion in the interconnected situation. In the second case, the criteria tend to be more stringent as there are less options to deal with potential lack of capacity (no mutual support can be considered as a mitigation measures).

The following table summarizes the criteria used in the Master Plan studies in the Western African countries. Globally the consultants have opted for LOLE in the range 24h/y to 150h/y.

Country	Criterion
Benin	LOLE (variable scenarios)
Burkina Faso	LOLE 150h/y (2011) -> 50h/y (2030)
Côte d'Ivoire	LOLE 24h/y (100h/y in dry year)
Ghana	LOLE 100h/y
Guinea Bissau	Reserve Margin
Niger	LOLE 100h/y
Senegal	LOLE 72h/y
Togo	LOLE 72h/y

Table 102: LOLE criteria applied in Western African countries

Elsewhere in the world, the following criteria are applied by planning teams:

Country	Criterion
US	LOLE 2.5h/y
Europe	LOLE 3-5h/y
Korea	LOLE 12h/y
GCCIA	LOLE 5h/y
South Africa	LOLE 22h/y

Table 103: LOLE criteria applied worldwide

As a consequence the panel of values identified does suggest that a 24 hours/year of LOLE in Western Africa is realistic at 2033 horizon, while considering an interconnected system where mutual support is possible to compensate for lack of generation in a given country.

6.1.2.2. OPTIONS FOR AN EVOLVING CRITERION

Considering the current situation of Western Africa, the consultant recommends an evolving criterion for Western Africa.

At short-term, due to the fact that the system is poorly interconnected and that a lot of countries are characterized by large volume of unserved energy, the 24h/y LOLE criterion is difficultly applicable. Indeed, such a situation would lead to a massive need of investment at very short-term which shall not be possible to undertake at short-notice. Therefore a LOLE criterion of 100h/y should be considered for the five first years of the study period.

After this period and considering the willingness of the countries to evolve to emergence, a more stringent criterion should be applied as discussed in the previous section.

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Moreover as per the methodology, the consultant will propose a risk assessment in the frame of generation planning. We would like to recommend applying different (less stringent) criteria while computing exceptional situations (dry years, gas shortage,..). Indeed do not consider any reserve to cope with these situations would potentially lead to disaster in case such an event occurs (no capacity available to supply the demand) but considering a very stringent criterion for an exceptional situation will lead to a strong overinvestment in the system.

The following table summarizes the criteria proposed for the update of the generation master plan:

	2018-2023	2024-2033
Normal Situation	100h/an	24h/an
Exceptional Event	200h/an	100h/an

Table 104: Proposition of LOLE for Western Africa

6.2. Operating criteria

The development of a master plan requires the definition of a number of criteria and standards to be met. These correspond on the one hand to safety criteria related to the operation of the networks and on the other hand to criteria related to the reliability of the power system. The final goal is to harmonise these criteria for all the member countries of the WAPP.

The WAPP has completed the definition of common criteria for planning and operation in the WAPP operation handbook which will be used as reference for the study.

The guidelines mentioned in this document will moreover be supplemented by rules followed in Europe (ENTSO-E) and in African countries. The standards used in Europe cannot, at least in the first years, be applied in the WAPP countries, taking into account the characteristics of the networks and the important current capacity deficits in the regional reference system. It is thus necessary to consider a phasing to gradually mitigate these deficits.

6.2.1. WAPP Operating Manual (July 2007)

In this operation handbook, the main directives to be considered for network operation relate to the following topics:

- The power-frequency control (directive 1);
- The interchange scheduling and accounting between control areas (directive 2);
- The operational security (directive 3);
- The operational planning (directive 4);
- Emergency procedures (directive 5).

For the primary control, the reference incident is the simultaneous loss of the largest unit in Nigeria (220 MW) and the largest unit of the group Ghana-Côte d'Ivoire-Togo-Benin-Burkina Faso (220 MW). This criterion is currently not respected due to the chronic lack of generation. The objective of the different synchronous blocks is to maintain a primary reserve equal to the largest unit of this block.

One can notice that, regarding the secondary control, the correction process must be able to be carried out in 20 minutes and corresponds to the largest unit of the control area considered.

Regarding the operational security, the N-1 criterion is applied (loss of a generator or an element of the transmission network) in all control areas.

6.2.2. Definition of operating criteria for this study

The N-1 criterion means that the network must be planned and operated in order to be able to support at any time the loss of a generation group or a component of the transmission system in accordance with the following conditions:

- The voltage must remain within the permissible range (see table below for status N-1);
- The load rate of the network elements must not exceed the predefined thresholds (see table below for status N-1);
- The loss of the element must not cause any loss of charge or activate any defensive measures (generator or interconnection protection, UFLS,...)
- The transient and dynamic stability of the network must be retained;
- The oscillations caused by the incident must be amortized and adhere to the predefined limits (see below).

Each control area operator must apply the N-1 rule taking into account the specifics of its local network to avoid overloads, unacceptable voltage drops, and loss of stability, cascade triggers, etc. It will also have to take the necessary corrective actions such as reduction of loads and shedding if necessary to ensure the safe operation of the entire interconnected network.

In addition, the integration of renewable energies integrates a new dimension in the operation of the system, generating strong constraints for the system not only in case of contingency but also in normal operating conditions (temporal variability of solar production). Technical studies will further analyse these specific constraints.

In order to standardize the security criteria for all countries while taking into account the specificities of African countries, the following assumptions are proposed for the present study for the whole region. It should be stressed that these criteria are an objective that can only be achieved in many countries after a period of transition and upgrading of the transmission network.

Permissible Voltage Range

In normal operation, the voltage of the networks 400kV, 330 kV, 225 kV, 161 kV and 132 kV of the interconnected transmission system will remain within the limits ± 5% of the nominal value. Under incident, it is possible to exceed these limits for a period of maximum 15 minutes and without ever exceeding ±10%.

VNominal	VNormal exploit ± 5%	Vmin -10%	VMax +10%
400kV	380-420	360	440
330kV	315-345	300	360
225kV	214-236	200	245
161kV	153-169	145	175
132kV	126-138	120	145

Table 105: Operating voltages, minimum and maximum

The reactive energy transits on the interconnections are maintained at a minimum level, in order to limit the voltage drops and allocate the transfer capacity to the active power.

Maximum load of transmission infrastructure

Works	State N (Normal Situation)	State N-1 (Under Incident)
	% nominal power	% nominal power
Lines	100 %	110 %
Transformers	100 %	120 %

Table 106: Maximum load of transmission infrastructure

Permissible frequency range in operation

In normal situations, the frequency should remain in the range 49.9 Hz – 50.1 Hz. In case of contingency (loss of a production unit or an interconnection in an import situation):

- The quasi-stationary deviation (observed deviation 30 seconds after the incident) of the frequency shall not exceed-200 MHz;
- The maximum transient deviation must not exceed 0.5 Hz (f dyn max < 500 mHz)

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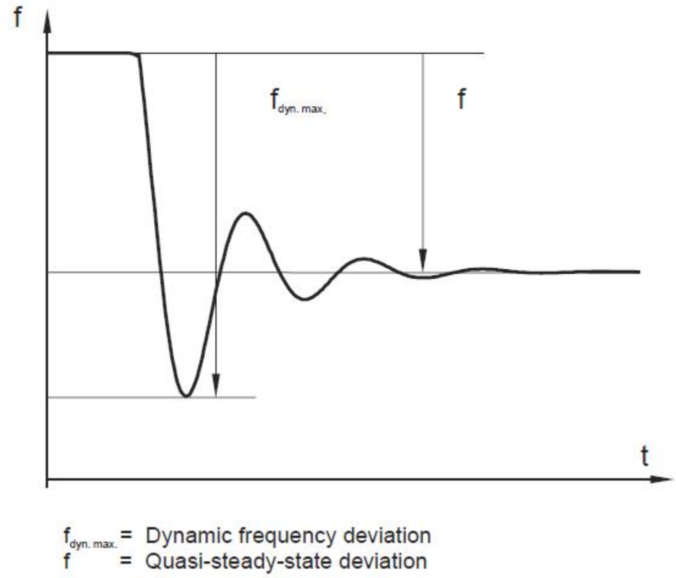

Figure 72: Frequency deviation

The frequency should remain at any time and independently of the severity of the incident in the frequency range 48Hz – 51.5 Hz.

Transit of Reactive Energy on interconnections

Reactive energy transits on interconnections are maintained at a minimum level (power transit maintained if possible below natural power) in order to limit voltage drops and allocate transfer capacity to energy Active.

Dynamic stability of the system Following a Short circuit)

A permanent three-phase defect on a line at the start of a processing station will be considered sufficiently probable to constitute the contingency to be taken into account to verify the dynamic stability of the network. This contingency will be applied by choosing the most critical operating conditions. The stability criterion implies that all alternators maintain their synchronism and remain in operation after the contingency.

Transient stability

The application of the stability criterion leads to the definition of a critical clearing time by voltage level:

- Voltage level 90 KV and 132kV: CCT is 150 ms (7.5 cycles)
- Voltage level 225 KV, 330 kV and 400kV: CCT is 100 ms (5 cycles)

System amortization after an incident

After the loss of an equipment, the system must be properly dampened to ensure the small signal stability of the system and avoid any protective action. The system will be deemed to be properly dampened if the oscillations of the angle of the machine and the speed returned in less than 20 seconds to below 15% of the maximum deviation observed following the incident.

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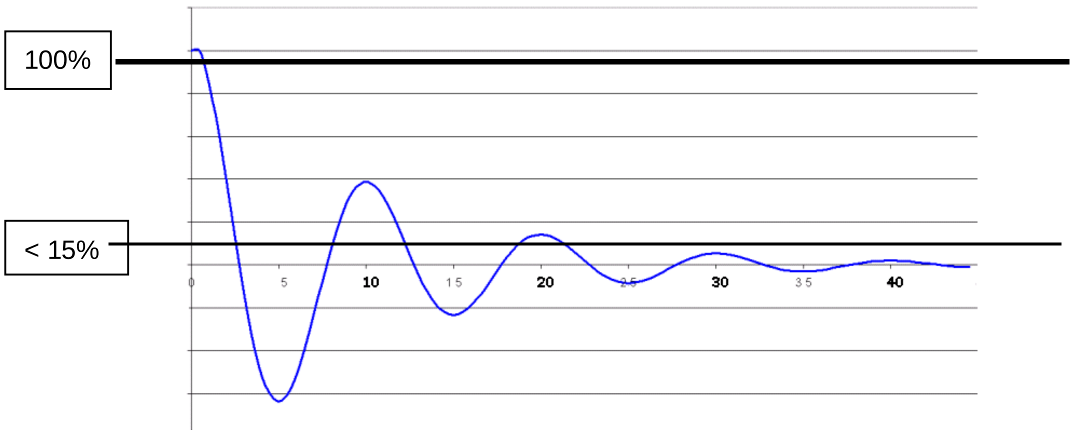

Figure 73: System dampening after an incident

Level of compensation in distribution

Given the presence of air conditioning in the loads (induction motors), a high power factor should be ensured in the distribution substations in order to reduce the risk of voltage collapse and minimize investment in transmission infrastructure. It is proposed to aim in the long term at a minimum power factor of 0.9 at this level.

Permissible short-circuit powers

The proposed target values are:

- 400 kV: 50 kA
- 330 kV: 50 kA
- 225 kV: 50 kA
- 161 kV: 40 kA

Reliability of network elements

The reliability of the lines and transformers is assumed to be 0.995. This value corresponds to a total unavailability (scheduled + unplanned) of 44 hours per year.

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APPENDIX A: LIST OF COLLECTED DATA

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BENIN	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	Plan stratégique de développement 2007_2026	CEB	2007		
2	PLAN D'ACTION POUR LE DEVELOPPEMENT DU SECTEUR DE L'ENERGIE ELECTRIQUE DE LA CEB 2011-	CEB	2011		
3	Etudes pour le Projet WAPP Dorsale Nord 330 Kv	CEB	2008		
4	ETUDE DE L'EXPLOITATION EN BOUCLAGE DU RESEAU SUD DE LA CEB	CEB	2012		
5	Analyse économique du projet de construction du barrage hydroélectrique d'Adjarala	CEB	2012		
6	Faisabilité Lignes d'interconnexion 161 kV Lomé-Atakpamé et postes associés	CEB	2013		
7	Plan directeur bénin	CEB	2015		
	Data on the system				
1	PARAMETRES DU RESEAU CEB	CEB	2018		Détails lignes, transfos, générateurs, liste des postes, courbe de charge par poste, historique
2	Courbes de charge	CEB	2017		
3	Energie Non Désservie par la CEB en 2010	CEB	2010		
4	Rapports d'activité 2012-2016	CEB			
5	Diagramme de puissance de NAN	CEB			
6	Diagramme de puissance des TAGs	CEB			
7	Dynamic data generator	CEB			
8	Exitation des TAGs	CEB			
9	MODERNISATION DU REGULATEUR DE VITESSE CENTRALE HYDRAULIQUE DE NANGBETO	CEB			
10	STANDARDS CEB Postes	CEB			
11	Stability Criteria	CEB			
12	Schémas unifilaires	CEB	2013		
13	Prevision de developement de réseau	CEB			
14	CARACT_LIGNES-TRANSFOS	CEB			
15	Carte électrique SBEE vf	SBEE			
16	Caracteristique_groupe+alternateur	SBEE			
17	Demande de pointe totale et par poste	SBEE			
18	DONNEES SUR LA PRODUCTION	SBEE			
19	PUISSANCES INSTALEES DES CENTRALES DE PRODUCTION DE LA SBEE EN 2017	SBEE	2017		

	Others				
1	Rapport des commissaires aux comptes	CEB			
2	Code Benino-Togolais de l'électricité	CEB			

BURKINA FASO	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	PLAN DIRECTEUR NATIONAL PRODUCTION-TRANSPORT-DISTRIBUTION ET D'ELECTRIFICATION RURALE 2017-2025	Ministère	Juin 2017		Ministère de l'énergie
2	Schéma directeur du BF	SONABEL	Mai 2013		Etude réalisée par EDF
3	MT Strategy and road map Burkina Faso	TE	Août 2016		
4	Etude prospective sur l'énergie au Burjina Faso		Avril 2009		
5	SONABEL OPTIMISATION PRODUCTION&TRANSPOR	TE	2016		
	Data on the system				
1	Rapports d'activités 2002-2016		2016		
2	Schéma électrique du réseau		2014		
3	Sonabel - Pointe 2016 et 2017 (Neplan)		2017		
4	Carte du réseau HT du Burkina		Février 2018		
5	Données de production CESI				
6	Courbes et monotones de charge 2010-2015		2015		
7	Courbe irradiation Burkina Faso	TE			
	Laws				
1	Décret portant adoption de la Lettre de Politique Sectorielle de	Ministère	2016		
2	Décret portant règlementation générale du secteur de	Ministère	2017		
3	Décret régime juridique du partenariat public-privé au BF	Ministère	2013		
4	Politique sectorielle de l'énergie 2014-2025	Ministère	Mai 2013		
5	Assistance à la mise en place des conditions technico-économiques pour le soutien au développement de la filière photovoltaïque raccordée au réseau	Ministère	Novembre 2016		
6	Contrat plan 2015-2019	SONABEL			
7	Grille tarifaire 2008	SONABEL			

COTE D'IVOIRE	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	Electricité de Côte d'ivoire en Chiffres: 1960 – 2014	CI-ENERGIES	Septembre 2015		CI-ENERGIES
2	DEVELOPPEMENT DU SECTEUR DE L'ELECTRICITE DE LA CÔTE D'IVOIRE	CI-ENERGIES	Février 2018		
3	Plan Directeur d'Electrification Rurale de Côte d'Ivoire	CI-ENERGIES	Juillet 2015		IED, TERRABO
4	TRANSPORT D'ENERGIE ELECTRIQUE DE LA COTE D'IVOIRE POUR LA PERIODE 2014-2030	CI-ENERGIES	Juin 2015		TE
5	Plan National de développement 2016-2020	DGE	2015		
6	SITUATION ÉCONOMIQUE EN CÔTE D'IVOIRE	DGE	2018		FMI
	Data on the system				
1	Carte réseau national 2020, 2030	CI-ENERGIES	2017		
2	RESEAU DE TRANSPORT D'ABIDJAN 2016	CI-ENERGIES	2016		
3	EVOLUTION RESEAU DE TRANSPORT D'ABIDJAN 2017- 2020	CI-ENERGIES	Janvier 2017		
4	Carte potentiel hydroélectrique	CI-ENERGIES	2013		
5	Carte potentiel biomasse	CI-ENERGIES	mars 2016		
6	Carte potentiel solaire	CI-ENERGIES	2011		
7	RELATIF AU RESEAU DE LA COTE D'IVOIRE POUR LES ANNEES	CI-ENERGIES	Janvier 2018		
8	Statistiques production hydroliques	CIE	2017		
9	Prix du combustible 2008-2017	CIE	2017		
10	Consommation de combustible	CIE	2017		
11	Données techniques des groupes de production/Transformateurs groupes	CIE	2017		
12	Données historiques énergies non désservie 2014-2017	CIE	2017		
13	Pertes techniques 1984-2017	CIE	2017		
14	Consommation annuelle 1980-2017	CIE	2017		données en énergie par mois
15	Pointe de charge 1980-2017	CIE	2017		et pointes mensuelles
16	Inventaire des équipements HT 2017	CIE	2017		
17	Consommation par catégorie 2006-2016	CIE	2016		
18	Pointes des postes de sources 2004-2017	CIE	2017		
19	Profil horaire de charge 2007-2017	CIE	2017		
20	Rapport de Plan de Défense sur le Réseau Electrique Ivoirien	CIE	2016		

COTE D'IVOIRE	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Tariffs				
1	Arrêté interministériel n° 409 portant modification des tarifs de l'électricité	CI-ENERGIES	2016		
	Laws				
1	Code de l'électricité	CI-ENERGIES	2016		Code pour racoordement au réseau
2	Cadre institutionnel du secteur de l'electricité	DGE			
3	Liste des conventions de concession de production	DGE	février 2018		
4	Code des Investisssements & Code des douanes RCI	DGE			
5	Code des Marchés Publics RCI	DGE	2009		
6	Décrets relatifs aux PPP RCI	DGE			
7	Document de Politique enegétique et Note sur la stratégie de Dev EnR RCI	DGE			
	MoM				
1					

GAMBIE	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	FEASIBILITY STUDY FOR ELECTRIFICATION AND NETWORK UPGRADING IN THE GREATER BANJUL AREA AND THE WESTERN REGION OF THE GAMBIA	NAWEC	2009		
2	FEASIBILITY STUDY Small Scale Wind Park Lahmeyer	NAWEC			
3	The Gambia Electricity Sector Roadmap – High Level	NAWEC	2017		
4	Renewable Energy Act 2013	NAWEC			
5	Gambian National Transmission & Distribution Project	NAWEC	2017		
	Data on the system				
1	LOAD PROFILE - 2013_14_15	NAWEC			
2	ONGOING PROJECTS	NAWEC			
3	Production des centrales Brikama et Kotu	NAWEC			
4	Revised 33_11kV Single line.dwg	NAWEC			
	Others				
1	Rapports annuels	NAWEC			

GHANA	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	Renewable Energy Masterplan for Ghana	Energy Commission	2016		
	Data on the system				
1	Rapports annuels 2014-2017	GRIDco			
2	2018-2027 Demand and Energy Forecast	GRIDco			
3	Actual Hourly Reading 2010 - 2018	GRIDco			
4	GENERATOR DYNAMIC CHARACTERISTICS	GRIDco			
5	Ghana National Grid - rev MARCH 2017	GRIDco	2017		
6	Single line diagram - Feb, 2017	GRIDco	2017		
7	QUARTERLY REPORT customers	GRIDco			
8	Power plants in Ghana	Energy Commission			
9	NATIONAL ENERGY STATISTICS	Energy Commission			
	Others				
1	Gas Master Plan 2016	Energy Commission			
2	Gas Supply_Forecast_Final (4)	GRIDco			
3	Ghana Renewable Energy Grid-Code	GRIDco			
4	National_Elect_Grid_Code_2009_final_EC[1]	GRIDco			

GUINEE	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	Etudes de la ligne d'interconnexion électrique 225 kV Guinée-Mali	EDG			Prévision de la demande + Etude de l'offre
2	Contrat de gestion d'EDG - Diagnostic de la fonction transport	EDG			
3	Etudes de faisabilité et d'impact environnemental et social de la ligne de transport électrique Linsan-Fomi	CLSG			
	Data on the system				
1	Etat de la satisfaction de la demande	EDG			
2	Production des centrales EDG	EDG			
3	Statistiques d'apports en eau mensuel en hm^3 des lacs	EDG			
4	6. plan detaillé de production 2017-2020 EDG	CLSG			
5	Accroissement Demande 2016-2017	CLSG			

GUINEE BISSAU	Collected documents	Transmitted by	Date document	Transmission date	Comment
	<u>Previous studies</u>				
1	Plan directeur 2012		2012		
2	Plan de production à moindre coût et modèle		2018		
	<u>Data on the system</u>				
1	Détails centrale de Bor				
2	Plans des pylones				
	<u>Others</u>				
1	Plan de Gestion environnementale et sociale Vfr		2015		

LIBERIA	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	Plan directeur Fichtner 2013	LEC	2013		
2	Rural electrification RREA 5 Yr Investment Plan _	LEC			
	RURAL ENERGY STRATEGY AND MASTER	LEC	2016		
	Data on the system				
1	Annex II Certain Information for Applicants	LEC			
2	Etude tarifaire USAID				

NIGER	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	Projet d'expansion de l'accès à l'électricité	DGE	Février 2017		Etude TE
2	Etude tarifaire	DGE	Septembre 2017		Etude macroconsulting
3	Plan d'affaire 2016-2027	Nigelec	Décembre 2016		
	Data on the system				
1	Carte réseau existant	Nigelec	2017		
2	Liste projets production_transport	Nigelec			
3	Zone NCE - Schéma Unifilaire	Nigelec			
4	Zone Fleuve - Schéma Unifilaire	Nigelec			
5	Rapports d'activité 2005-2016	Nigelec	2016		
6	Courbes de charge NCE, Niamey (2015-2017)	Nigelec	2017		
7	Zone NCE - modèles PSSE 2016/2020	Nigelec			
8	Zone Fleuve - modèles PSSE 2016/2020	Nigelec			
	Laws				
1	Loi ANPER	DGE	2013		
2	Code investissements	DGE	2014		
3	Code d'Electricité et décrets	DGE	2016		
4	Code marchés publiques	DGE	2013		
5	Code général des impôts	DGE	2012		
6	Décrets-structure-Tarifs	DGE	2017		
7	Loi ARSE	DGE	2015		

NIGERIA	Collected documents	Transmitted by	Date document	Transmission date	Comment
	<u>Previous studies</u>				
1	Transmission expansion plan		Décembre 2017		Etude Fichtner
	<u>Data on the system</u>				
1	Transmission pojects for 10000 MW				
2	Transmission pojects for 20000 MW				
3	Power sector gas demand profile				

MALI	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	Etude de la demande et du plan directeur d'investissements optimaux pour le secteur de l'électricité au Mali	EDM	MARS 2015		
2	Faisabilité technique de l'aménagement de Gouina	EDM	MARS 2004		
3	DIAGNOSTIC ET EVALUATION DES INVESTISSEMENTS DE RENFORCEMENT ET DE MODERNISATION DU	EDM	JUIN 2017		
	Data on the system				
1	Pointe RI 1975 à 2014 _VDK	EDM			
2	Données EDM SA etudes 12 08 2014	EDM			
3	Production et ventes électricité de 1985 à 2012	EDM			
4	Rapports d'activité 2008-2016	EDM			
5	Schéma unifilaire réseau 2016	EDM	OMVS		
6	Carte réseau WAPP	EDM			

SENEGAL	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	Prévisions de la Demande 2016-2035	Senelec	2017		
2	Stratégie de Maîtrise de l'Energie du Sénégal (SMES)	Senelec			
3	PLAN D'ACTION MAITRISE DE LA DEMANDE ET EFFICACITE ENERGETIQUE	Senelec			
4	Étude du Plan directeur de développement du réseau de transport de l'O.M.V.S pour la période 2015-2030	OMVS			
5	ÉTUDE DE FAISABILITÉ ET D'AVANT-PROJET SOMMAIRE (APS) DE L'AMÉNAGEMENT HYDROÉLECTRIQUE DE GOURBASSI	OMVS			
6	Aménagement hydro de koukoutamba	OMVS			
7	POLITIQUE ENE RGE T IQUE C OMMUNE DE S PA Y S MEMB R E S DE L 'OMV S (PEC-OMVS	OMVS			
8	REVUE/ACTUALISATION DES ETUDES TECHNIQUES DE L'INTERCONNEXION	OMVG			
9	PLAN STRATEGIQUE DE DEVELOPPEMENT 2018-2022	MPE			
10	ACTUALISATION DU SCHEMA DIRECTEUR PRODUCTION ET TRANSPORT DANS LA PERIODE	Senelec			
	Data on the system				
1	Rapports annuels 2012-2016	Senelec			
2	Energitique (SIE)	Senelec	2014-2015		
3	Rapport annuel Mouvements d'énergie 2010-2016	Senelec			
4	Etude tarifaire	Senelec	2015		
5	Historique consommation d'énergie et pertes 2007-2017	Senelec			
6	INFORMATION REQUEST ON WAPP GENERATION AND TRANSMISSION PROJECTS	OMVS			

7	Pointes par poste source	Senelec			
8	Transformateurs	Senelec			
9	Postes	Senelec			
10	Lignes	Senelec			
11	Charges	Senelec			
12	Centrales	Senelec			
13	Compensation	Senelec			
	Others				
1	Projections PIB	Senelec			
2	Projections démographiques	Senelec			
3	FONCTIONNEMENT DE LA REGULATION CRSE	Senelec			

SIERRA LEONE	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	Roadmap for the Reform of the Electricity Sector	EWRC	2017		
2	Master Plan JICA	EWRC	2009		
	Others				
1	Public procurement Act	EWRC			
2	EWRC Act No 13 2011 (1)	EWRC			
3	EWRC_Mini-Grid_Regulations_2017_Draft	EWRC			
4	National Electricity Act No 16 2011	EWRC			
5	regulatory instruments for EWRC	EWRC			

TOGO	Collected documents	Transmitted by	Date document	Transmission date	Comment
	Previous studies				
1	Plan directeur Togo	CEET	2014		
	Data on the system				
1	Parc de production CEET	CEET			
2	Étude de la Réssource Éolienne pour 3 Sites de la	DGE			
	Others				
1	Code Benino-Togolais de l'électricité	CEET			
2	Tarif	CEET	2010		
3	Lettre de Politique de Développement du Secteur de	DGE			
4	Plan Actions National d'Efficacité Energétique	DGE			
5	ENERGIE DURABLE POUR TOUS (SE4ALL) PROGRAMME D'ACTION NATIONAL	DGE			
6	Togo-Code des investissements_2012	ARSE	2012		
7	Loi du secteur électrique	ARSE			
8	Législations sur les marchés publics	ARSE			
9	Arrêtés tarifaires	ARSE			
10	Facilité d'Assistance Technique Énergie Durable Pour Tous (SE4ALL) Afrique Occidentale et	DGE			

APPENDIX B : LIST OF EXISTING GENERATION UINTS

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4.3.8. Appendix: Simulations "Thermoflow" gas and coal

TRACTEBEL Engineering GDF SUEZ Rev: B Latest revision date :	01/04/2011	WAPP Power Generation Simulation Hypothesis and Comments

Item Nr.	Keyword	Thermoflow case	Subject/Item	Comment	
1	Temperature	general	ambiant temp	33 °C	
2	Rh	general	Relative humidity	70%	
3	Frequency	general	Elec Network	50 Hz	
4	SW T°	general	SW temperature	25 °C. T° difference between Sw in and outlet :Sw out -SW in = 7°C	
5	Cost	general	Regional Cost considered	South Africa, no other african country available within Thermoflow library.	
6	Indoor/outdoo	general	Site configuration	GT + ST are indoor. HRSG outdoor as well as utilities.	
7	Pressure Level	general (Except 5-6)	Cycle configuration	3 pressure levels reheat	
8	Fuel	general	Fuel	Natural Gaz with sufficient network pressure. (No additional fuel gas compressor)	
9	Fuel	general	Fuel	Dual fuel package included. Base case is Natural Gas not Diesel Oil.	
10	Fuel	general	Fuel	Distillated Oil as standard selection in Thermoflow library. No other option available.	
11	CAPEX	general	CAPEX philosphy	Based on low cost calculation and not on efficiency optimisation which leads to higher investment (among other in the number of aero condenser)	
12	HRSG	all	Performances	Pinch set at 10 - 15 -15 for LP and IP and HP respectively.	
13	HRSG	all	Availability	By pass stack	
14	ST Condenser		water cooling	Seawater	
15	CAPEX options	all	Spare Parts	2% of total EPC cost	
16	ALSTOM GT	1-2		In case of ALSTOM GT the net power generated is 319MW. Rem: Silo combustor (high fuel flexibility)	

TRACTEBEL Engineering GDF SUEZ Rev: B Latest revision date : 01/04/2011				**WAPP Power Generation Simulation** **Hypothesis and Comments**	
Item Nr.	**Keyword**	**Thermoflow case**	**Subject/Item**	**Comment**	
17	Gas Turbine	1-2	Main characteristics of Gas Turbine selected	- Low NOX (dry low Nox combustor) - Reliable, robust and proven technology. - High Fuel flexibility (Crude Oil),	
18	Air-cooled condenser	1-3-5	Air cooled Condenser	This solution has the following advantage and desadvantages: - No need of water consumption (especially at location where water is not easily available), - Higher electrical consumption, - Higher footprint, - Higher capex, - lower efficiency, Improved solutions (e.g.: wet tower, hybrid cooling systems, Heller systems) could be used instead but depends on the site location and specifications.	
19	Air-cooled condenser	1-3-5	Design point	Condenser pressure fixed at 200 mbar following the site conditions.	
20	Pressure level HRSG	5-6	Cycle configuration	2 pressure levels (2P) but only HP connected to the Steam Turbine. LP is routed directly to the Deaerator. HP Steam temperature limited to 520 °C.	
21	GT type	5-6	GT selection	Aero-derivative GT not selected because of higher technical complexity for small power generated. The selected GT's are limited to the use of Natural Gas of Distalaate Oil #2 as combustion fuel.	
22	GT type	3-4	GT Selection	GT 7FA with Gross output of 171MW with 9 ppm Nox emission should also be suitable.	
23	Coal fire	10	Defintion of "CFB" See figure 2.	Circulating Fluidised Bed technology means that in fluidised bed, coal is burned in a self mixing suspension of gas and solid bed material in which air for combustion enters from below. In circulating (fluidisation velocity of about 8m/s) fluidised bed combustion (CFBC) the captured solids including any unburned carbon are re-injected directly back into the combustion chamber without passing through an external recirculation. The internal solids ciculation in CFB provides longer residence time for fuel and limestone, resulting in good combustion and improved sulphur capture.	
24	Coal fire	11	Defintion of "PC" See figure 1.	Pulverised Coal technology means that the raw coal in the silos is conducted to the coal mills where it is dried up , finely pulverised (<80µm) and the size classified using preheated primary air.The pulverised coal is directly injected with primary air in the burners located at different levels of the boiler.	

Thermal Plants

Benin

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity [MW]	Available Capacity [MW]	Efficiency (primary fuel) [GJ/MWh]	Efficiency (secondary fuel) [GJ/MWh]	Commissioning Date	Decommissioning Date	Forced outage rate [%]	Planned Maintenance [h/year]	Variable O&M costs [$/MWh]	Fixed O&M costs [$/kW/year]
Maria Gleta	TAG CEB	DI	NG	DDO	20	20	14.8	14.8	1998	2025	VS	VS	VS	VS
Akpakpa	DI SBEE	DI	HFO		30	0	11.1				VS	VS	VS	VS
Natitingou	DI SBEE	DI	DDO		12	4	11				VS	VS	VS	VS
Parakou	DI SBEE	DI	DDO		25.3	4	9.4				VS	VS	VS	VS
Porto-Novo	DI SBEE	DI	DDO		12	6	10.8				VS	VS	VS	VS
Parakou	DI MRI	DI	DDO		17	5	VS				VS	VS	VS	VS
Vedoko	DI MRI	DI	DDO		26	20	VS				VS	VS	VS	VS
Akpakpa	DI AGGREKO	DI	DDO		35	35	VS				VS	VS	VS	VS
Gbegamey	DI AGGREKO	DI	DDO		16	15	VS				VS	VS	VS	VS
Maria Gleta	DI AGGREKO	DI	DDO		57	50	VS				VS	VS	VS	VS
CAI	TAG	GT	DDO	NG*	80	0	VS				VS	VS	VS	VS

** Currently no gas available*

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Burkina Faso

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity *[MW]*	Available Capacity *[MW]*	Efficiency (primary fuel) *[GJ/MWh]*	Efficiency (secondary fuel) *[GJ/MWh]*	Commissioning Date	Decommissioning Date	Forced outage rate *[%]*	Planned Maintenance *[h/year]*	Variable O&M costs *[$/MWh]*	Fixed O&M costs *[$/kW/year]*
OUAGA I			DDO		5.4	5	VS	VS			VS	VS	VS	VS
OUAGA II			HFO	DDO	35.08	23.3	VS	VS		2020	VS	VS	VS	VS
KOMSILGA			HFO	DDO	94	79.5	VS	VS			VS	VS	VS	VS
KOSSODO			HFO	DDO	64	51	VS	VS			VS	VS	VS	VS
BOBO II			HFO	DDO	68	57	VS	VS			VS	VS	VS	VS
GAOUA			DDO		2.4	1.9	VS	VS			VS	VS	VS	VS
DEDOUGOU			DDO		5.68	4.4	VS	VS			VS	VS	VS	VS
FADA			DDO		2	1.1	VS	VS			VS	VS	VS	VS
DORI			DDO		4.37	3	VS	VS			VS	VS	VS	VS
OUAHIGOUYA			DDO		5.2	3.7	VS	VS			VS	VS	VS	VS

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Côte d'Ivoire

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity *[MW]*	Available Capacity *[MW]*	Efficiency (primary fuel) *[GJ/MWh]*	Efficiency (secondary fuel) *[GJ/MWh]*	Commissioning Date	Decommissioning Date	Forced outage rate *[%]*	Planned Maintenance *[h/year]*	Variable O&M costs *[$/MWh]*	Fixed O&M costs *[$/kW/year]*
Azito	TG1	CC	NG		156	152	VS	VS	2000		VS	VS	VS	VS
Azito	TG2	CC	NG		156	152	VS	VS	2000		VS	VS	VS	VS
Azito	TAV	CC			168	168	VS	VS	2015		VS	VS	VS	VS
Ciprel	TG5	GT	NG	HVO+DDO		33	VS	VS	1995		VS	VS	VS	VS
Ciprel	TG6	GT	NG		34.5	33	VS	VS	1995		VS	VS	VS	VS
Ciprel	TG7	GT	NG		34.5	33	VS	VS	1995		VS	VS	VS	VS
Ciprel	TG8	GT	NG			111	VS	VS	1997		VS	VS	VS	VS
Ciprel	TG9	CC	NG			111	VS	VS	2013		VS	VS	VS	VS
Ciprel	TG10	CC	NG			117	VS	VS	2014		VS	VS	VS	VS
Ciprel	TAV	CC				111	VS	VS	2016		VS	VS	VS	VS
Vridi	TG1	GT	NG			21.5	VS	VS	1984		VS	VS	VS	VS
Vridi	TG2	GT	NG			21.5	VS	VS	1984		VS	VS	VS	VS
Vridi	TG3	GT	NG			21.5	VS	VS	1984		VS	VS	VS	VS
Vridi	TG4	GT	NG			21.5	VS	VS	1984		VS	VS	VS	VS
Aggreko	T1	GT	NG			35	VS	VS		2020	VS	VS	VS	VS
Aggreko	T2	GT	NG			30	VS	VS		2020	VS	VS	VS	VS
Aggreko	T3	GT	NG			35	VS	VS		2020	VS	VS	VS	VS
Aggreko	T4	GT	NG			50	VS	VS		2020	VS	VS	VS	VS
Aggreko	T5	GT	NG			50	VS	VS		2020	VS	VS	VS	VS

Gambia

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity [MW]	Available Capacity [MW]	Efficiency (primary fuel) [GJ/MWh]	Efficiency (secondary fuel) [GJ/MWh]	Commissioning Date	Decommissioning Date	Forced outage rate [%]	Planned Maintenance [h/year]	Variable O&M costs [$/MWh]	Fixed O&M costs [$/kW/year]
Kotu	G1	DI	HFO		3	3			2001	2018	VS	VS	VS	VS
Kotu*	G2	DI	HFO		3	0			2001		VS	VS	VS	VS
Kotu	G3	DI	HFO		3.4	3			2001	2025	VS	VS	VS	VS
Kotu	G4R	DI	HFO		6.4	5.5			2001	2023	VS	VS	VS	VS
Kotu	G6	DI	HFO		6.4	5.5			1990	2025	VS	VS	VS	VS
Kotu	G7	DI	HFO		6.4	5.5			2001	2024	VS	VS	VS	VS
Kotu	G8	DI	HFO		6.4	5.5			2001		VS	VS	VS	VS
Kotu	G9	DI	HFO		6.4	5.5			2009	2023	VS	VS	VS	VS
Brikama I	G1	DI	HFO		6.4	5.5			2006	2024	VS	VS	VS	VS
Brikama I	G2	DI	HFO		6.4	5.5			2006	2024	VS	VS	VS	VS
Brikama I	G3	DI	HFO		6.4	5.5			2006	2024	VS	VS	VS	VS
Brikama I	G4	DI	HFO		6.4	5.5			2006	2024	VS	VS	VS	VS
Brikama I	G5	DI	HFO		6.4	5.5			2013	2024	VS	VS	VS	VS
Brikama I	G6	DI	HFO		6.4	5.5			2013	2024	VS	VS	VS	VS
Brikama II*	Warsila	DI	HFO		8	0			2011		VS	VS	VS	VS

** Hors Service*

Ghana

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity *[MW]*	Available Capacity *[MW]*	Efficiency (primary fuel) *[GJ/MWh]*	Efficiency (secondary fuel) *[GJ/MWh]*	Commissioning Date	Decommissioning Date	Forced outage rate *[%]*	Planned Maintenance *[h/year]*	Variable O&M costs *[$/MWh]*	Fixed O&M costs *[$/kW/year]*
TAPCO	GT1	CC	DDO	NG	110	100	8	8.7	1997		35%		2/ 5	VS
TAPCO	GT2	CC	DDO	NG	110	100	8	8.7	1997				2/ 5	VS
TAPCO	ST	CC	DDO	NG	110	100	8	8.7	1998				2/ 5	VS
TICO	GT1	CC	DDO	NG	110	100	8	8.7	2001		15%		2/ 5	VS
TICO	GT2	CC	DDO	NG	110	100	8	8.7	2001				2/ 5	VS
TICO	ST	CC	DDO	NG	120	100	8	8.7	2012				2/ 5	VS
CENIT	GT1	GT	DDO	NG	126	100	11.4	11.6	2012		8%		4.5	VS
TT1PP	GT1	GT	DDO	NG	126	100	11.4	11.6	2009		12%		VS	VS
TT2PP	GT1	GT	DDO	NG	12.9	11.7	11.1	11.2	2010		15%		VS	VS
TT2PP	GT2	GT	DDO	NG	12.9	11.7	11.1	11.2	2010		15%		VS	VS
TT2PP	GT3	GT	DDO	NG	7.9	7.2	11.1	11.2	2010		15%		VS	VS
TT2PP	GT4	GT	DDO	NG	7.9	7.2	11.1	11.2	2010		15%		VS	VS
TT2PP	GT5	GT	DDO	NG	7.9	7.2	11.1	11.2	2010		15%		VS	VS
KTPP1	GT1	CC	DDO	NG	110	100	VS	VS	2017		15%		VS	VS
KTPP2	GT2	CC	DDO	NG	110	100	VS	VS	2017		15%		VS	VS
AKSA	GT	GT	HFO		370	345	VS	VS	2017		10%		VS	VS
KARPOWER III	GT	GT	HFO		675	646	VS	VS	2015-2018		10%		VS	VS
AMERI	GT	GT	NG		250	230		VS	2016		10%		VS	VS
SUNSON ASOGLI	CC1	CC	NG		200	180			2010		10%		VS	VS
SUNSON ASOGLI	CC2	CC	NG	DDO	360	340			2016		15%		VS	VS

Final version

Guinea

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity *[MW]*	Available Capacity *[MW]*	Efficiency (primary fuel) *[GJ/MWh]*	Efficiency (secondary fuel) *[GJ/MWh]*	Commissioning Date	Decommissioning Date	Forced outage rate *[%]*	Planned Maintenance *[h/year]*	Variable O&M costs *[$/MWh]*	Fixed O&M costs *[$/kW/year]*
G-Energie	G1	DI	DDO		21.25	17			2015		VS	VS	VS	VS
G-Energie	G2	DI	DDO		21.25	17			2015		VS	VS	VS	VS
Kaloum1	11G	DI	HFO		4.06	3.7			2015		VS	VS	VS	VS
Kaloum1	12G	DI	HFO		4.06	3.7			2015		VS	VS	VS	VS
Kaloum1	13G	DI	HFO		4.06	3.7			2015		VS	VS	VS	VS
Kaloum1	14G	DI	HFO		4.06	3.7			2015		VS	VS	VS	VS
Kaloum1	15G	DI	HFO		4.06	3.7			2015		VS	VS	VS	VS
Kaloum1	16G	DI	HFO		4.06	3.7			2015		VS	VS	VS	VS
Kaloum2	21G	DI	HFO		8.74	7.6			2016		VS	VS	VS	VS
Kaloum2	22G	DI	HFO		8.74	7.6			2016		VS	VS	VS	VS
Kaloum2	23G	DI	HFO		8.74	7.6			2016		VS	VS	VS	VS
Kaloum3	31G	DI	HFO		11.2	10			1997		VS	VS	VS	VS
Kaloum3	32G	DI	HFO		11.2	10			1997		VS	VS	VS	VS
Kaloum3	33G	DI	HFO		11.2	10			1997		VS	VS	VS	VS
Kaloum3	34G	DI	HFO		11.2	10			1999		VS	VS	VS	VS
Kaloum5	51G	DI	HFO		11.0	10			2005		VS	VS	VS	VS
Kaloum5	52G	DI	HFO		11.0	10			2005		VS	VS	VS	VS
Kaloum5	53G	DI	HFO		11.0	10			2005		VS	VS	VS	VS
Kipé	G1	DI	HFO		8.74	6.5			2016		VS	VS	VS	VS
Kipé	G2	DI	HFO		8.74	6.5			2016		VS	VS	VS	VS
Kipé	G3	DI	HFO		8.74	6.5			2016		VS	VS	VS	VS
Kipé	G4	DI	HFO		8.74	6.5			2016		VS	VS	VS	VS

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity [MW]	Available Capacity [MW]	Efficiency (primary fuel) [GJ/MWh]	Efficiency (secondary fuel) [GJ/MWh]	Commissioning Date	Decommissioning Date	Forced outage rate [%]	Planned Maintenance [h/year]	Variable O&M costs [$/MWh]	Fixed O&M costs [$/kW/year]
Kipé	G5	DI	HFO		8.74	6.5			2016		VS	VS	VS	VS
Kipé	G6	DI	HFO		8.74	6.5			2016		VS	VS	VS	VS

Guinea Bissau

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity [MW]	Available Capacity [MW]	Efficiency (primary fuel) [GJ/MWh]	Efficiency (secondary fuel) [GJ/MWh]	Commissioning Date	Decommissioning Date	Forced outage rate [%]	Planned Maintenance [h/year]	Variable O&M costs [$/MWh]	Fixed O&M costs [$/kW/year]
Aggrekko	Location1	DI	DDO		15	15	VS	VS		2018	VS	VS	VS	VS

Liberia

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity [MW]	Available Capacity [MW]	Efficiency (primary fuel) [GJ/MWh]	Efficiency (secondary fuel) [GJ/MWh]	Commissioning Date	Decommissioning Date	Forced outage rate [%]	Planned Maintenance [h/year]	Variable O&M costs [$/MWh]	Fixed O&M costs [$/kW/year]
Existing	DI1	DI	DDO		22.6		VS	VS		2018	VS	VS	VS	VS

Final version

Mali

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity [MW]	Available Capacity [MW]	Efficiency (primary fuel) [GJ/MWh]	Efficiency (secondary fuel) [GJ/MWh]	Commissioning Date	Decommissioning Date	Forced outage rate [%]	Planned Maintenance [h/year]	Variable O&M costs [$/MWh]	Fixes O&M costs [$/kW/year]
Darsalam	TAC	GT	DDO		24.6	24.6	15.6		1999	2023	VS	VS	VS	VS
Balingué	G1	DI	HFO		6.46	6.46	9.4		2000	2020	VS	VS	VS	VS
Balingué	G2	DI	HFO		6.46	6.46	9.4		2000	2020	VS	VS	VS	VS
Balingué	G3	DI	HFO		6.46	6.46	9.4		2000	2020	VS	VS	VS	VS
Balingué	G4	DI	HFO		4.94	4.94	9.4		2001	2021	VS	VS	VS	VS
Balingué BID	G1	DI	HFO		12.16	8.45	VS		2011	2026	VS	VS	VS	VS
Balingué BID	G2	DI	HFO		12.15	8.45	VS		2011	2026	VS	VS	VS	VS
Balingué BID	G3	DI	HFO		12.15	8.45	VS		2011	2026	VS	VS	VS	VS
Balingué BID	G4	DI	HFO		12.15	8.45	VS		2011	2026	VS	VS	VS	VS
Balingué BID	G5	DI	HFO		11.5	8.1	VS		2015	2030	VS	VS	VS	VS
Balingué BID	G6	DI	HFO		11.5	8.1	VS		2015	2030	VS	VS	VS	VS
Aggreko (Balingué)		DI	DDO		30	30	VS				VS	VS	VS	VS
Aggreko (DarSalam)		DI	DDO		11	11	VS				VS	VS	VS	VS
Aggreko (Kati)		DI	DDO		22	22	VS				VS	VS	VS	VS
SES (Lafia)		DI	DDO		10	10	VS				VS	VS	VS	VS
SES (Koutiala)		DI	DDO		10	10	VS				VS	VS	VS	VS
Aggreko (Dakar)		DI	DDO		40	40	VS				VS	VS	VS	VS

Final version

Niger

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity [MW]	Available Capacity [MW]	Efficiency (primary fuel) [GJ/MWh]	Efficiency (secondary fuel) [GJ/MWh]	Commissioning Date	Decommissioning Date	Forced outage rate [%]	Planned Maintenance [h/year]	Variable O&M costs [$/MWh]	Fixed O&M costs [$/kW/year]
NIAMEY	1	DI	DO		11.5	9			1980		VS	VS	VS	VS
NIAMEY	2	DI	DO		12	9			1982		VS	VS	VS	VS
GOUDEL	PC4	DI	DO		10	9			1980		VS	VS	VS	VS
GOUDEL	MTU1-7	DI	DO		15.4	12.6			2009		VS	VS	VS	VS
GAYA	CAT	DI	DO		0.292	0.2			1998		VS	VS	VS	VS
GAYA	VOLVO	DI	DO		0.504	0.42			2011		VS	VS	VS	VS
MARADI	CAT	DI	DO		0.728	0.7			1989		VS	VS	VS	VS
MARADI	VOLVO P1-3	DI	DO		1.512	1.2			2009		VS	VS	VS	VS
MARADI	MTU1-2	DI	DO		4.2	3.4			2009		VS	VS	VS	VS
TAHOUA	CAT	DI	DO		2.548	1.5			1988-1991		VS	VS	VS	VS
TAHOUA	VOLVO P1-2	DI	DO		1.008	0.8			2009		VS	VS	VS	VS
MALBAZA	MTU	DI	DO		1.28	0.75			1999		VS	VS	VS	VS
MALBAZA	AGO	DI	DO		1.1	0.8			1980		VS	VS	VS	VS
MALBAZA	MTU1-4	DI	DO		6.4	6			2015		VS	VS	VS	VS
ZINDER		DI	DO		3.192	2.6			1991		VS	VS	VS	VS
ZINDER	MTU1-2	DI	DO		4	3.2			2009		VS	VS	VS	VS
SONICHAR	GTA1		COAL		18.8	18.8			1981		VS	VS	VS	VS
SONICHAR	GTA2		COAL		18.8	18.8			1982		VS	VS	VS	VS
AGADEZ	GR1-6	DI	DO		1.888	1.4			1979-2012		VS	VS	VS	VS
DIFFA	GR1-10	DI	DO		7.552	6.664			2004-2015		VS	VS	VS	VS
GOROU BANDA	1	DI	DO		20	20	195,597 kg/MWh		2016		VS	VS	VS	VS
GOROU BANDA	2	DI	DO		20	20	195,597 kg/MWh		2016		VS	VS	VS	VS

Final version

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Commissioning Date	Decommissioning Date	Forced outage rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*			*[%]*	*[h/year]*	*[$/MWh]*	*[$/kW/year]*
GOROU BANDA	3	DI	DO		20	20	195,597 kg/MWh		2016		VS	VS	VS	VS
GOROU BANDA	4	DI	COAL		20	20	195,597 kg/MWh		2016		VS	VS	VS	VS
AGGREKO		DI	DO		10	10			2012		VS	VS	VS	VS
AGGREKO		DI	DO		10	10			2012		VS	VS	VS	VS
AGGREKO		DI	DO		10	10			2012		VS	VS	VS	VS

Nigeria

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Commissioning Date	Decommissioning Date	Forced outage rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*			*[%]*	*[h/year]*	*[$/MWh]*	*[$/kW/year]*
DELTA		GT	NG		879	511	14.152		1990-2005		VS	VS	VS	VS
AFAM IV-V		GT	NG		804	0			1982-2002		VS	VS	VS	VS
GEREGU GAS		GT	NG		414	414	11.134		2013		VS	VS	VS	VS
OMOTOSHO GAS		GT	NG		335	335	12.649		2007		VS	VS	VS	VS
OLORUNSOGO GAS		GT	NG		335	293	23.21		2007		VS	VS	VS	VS
GEREGU NIPP		GT	NG		444	444	11.622		2013		VS	VS	VS	VS
SAPELE NIPP		GT	NG		454	113	10.149		2011		VS	VS	VS	VS
ALAOJI NIPP		GT	NG		480	240			2013		VS	VS	VS	VS
OLORUNSOGO NIPP		CC	NG		758	631	13.307		2011-2012		VS	VS	VS	VS
OMOTOSHO NIPP		GT	NG		505	505	15.366		2012		VS	VS	VS	VS
ODUKPANI NIPP		GT	NG		565	113			2015		VS	VS	VS	VS

Final version

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity *[MW]*	Available Capacity *[MW]*	Efficiency (primary fuel) *[GJ/MWh]*	Efficiency (secondary fuel) *[GJ/MWh]*	Commissioning Date	Decommissioning Date	Forced outage rate *[%]*	Planned Maintenance *[h/year]*	Variable O&M costs *[$/MWh]*	Fixed O&M costs *[$/kW/year]*
IHOVBOR NIPP		GT	NG		452	339	12.444		2013-2014		VS	VS	VS	VS
OKPAI		CC	NG		450	450	8.426		2005		VS	VS	VS	VS
AFAM VI		CC	NG		728	650	8.839		2005-2009		VS	VS	VS	VS
IBOM POWER		GT	NG		196	154	13.465		2009-2016		VS	VS	VS	VS
AES EBUTE BARGE		GT	NG		279	279			2002		VS	VS	VS	VS
OMOKU		GT	NG		150	75			2006		VS	VS	VS	VS
TRANS AMADI		GT	NG		100	75			2010		VS	VS	VS	VS
RIVERS IPP		GT	NG		191	160			2012		VS	VS	VS	VS
GBARAIN		GT	NG		113	113			2016		VS	VS	VS	VS
PARAS ENERGY		GT	NG		52	52					VS	VS	VS	VS
EGBIN		ST	NG		1320	880	11.479		1985-1987		VS	VS	VS	VS
SAPELE		ST	NG		528	528	15.304		1990		VS	VS	VS	VS

Senegal

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity *[MW]*	Available Capacity *[MW]*	Efficiency (primary fuel) *[GJ/MWh]*	Efficiency (secondary fuel) *[GJ/MWh]*	Commissioning Date	Decommissioning Date	Forced outage rate *[%]*	Planned Maintenance *[h/year]*	Variable O&M costs *[$/MWh]*	Fixed O&M costs *[$/kW/year]*
Bel-air	G601	DI	HFO		16.45	15	16		2006		VS	VS	VS	VS
Bel-air	G602	DI	HFO		16.45	15	16		2006		VS	VS	VS	VS
Bel-air	G603	DI	HFO		16.45	15	16		2006		VS	VS	VS	VS
Bel-air	G604	DI	HFO		16.45	15	16		2006		VS	VS	VS	VS
Bel-air	G605	DI	HFO		16.45	15	16		2013		VS	VS	VS	VS

Final version

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity *[MW]*	Available Capacity *[MW]*	Efficiency (primary fuel) *[GJ/MWh]*	Efficiency (secondary fuel) *[GJ/MWh]*	Commissioning Date	Decommissioning Date	Forced outage rate *[%]*	Planned Maintenance *[h/year]*	Variable O&M costs *[$/MWh]*	Fixed O&M costs *[$/kW/year]*
Bel-air	G606	DI	HFO		16.45	15	16		2013		VS	VS	VS	VS
Cap-des-Biches	G401	DI	HFO		21	17.5	9.4		1969	2020	VS	VS	VS	VS
Cap-des-Biches	G402	DI	HFO		21	17.5	9.4		1969	2020	VS	VS	VS	VS
Cap-des-Biches	G403	DI	HFO		23	20	9.2		1997		VS	VS	VS	VS
Cap-des-Biches	G404	DI	HFO		15	13	8.8		2003		VS	VS	VS	VS
Cap-des-Biches	G405	DI	HFO		15	13	8.8		2003		VS	VS	VS	VS
Cap-des-Biches	IPP	CC	HFO		82	82	VS				VS	VS	VS	VS
Tobene	IPP	GT	HFO		105	105	VS				VS	VS	VS	VS
Kaolack	C7	DI	HFO		90	90	VS				VS	VS	VS	VS
Kounoune	IPP	DI	HFO		43	43	9.2		2007		VS	VS	VS	VS
Boutoute	Boutoute	GT	DDO		18.8	18.8	VS		1984-2005		VS	VS	VS	VS
Boutoute	Location		DDO		10	10	VS		2010	2021	VS	VS	VS	VS

Sierra Leone

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity *[MW]*	Available Capacity *[MW]*	Efficiency (primary fuel) *[GJ/MWh]*	Efficiency (secondary fuel) *[GJ/MWh]*	Commissioning Date	Decommissioning Date	Forced outage rate *[%]*	Planned Maintenance *[h/year]*	Variable O&M costs *[$/MWh]*	Fixed O&M costs *[$/kW/year]*
Freetown	G1	DI	DDO		37	VS	VS	VS			VS	VS	VS	VS

Togo

Plant name	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity *[MW]*	Available Capacity *[MW]*	Efficiency (primary fuel) *[GJ/MWh]*	Efficiency (secondary fuel) *[GJ/MWh]*	Commissioning Date	Decommissioning Date	Forced outage rate *[%]*	Planned Maintenance *[h/year]*	Variable O&M costs *[$/MWh]*	Fixed O&M costs *[$/kW/year]*
Lomé	TAG CEB	GT	NG	JET A1	20	20	14.8	14.8	1998	2025	VS	VS	VS	VS
Contour Global	TG1	GT	NG		16.62	15			2010		VS	VS	VS	VS
Contour Global	TG2	GT	NG		16.62	15			2010		VS	VS	VS	VS
Contour Global	TG3	GT	NG		16.62	15			2010		VS	VS	VS	VS
Contour Global	TG4	GT	NG		16.62	15			2010		VS	VS	VS	VS
Contour Global	TG5	GT	NG		16.62	15			2010		VS	VS	VS	VS
Contour Global	TG6	GT	NG		16.62	15			2010		VS	VS	VS	VS
Lome	DI CEET	DI	DDO		16	5	12.9	12.9	1979		VS	VS	VS	VS
Kara	DI CEET	DI	DDO		16	4	13.3		1968		VS	VS	VS	VS
Sokodé	DI CEET	DI	DDO		4	1.5	13.3				VS	VS	VS	VS

Hydroelectric Plant

Benin

Plant Name	Group	Type	Installed Capacity	Available Capacity	Commis-sioning Date	Decommis-sioning Date	Forced Outage Rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs	Yearly Average Energy	Yearly Firm Energy
			[MW]		*[MW]*		*[%]*	*[h/year]*	*[$/MWh]*	*[$/MWh]*	*[$/kW/year]*	*[$/kW/year]*
Yéripao	G1	DAM	0.5	0.5			VS	VS	VS	VS	VS	VS

Burkina Faso

Plant Name	Group	Type	Installed Capacity	Available Capacity	Commis-sioning Date	Decommis-sioning Date	Forced Outage Rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs	Yearly Average Energy	Yearly Firm Energy
			[MW]		*[MW]*		*[%]*	*[h/year]*	*[$/MWh]*	*[$/MWh]*	*[$/kW/year]*	*[$/kW/year]*
BAGRE			16.72	16	1993	2018	VS	VS	VS	VS	VS	VS
KOMPIENGA			14.28	14	1989	2013	VS	VS	VS	VS	VS	VS
NIOFILA			1.5	1.5	1996	2021	VS	VS	VS	VS	VS	VS
TOURNI			0.5	0.5	1996	2021	VS	VS	VS	VS	VS	VS

Final version

Côte d’Ivoire

Plant Name	Group	Type	Installed Capacity	Available Capacity	Commis-sioning Date	Decommis-sioning Date	Forced Outage Rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs	Yearly Average Energy	Yearly Firm Energy
			[MW]		*[MW]*		*[%]*	*[h/year]*	*[$/MWh]*	*[$/MWh]*	*[$/kW/year]*	*[$/kW/year]*
Ayamé 1	G1	DAM	11	11	1959		VS	VS	VS	VS	VS	VS
Ayamé 1	G2	DAM	11	11	1959		VS	VS	VS	VS	VS	VS
Ayamé 2	G3	ROR	15.2	15.2	1965		VS	VS	VS	VS	VS	VS
Ayamé 2	G4	ROR	15.2	15.2	1965		VS	VS	VS	VS	VS	VS
Buyo	G1	DAM	54.9	54.9	1980		VS	VS	VS	VS	VS	VS
Buyo	G2	DAM	54.9	54.9	1980		VS	VS	VS	VS	VS	VS
Buyo	G3	DAM	54.9	54.9	1980		VS	VS	VS	VS	VS	VS
Kossou	G1	DAM	58.5	58.5	1972		VS	VS	VS	VS	VS	VS
Kossou	G2	DAM	58.5	58.5	1972		VS	VS	VS	VS	VS	VS
Kossou	G3	DAM	58.5	58.5	1972		VS	VS	VS	VS	VS	VS
Soubré	G1	DAM	93	93	2017		VS	VS	VS	VS	VS	VS
Soubré	G2	DAM	93	93	2017		VS	VS	VS	VS	VS	VS
Soubré	G3	DAM	93	93	2017		VS	VS	VS	VS	VS	VS
Taabo	G1	DAM	70.2	70.2	1979		VS	VS	VS	VS	VS	VS
Taabo	G2	DAM	70.2	70.2	1979		VS	VS	VS	VS	VS	VS
Taabo	G3	DAM	70.2	70.2	1979		VS	VS	VS	VS	VS	VS
Faye	G1	ROR	2.5	2.5			VS	VS	VS	VS	VS	VS
Faye	G2	ROR	2.5	2.5			VS	VS	VS	VS	VS	VS

Ghana

Plant Name	Group	Type	Installed Capacity	Available Capacity [MW]	Commis-sioning Date [MW]	Decommis-sioning Date	Forced Outage Rate [%]	Planned Maintenance [h/year]	Variable O&M costs [$/MWh]	Fixed O&M costs [$/MWh]	Yearly Average Energy [$/kW/year]	Yearly Firm Energy [$/kW/year]
Akosombo	G1	DAM	170	150	1965		10%		0.1	14.3	4171	3100
Akosombo	G2	DAM	170	150	1965		10%		0.1	14.3		
Akosombo	G3	DAM	170	150	1965		10%		0.1	14.3		
Akosombo	G4	DAM	170	150	1965		10%		0.1	14.3		
Akosombo	G5	DAM	170	150	1965		10%		0.1	14.3		
Akosombo	G6	DAM	170	150	1965		10%		0.1	14.3		
Bui	G1	DAM	133.3	114	2013		15%		0.1	14	1000	
Bui	G2	DAM	133.3	114	2013		15%		0.1	14		
Bui	G3	DAM	133.3	114	2013		15%		0.1	14		
Kpong	G1	ROR	40	36	1982		28%		0.1	14.3	880	622
Kpong	G2	ROR	40	36	1982		28%		0.1	14.3		
Kpong	G3	ROR	40	36	1982		28%		0.1	14.3		
Kpong	G4	ROR	40	36	1982		28%		0.1	14.3		

Final version

Guinea

Plant Name	Group	Type	Installed Capacity	Available Capacity	Commis-sioning Date	Decommis-sioning Date	Forced Outage Rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs	Yearly Average Energy	Yearly Firm Energy
			[MW]	*[MW]*			*[%]*	*[h/year]*	*[$/MWh]*	*[$/MWh]*	*[$/kW/year]*	*[$/kW/year]*
Kaleta	1	ROR	80	80	2015		VS	VS	VS	VS	938.8	228
Kaleta	2	ROR	80	80	2015		VS	VS	VS	VS		
Kaleta	3	ROR	80	80	2015		VS	VS	VS	VS		
Garafiri	1	DAM	25	25	1999		VS	VS	VS	VS	258	204
Garafiri	2	DAM	25	25	1999		VS	VS	VS	VS		
Garafiri	3	DAM	25	25	1999		VS	VS	VS	VS		
Grandes Chutes	1	DAM	5	4.5	1954		VS	VS	VS	VS	127	99.2
Grandes Chutes	2	DAM	5		1954		VS	VS	VS	VS		
Grandes Chutes	3	DAM	8.5	6.6	1986		VS	VS	VS	VS		
Grandes Chutes	4	DAM	8.5	6.7	1986		VS	VS	VS	VS		
Donkea	1	ROR	7.5	7.5	1970		VS	VS	VS	VS	72.4	55.5
Donkea	2	ROR	7.5	7.5	1970		VS	VS	VS	VS		
Banéah	1	DAM	2.5	0	1989		VS	VS	VS	VS	6.4	
Banéah	2	DAM	2.5	0	1989		VS	VS	VS	VS		
Kinkon	1	DAM	0.85	0.85	1970/2006		VS	VS	VS	VS	11.6	10.8
Kinkon	2	DAM	0.85	0.85	1970/2007		VS	VS	VS	VS		
Kinkon	3	DAM	0.85	0.85	1970/2008		VS	VS	VS	VS		
Kinkon	4	DAM	0.85	0.85	1970/2009		VS	VS	VS	VS		
Tinkisso	3	DAM	0.533	05	1974		VS	VS	VS	VS	5	

Final version

Mali

Plant Name	Group	Type	Installed Capacity	Available Capacity	Commis-sioning Date	Decommis-sioning Date	Forced Outage Rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs	Yearly Average Energy	Yearly Firm Energy
			[MW]		[MW]		[%]	[h/year]	[$/MWh]	[$/MWh]	[$/kW/year]	[$/kW/year]
SELINGUE	T1	DAM	12.15	11.75	1980		VS	VS	VS	VS		
SELINGUE	T2	DAM	12.15	11.75	1981		VS	VS	VS	VS	231.9	197.7
SELINGUE	T3	DAM	12.15	11.75	1980		VS	VS	VS	VS		
SELINGUE	T4	DAM	12.15	11.75	1981		VS	VS	VS	VS		
SOTUBA	T1	ROR	2.85	2.85	1966		VS	VS	VS	VS	34.5	33.4
SOTUBA	T2	ROR	2.85	2.85	1966		VS	VS	VS	VS		
MANANTALI	1	DAM	40	40	1988		VS	VS	VS	VS		
MANANTALI	2	DAM	40	40	1988		VS	VS	VS	VS		
MANANTALI*	3	DAM	40	40	1988		VS	VS	VS	VS	800	500
MANANTALI*	4	DAM	40	40	1988		VS	VS	VS	VS		
MANANTALI*	5	DAM	40	40	1988		VS	VS	VS	VS		
FELOU*	1	ROR	21.5	20	2013		VS	VS	VS	VS		
FELOU*	2	ROR	21.5	20	2013		VS	VS	VS	VS	350	320
FELOU*	3	ROR	21.5	20	2013		VS	VS	VS	VS		

** OMVS*

Final version

Nigeria

Plant Name	Group	Type	Installed Capacity	Available Capacity	Commis-sioning Date	Decommis-sioning Date	Forced Outage Rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs	Yearly Average Energy	Yearly Firm Energy
				[MW]	*[MW]*		*[%]*	*[h/year]*	*[$/MWh]*	*[$/MWh]*	*[$/kW/year]*	*[$/kW/year]*
KAINJI	G5-6		2x 120	240	1968		VS	VS	VS	VS		
KAINJI	G7-10		4x 80	0	1978		VS	VS	VS	VS		
KAINJI	G11-12		2x 100	200	1976		VS	VS	VS	VS		
JEBBA	G1-6		6x 101	506	1983-1988		VS	VS	VS	VS		
SHIRORO	G1-4		4x 150	450	1990		VS	VS	VS	VS		

Sierra Leone

Plant Name	Group	Type	Installed Capacity	Available Capacity	Commis-sioning Date	Decommis-sioning Date	Forced Outage Rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs	Yearly Average Energy	Yearly Firm Energy
				[MW]	*[MW]*		*[%]*	*[h/year]*	*[$/MWh]*	*[$/MWh]*	*[$/kW/year]*	*[$/kW/year]*
Bumbuna	G1	DAM	45	VS	VS	VS	VS	VS	VS	VS	VS	VS
Dodo	G1	DAM	6	VS	VS	VS	VS	VS	VS	VS	VS	VS
Bankasoka, Charlotte, Makali	G1	DAM	5	VS	VS	VS	VS	VS	VS	VS	VS	VS

Togo

Plant Name	Group	Type	Installed Capacity	Available Capacity	Commis-sioning Date	Decommis-sioning Date	Forced Outage Rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs	Yearly Average Energy	Yearly Firm Energy
				[MW]	*[MW]*		*[%]*	*[h/year]*	*[$/MWh]*	*[$/MWh]*	*[$/kW/year]*	*[$/kW/year]*
Nangbeto	G1	DAM	32.8	32.5	VS	VS	VS	VS	VS	VS	172.7	91
Nangbeto	G2	DAM	32.8	32.5	VS	VS	VS	VS	VS	VS		

Renewable Plants

Burkina Faso

Plant Name	Group	Installed Capacity	Available Capacity	Commis-sioning Date	Decommis-sioning Date	Forced Outage Rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs
		[MW]	*[MW]*			*[%]*	*[h/year]*	*[$/MWh]*	*[$/kW/year]*
Zagtouli	PV	33		2017		VS	VS	VS	VS
Ziga	PV	11		2017		VS	VS	VS	VS

Ghana

Plant Name	Group	Installed Capacity	Available Capacity	Commis-sioning Date	Decommis-sioning Date	Forced Outage Rate	Planned Maintenance	Variable O&M costs	Fixed O&M costs
		[MW]	*[MW]*			*[%]*	*[h/year]*	*[$/MWh]*	*[$/kW/year]*
Winneba	PV	20	20	2016		VS	VS	VS	VS
Navrongo	PV	2.5	2.5	2013		VS	VS	VS	VS

Final version

Senegal

Plant Name	Group	Installed acity	Available acity	Commis- ing Date	Decommis- ing Date	Forced age Rate	Planned ntenance	Variable M costs	Fixed O&M s
		[MW]	*[MW]*			*[%]*	*[h/year]*	*[$/MWh]*	*[$/kW/year]*
Bokhol	PV	20	20	2016		VS	VS	VS	VS
Malicounda	PV	22	11	2016		VS	VS	VS	VS
Mékhé	PV	30	29	2017		VS	VS	VS	VS
Mérina ıar	PV	30	20	2017		VS	VS	VS	VS
Sakal	PV	20	20	2018		VS	VS	VS	VS
Senergy	PV	29.5	29.5			VS	VS	VS	VS
Kaolack	PV	20	20			VS	VS	VS	VS

Final version

APPENDIX C : LISTE OF PLANNED AND CANDIDATE POWER PLANTS

Thermal Projects

Benin

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*		
Maria Gleta	TAG- APR	GT	NG		50	50	VS		Decided	2020
Maria Gleta	CC	CC	NG		450	450	VS		Candidate	

Burkina Faso

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*		
FADA					7.5	7.5	VS		Decided	2018
KOSSODO					50	50	VS		Decided	2020
Ouaga-Ouest					100	100	VS		Candidate	
Ouaga-NordOuest					70	70	VS		Candidate	

Final version

Côte d'Ivoire

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*		
Azito IV	TAG	CC	NG		180	180	VS		Decided	2019
Azito IV	TAV	CC			100	100	VS		Decided	2020
Ciprel V	TAG	CC	NG		260	240	VS		Decided	2019
Ciprel V	TAV	CC			130	110	VS		Decided	2020
Songon	TAG1	CC	NG		123	123	VS		Candidate	
Songon	TAG2	CC	NG		123	123	VS		Candidate	
Songon	TAV	CC	NG		123	123	VS		Candidate	
Abatta	TAG1	CC	NG		123	123	VS		Candidate	
Abatta	TAG2	CC	NG		123	123	VS		Candidate	
Abatta	TAV	CC	NG		123	123	VS		Candidate	
Aboisso (Biokala)			BIO		23	23	VS		Candidate	
Aboisso (Biokala)			BIO		23	23	VS		Candidate	
San Pedro I	ST 1	ST	COAL		350	350	VS		Candidate	
San Pedro I	ST 2	ST	COAL		350	350	VS		Candidate	
San Pedro II	ST 1	ST	COAL		350	350	VS		Candidate	
San Pedro II	ST 2	ST	COAL		350	350	VS		Candidate	

Gambia

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity *[MW]*	Available Capacity *[MW]*	Efficiency (primary fuel) *[GJ/MWh]*	Efficiency (secondary fuel) *[GJ/MWh]*	Status	Commissioning Date
Kotu	G5	DI	HFO		6.4	5.5	VS		Decided	2018
Brikama I	G7	DI	HFO		6.4	5.5	VS		Decided	2018
Brikama II	G1	DI	HFO		8	7	VS		Decided	2018
Brikama III	G1	DI	HFO		10	8.5	VS		Decided	2019
Brikama III	G2	DI	HFO		10	8.5	VS		Decided	2020

Ghana

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity *[MW]*	Available Capacity *[MW]*	Efficiency (primary fuel) *[GJ/MWh]*	Efficiency (secondary fuel) *[GJ/MWh]*	Status	Commissioning Date
KPONT	ST	CC	NG	DDO	120	100	VS	VS	Decided	2018
CENPOWER	CC	CC	NG	DDO	360	340	VS	VS	Decided	2018

Final version

Guinea Bissau

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*		
Bor (BOAD)	1	DI	HFO		15	15	VS	VS	Decided	2018
BADEA	1	DI	DDO		22	22	VS	VS	Decided	2018

Liberia

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*		
Bushrod		DI	HFO		48	48	VS		Decided	2019

Mali

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*		
ALBATROS (Kayes)		DI	HFO		92	92	VS		Decided	2020

Final version

Niger

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*		
SONICHAR			COAL		68.8	68.8	VS		Decided	2018
GOROU BANDA 2		DI	DO		20	20	VS		Decided	2017-2019
Diesel Nord		DI	DO		4.5	4.5	VS		Decided	2017
SALKADAMNA phase 1	1	ST	COAL		50	50	VS		Candidate	
SALKADAMNA phase 1	2	ST	COAL		50	50	VS		Candidate	
SALKADAMNA phase 1	3	ST	COAL		50	50	VS		Candidate	
SALKADAMNA phase 1	4	ST	COAL		50	50	VS		Candidate	
SALKADAMNA phase 2		ST	COAL		4x100	4x100	VS		Candidate	

Nigeria

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*		
GBARAIN/UBIE I		GT	NG		113	113			Decided	2017
EGBEMA I - NIPP		GT	NG		113	113			Decided	2018
OMOKU - NIPP		GT	NG		113	113			Decided	2018
ALAOJI 2+ NIPP		ST	NG		285	285			Decided	2025
EGBEMA I - NIPP		GT	NG		113	113			Decided	2019
EGBEMA I - NIPP		GT	NG		113	113			Decided	2019
KADUNA IPP		GT	NG		215	215			Decided	2019

Final version

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
OMOKU - NIPP		GT	NG		113	113			Decided	2019
AZURA		GT	NG		3x150	450			Candidate	2018
AFAM III		GT	NG		8x30	240			Candidate	2018
OKPAI IPP II - AGIP		GT	NG		2x150	300			Candidate	2020
OKPAI IPP II - AGIP		ST	NG		150	150			Candidate	2020
IBOM II		GT	NG		4x138	552			Candidate	2020
ASCO		GT	NG		2x55	110			Candidate	2021
ELEME		GT	NG		75	75			Candidate	2021
QUA IBOE POWER PLANT		GT	NG		4x130	250			Candidate	2021
Cummins Power Gen LTD		GT	NG		150	150			Candidate	2021
ONDO IPP - King Line		GT	NG		200	200			Candidate	2021
TURBINE DRIVE		GT	NG		3x167	501			Candidate	2021
EGBIN 2+		GT	NG		4x300	1200			Candidate	2021
EGBIN 2+		ST	NG		2x350	700			Candidate	2021
SAPELE POWER PLC		GT	NG		30x20	600			Candidate	2021
ZUMA		GT	NG		374	374			Candidate	2021
PARAS		GT	NG		2x150	300			Candidate	2022
OMA POWER GENERATION COMPANY		GT	NG		500	500			Candidate	2022
CENTURY IPP		GT	NG		4x124	496			Candidate	2022
BRESSON NIGERIA LTD		GT	NG		2x45	90			Candidate	2022
SAPELE POWER PLC		GT	NG		100	100			Candidate	2022
ETHIOPE		GT	NG		2x172	344			Candidate	2022
ONDO IPP - King Line		GT	NG		150	150			Candidate	2022
ONDO IPP - King Line		GT	NG		2x100	200			Candidate	2022

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
ETHIOPE		ST	NG		156	156			Candidate	2023
PROTON		GT	NG		150	150			Candidate	2023
ZUMA		COAL	COAL		4x300	1200			Candidate	2023
DELTA III 2+		GT	NG		143	143			Candidate	2023
DELTA IV 2+		GT	NG		4x148.5	594			Candidate	2023
LAFARGE PHASE I		GT	NG		50	50			Candidate	2023
CALEB INLAND		GT+ST	NG		2x250	500			Candidate	2023
ALSCON (Phase 1)		GT	NG		100	100			Candidate	2024
YELLOW STONE		GT	NG		2x180	360			Candidate	2024
ETHIOPE		GT	NG		2x172	344			Candidate	2024
ETHIOPE		ST	NG		156	156			Candidate	2024
IKOT ABASI		GT	NG		2x125	250			Candidate	2025
LAFARGE PHASE II		GT	NG		2x110	220			Candidate	2025
CALEB INLAND		GT+ST	NG		2x250	500			Candidate	2025
ALSCON (Phase 2)		GT	NG		2x130	260			Candidate	2026
ESSAR		GT	NG		6x110	660			Candidate	2026
GEREGU NIPP 2		ST	NG		285	285			Candidate	2027
OMOTOSHO II 2+		ST	NG		2x127	254			Candidate	2027
CALEB INLAND		GT+ST	NG		2x250	500			Candidate	2027
SAPELE 2 - NIPP		GT	NG		3x151	453			Candidate	2028
OATS		GT	NG		7x100	700			Candidate	2028
GEREGU FGN1-2		GT	NG		3x138	414			Candidate	2029
CALABAR / ODUKPANI - NIPP		ST	NG		2x127	254			Candidate	2029
GBARAIN / UBIE 2		ST	NG		115	115			Candidate	2029
GEREGU NIPP 2		GT	NG		3x148	444			Candidate	2030

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
CALABAR / ODUKPANI - NIPP		GT	NG		4x141	564			Candidate	2030
EGBEMA II		ST	NG		127	127			Candidate	2030
IHOVBOR (EYAEN) 2 - NIPP		ST	NG		2x127	254			Candidate	2030
GBARAIN / UBIE 2		GT	NG		8x113	904			Candidate	2030
CHEVRON AGURA		GT	NG		780	780			Candidate	2030
SUPERTEK		GT	NG		5x100	500			Candidate	2030
MBH		GT	NG		2x150	300			Candidate	2030
WESTCOM		GT	NG		2x250	500			Candidate	2030
HUDSON POWER		GT	NG		150	150			Candidate	2030
BRESSON AS NIGERIA		GT	NG		3x150	450			Candidate	2030
AZIKEL IPP		GT	NG		76	76			Candidate	2030
AZIKEL IPP		GT	NG		250	250			Candidate	2030
AZIKEL IPP		GT	NG		163	163			Candidate	2030
TOTALFINAELF		GT	NG		420	420			Candidate	2031
ANAMBRA STATE IPP		GT	NG		2x264	528			Candidate	2031
KNOX		GT	NG		3x167	501			Candidate	2031
DELTA STATE IPP		GT	NG		5x100	500			Candidate	2032
BENCO		GT	NG		7x100	700			Candidate	2033
ASHAKA		COAL	COAL		64	64			Candidate	2034
RAMOS		COAL	COAL		2x500	1000			Candidate	2034
ASHAKA / TPGL		COAL	COAL		2x250	500			Candidate	2034
KADUNA IPP		GT	NG		900	900			Candidate	2034
NASARAWA COAL		COAL	COAL		500	500			Candidate	2034
FORTUNE ELECTRIC		GT	NG		5x100	500			Candidate	2035
FORTUNE ELECTRIC		GT	NG		5x100	500			Candidate	2035

Final version

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
BENUE COAL POWER		COAL	COAL		1200	1200			Candidate	2037
ENUGU COAL POWER		COAL	COAL		2000	2000			Candidate	2037
GWAGWALADA		CC	NG		1350	1350			Candidate	2037

Senegal

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*		
Sendou	IPP CES I	ST	COAL		115	115	VS		2018	Decided
Sendou	IPP CES II	ST	COAL		115	115	VS			Candidate
Mboro	IPP	ST	COAL		90	90	VS			Candidate
Kayar		CC	NG		200	200	VS			Candidate

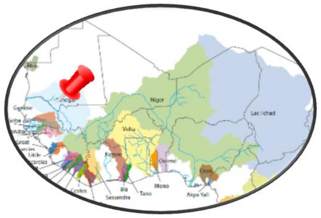
Togo

Name of the plant	Group	Type	Primary Fuel	Secondary Fuel	Installed Capacity	Available Capacity	Efficiency (primary fuel)	Efficiency (secondary fuel)	Status	Commissioning Date
					[MW]	*[MW]*	*[GJ/MWh]*	*[GJ/MWh]*		
Lomé	TG	GT	NG		60	60	VS	VS	2020	Decided

Final version

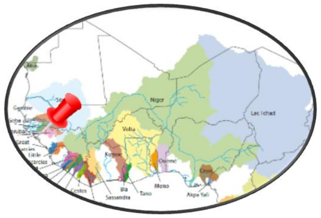
Hydroelectric Projects

Many hydroelectric projects are located in transboundary basins, which gives them a regional scale:



Senegal Basin (OMVS)

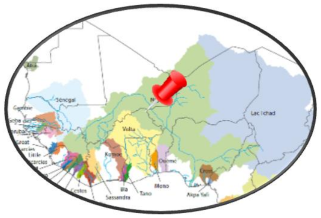
Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Guinée	**Balassa**	Bafing	DAM	181		Candidate	212	470	401
Guinée	**Boureya**	Bafing	DAM	160		Candidate	463	717	455
Guinée	**Diaoya**	Bafing	DAM	149		Candidate	412	581	389
Guinée	**Koukoutamba**	Bafing	DAM	294	2024	Decided	404	455	507
Guinée	**Tene I**	Tene	DAM	76.4		Candidate	151	199	129
Mali	**Gouina**	Sénégal	ROR	140	2020	Decided	407	565	227
Mali	**Gourbassi**	Falémé	DAM	21		Candidate	113	104	79
Mali	**Badoumbé**	Bakoyé	DAM	70		Candidate	244	410	312
Mali	**Bindougou**	Bafing	DAM	49.5		Candidate	196	289	220
Mali	**Moussala**	Falémé	DAM	30		Candidate	141	175	133



Gambie Basin (OMVG)

Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Guinée	**Digan**	Gambie	DAM	93.3		Candidate	139	243	24
Guinée	**Fello**	Sounga	Tomine	82		Candidate	353	333	286
Sénégal	**Sambangalou**	Gambie	DAM	128	2020	Decided	537	402	208
Guinée Bissau	**Saltinho**	Koliba	ROR	20		Candidate	105	82	24

Final version



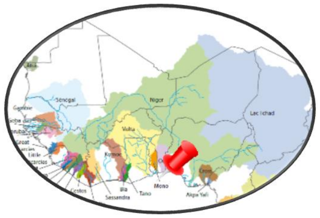
Niger Basin

Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Burkina Faso	**Samendeni**			2.76		Decided	?	?	?
Burkina Faso	**Bagré II**			14		Candidate	70 millards USD	73.5	?
Burkina Faso	**Bontioli**			5.1		Candidate	25 millards USD	11.7	?
Burkina Faso	**Gongourou**			5		Candidate	40 milliards USD	17.7	?
Burkina Faso	**Folonzo**			10.8		Candidate	63 milliards USD	27.3	?
Burkina Faso	**Ouéssa**			21		Candidate	?	?	?
Guinée	**Diaraguela**	Niger		72		Candidate	221	400	298
Guinée	**Amaria**	Konkouré		300	2023	Decided	377		1435
Mali	**Kénié**	Niger	ROR	42		Candidate	191	199	163
Mali	**Taoussa**	Niger	DAM	25		Candidate	259	108	82

Final version

Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
Mali	**Sotuba 2**	Niger	ROR	6	2021	Decided	59	39	37
Mali	**Markala**	Niger	DAM	10		Candidate	50	53	40
Niger	**Kandadji**	Niger		130		Candidate	502	629	478
Niger	**Gambou**	Niger		105		Candidate	715	528	402
Niger	**Dyodyonga**	Niger		26		Candidate	74	35	10
Nigeria	**Mambila**	Niger	DAM	3050	2024	Decided	5800	11214	8522
Nigeria	**Zungeru**	Kaduna	DAM	700	2022	Decided	1335	3019	2295
Nigeria	**Gurara**			30	2017	Decided	?	?	?
Nigeria	**Mabon**			39		Candidate	?	?	?
Nigeria	**Kashimbilla**			40		Candidate	?	?	?

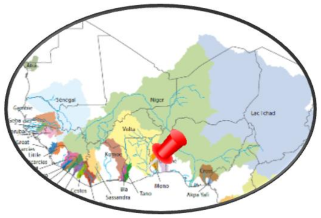
Final version



Oueme Basin

Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Bénin	**Ketou**	Ouémé	DAM	112		Candidate	417	114	39
Bénin	**Beterou**	Ouémé	DAM	23.2		Candidate	89	31	8
Bénin	**Vossa**	Ouémé	DAM	79.2		Candidate	305	105	28
Bénin	**Oulougbé**	Ouémé	DAM	30		Candidate	111	39	11

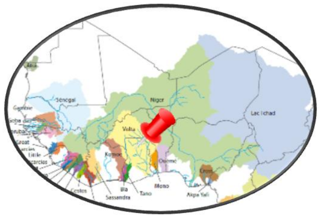
Final version



Mono Basin

Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Togo	**Adjarala**	Mono	DAM	147	2026	Decided	413	264	237
Togo	**Tététou**	Mono	DAM	60		Candidate	197	148	112
Togo	**Kpessi**	Mono	DAM	15.9		Candidate	87	69.5	

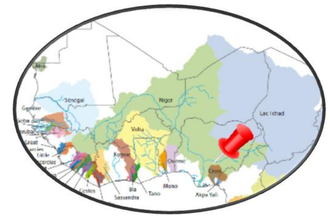
Final version



Volta Basin

Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Ghana	**Juale**		DAM	87		Candidate	383	405	308
Ghana	**Pwalugu**		DAM	48		Candidate	216	184	140
Ghana	**Daboya**		DAM	43		Candidate	250	194	147
Ghana	**Hemang**		ROR	93		Candidate	310	340	258
Ghana	**Kulpawn**		DAM	36		Candidate	362	166	126
Burkina Faso/Ghana	**Noumbiel/ Koulbi**	Black Volta	DAM	60		Abandoned	355	203	154
Togo	**Titira**	Kéran	DAM	23.8		Candidate	59 (MEUR)	94.2	
Togo	**Sarakawa**	Kara	DAM	24.2		Candidate	75	105.7	
Togo	**Wawa**	Wawa	DAM	8.4		Candidate	27	37.4	
Togo	**Baghan**	Mö	DAM	5.8		Candidate	34	25.5	

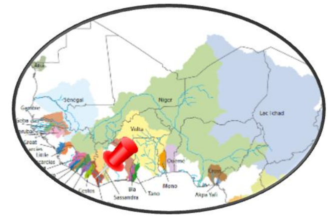
Final version



Comoé Basin

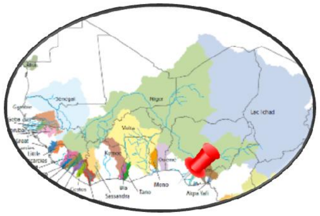
Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Côte d'Ivoire	**Aboisso**	Comoe	DAM	90		Candidate	308	392	298

Final version



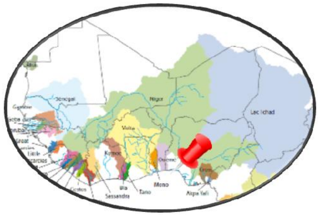
Sassandra Basin

Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Côte d'Ivoire	Gribo-Popoli	Sassandra	DAM	112		Candidate	451	515	391
Côte d'Ivoire	Boutoubre	Sassandra	DAM	150		Candidate	497	785	597
Côte d'Ivoire	Louga	Sassandra	DAM	246		Candidate	1650	1330	1011
Côte d'Ivoire	TayabYes	Sassandra	DAM	80		Candidate	1104	653	593



Cavally Basin

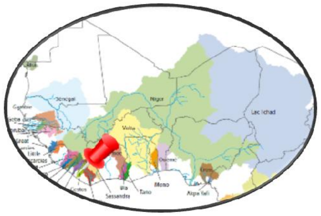
Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Côte d'Ivoire/Liberia	**Tiboto/Cavally**	Cavally	DAM	113	2026	Decided	578	912	912



Cestos Basin

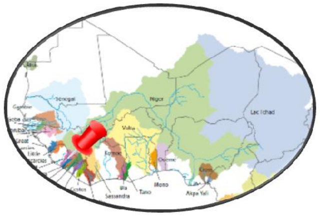
Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Liberia	**Cestos**	Cestos river		41		Candidate	150	177	134

Final version



Saint-John Basin

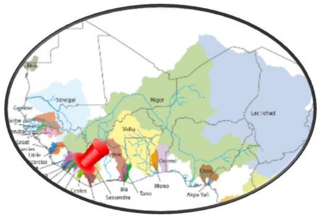
Country	Name of the plant	Name of the river	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
			[MW]			[M$]	[GWh/an]	[GWh/an]
Liberia	Saint-John	Saint-John	67		Candidate	300	289	220



Loffa Basin

Country	Name of the plant	Name of the river	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
			[MW]			[M$]	[GWh/an]	[GWh/an]
Liberia	Loffa	Loffa river	29		Candidate	100	125	95

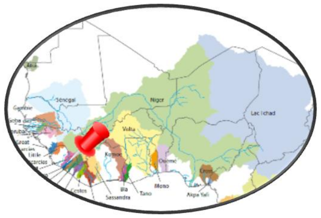
Final version



Saint-Paul Basin

Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Liberia	Mount Coffee Reservoir (to run the whole year)	Saint-Paul	DAM	88		Candidate	511		
Liberia	Saint-Paul 1B	Saint-Paul	DAM	78		Abandoned	303	512	389
Liberia	Saint-Paul 2	Saint-Paul	DAM	120		Abandoned	465	788	599
Liberia	Saint-Paul V1	Saint-Paul	DAM	132		Abandoned	511	569	433
Liberia	Mount Coffee (+V1)	Saint-Paul	DAM	66		Abandoned	290	285	216
Liberia	Saint-Paul 1B (+V1)	Saint-Paul	DAM	65		Abandoned	252	280	213
Liberia	Saint-Paul 2(+V1)	Saint-Paul	DAM	100		Abandoned	387	431	328

Final version



Mana Morro Basin

Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Sierra Leone/Libéria	Mano	River	Mano	180		Candidate	487	795	612

These projects will be considered as an investment option when optimizing the generation investment plan and will be put in competition with other technologies.

In addition, other projects located in basins of national scope but whose size or location would allow regional outreach were identified. They are summarized below. Like cross-border projects, they will also be considered as an investment option in the the generation investment plan. These projects are summarized below:

Final version

Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
				[MW]			[M$]	[GWh/an]	[GWh/an]
Côte d'Ivoire	Tiassalé	Bandama	DAM	51		Candidate	250	215	163
Côte d’Ivoire	Daboitié	Bandama	DAM	55		Candidate	376	529	319
Côte d’Ivoire	Singrobo	Bandama	DAM	44		Candidate	250	315	214
Guinée	Bonkon-Diaria			174		Candidate	211	319	315
Guinée	Fetore			124		Candidate	160	322	232
Guinée	Fomi	Niandan	DAM	90	2022	Decided	156	374	320
Guinée	Kogbédou- Frankonédou	Milo		102		Candidate	144	270	226
Guinée	Gozoguézia	Diani		48		Candidate	110	259	200
Guinée	Grand Kinkon			290		Candidate		720	618
Guinée	Kaba	Kassa B		135		Candidate	214	528	467
Guinée	Kouravel			135		Candidate	185	350	240
Guinée	Lafou			98		Candidate	128	255	210
Guinée	Morisakano	Sankarani		100		Candidate	260	523	438
Guinée	Nzébéla	Diani		48		Candidate	94	225	210
Guinée	Poudaldé			90		Candidate		342	319
Guinée	Souapiti	Konkouré		450	2021	Decided	1008	2016	3500
Guinée	Kéno			7		Decided			

Final version

Country	Name of the plant	Name of the river	Type	Installed Capacity	Commis-sioning Year	Status	Total Cost	Average Energy	Firm Energy
Guinée	Tiopo	Cogon		120		Candidate	295	590	480
Mali	Djenné (Centre Mali – No connecté RI)			10	2021	Decided		17.75	
Sierra Leone	Bumbana II		DAM	143	2023	Decided			237
Sierra Leone	Bumbuna III (Yiben)		DAM	90		Candidate	176	396	317
Sierra Leone	Bumbuna IV&V		DAM	95		Candidate	185	494	463
Sierra Leone	Goma II		DAM	6		Candidate	40	30.8	1.4
Sierra Leone	Benkongor I		DAM	34.8		Candidate	85	237	200
Sierra Leone	Benkongor II		DAM	80		Candidate	196	414	338
Sierra Leone	Benkongor III		DAM	85.5		Candidate	209	513	421

Final version

Renewable Projects

Benin

Name of the plant	Type	Installed Capacity *[MW]*	Commissioning Date	Status
Natitingou	PV	5	2020	Décidé
Djougou	PV	10		Envisagé
Parakou	PV	15		Envisagé
Bohicon	PV	15		Envisagé
Onigbolo	PV	35		Envisagé
Bembéréké	PV	2		Envisagé
Sakété	PV	20		Envisagé
Natitingou-Kandi	PV	20		Envisagé

Burkina Faso

Name of the plant	Type	Installed Capacity *[MW]*	Commissioning Date	Status
Zagtouli 2	PV	17		Candidate
Koudougou	PV	20		Candidate
Kaya	PV	10		Candidate
Zina	PV	26.6		Candidate

Final version

Name of the plant	**Type**	**Installed Capacity** ***[MW]***	**Commissioning Date**	**Status**
Centrale solaire PIE 1	PV	68.24		Candidate
Centrale solaire PIE 2	PV	80		Candidate
WAPP	PV	150		Candidate

Côte d'Ivoire

Name of the plant	Type	Installed Capacity *[MW]*	Commissioning Date	Status
KORHOGO	PV	20	2018	Decided
PORO POWER	PV	50	2019	Decided
Centrale solaire 1	PV	25		Candidate
Centrale solaire 2	PV	50		Candidate
Centrale solaire 3	PV	40		Candidate
Centrale solaire 4	PV	30		Candidate
Centrale solaire 5	PV	30		Candidate
Centrale solaire 6	PV	75		Candidate

Final version

Gambia

Name of the plant	Type	Installed Capacity *[MW]*	Commissioning Date	Status
Brkama (Z-One)	PV	10	2019	Decided

Guinea Bissau

Name of the plant	Type	Installed Capacity *[MW]*	Commissioning Date	Status
BOAD	PV	20	2020	Decided

Mali

Name of the plant	Type	Installed Capacity *[MW]*	Commissioning Date	Status
Segou	PV	33	2018	Decided
Kita	PV	50	2018	Decided
Sikasso	PV	50		Candidate
Koutiala	PV	25		Candidate
Kati	PV	40		Candidate

Niger

Name of the plant	Type	Installed Capacity *[MW]*	Commissioning Date	Status
Gorou Banda	PV	20	2018-2020	Decided
Gorou Banda	PV	30		Candidate
NCE	PV	30		Candidate
Dosso	PV	10		Candidate
Lossa	PV	10		Candidate

Nigeria

Name of the plant	Type	Installed Capacity *[MW]*	Commissioning Date	Status
Nova solar	PV	100		Candidate
Nova scotia power	PV	80		Candidate
Pan africa solar	PV	75		Candidate
Lr aaron solar power plant	PV	100		Candidate
Quaint energy solutions	PV	50		Candidate
Nigeria solat capital partners	PV	100		Candidate
Motir dusable	PV	100		Candidate
Middle band solar	PV	100		Candidate

Final version

Name of the plant	Type	Installed Capacity *[MW]*	Commissioning Date	Status
Afrinergia solar	PV	50		Candidate
KVK power nigeria LTD	PV	55		Candidate
Anheed kafachan solar IPP	PV	100		Candidate
CT cosmos	PV	70		Candidate
Oriental	PV	50		Candidate
EN consulting & projects - Kaduna	PV	100		Candidate
JBS Wind power plant	Wind	100		Candidate
Kazure (Kano disco)	PV	1000		Candidate

Senegal

Name of the plant	Type	Installed Capacity *[MW]*	Commissioning Date	Status
Diass	PV	25	2018	Decided
WB	PV	100	2020	Candidate

Final version

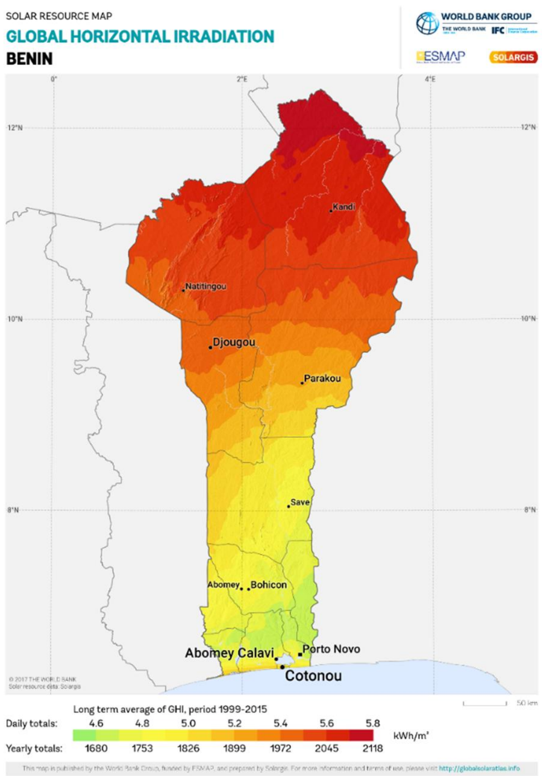
Togo

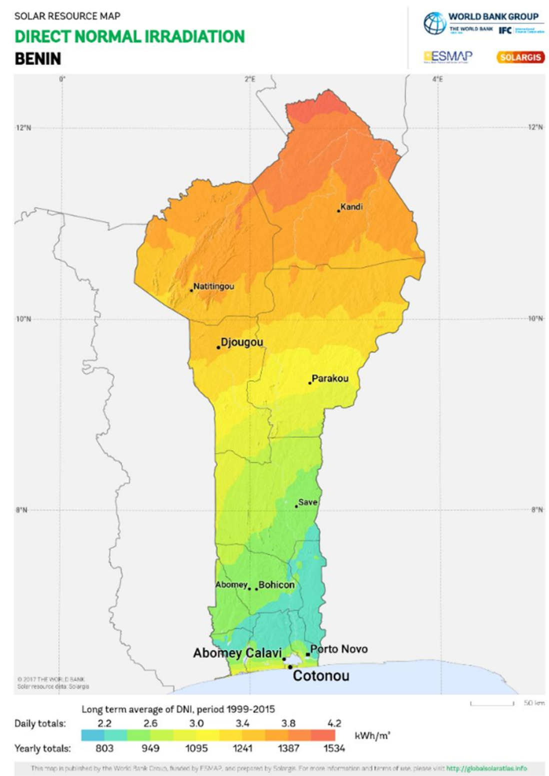
Name of the plant	**Type**	**Installed Capacity *[MW]***	**Commissioning Date**	**Status**
CEB PV	PV	5		Candidate

Final version

APPENDIX D : SOLAR POTENTIAL PER COUNTRY

Benin





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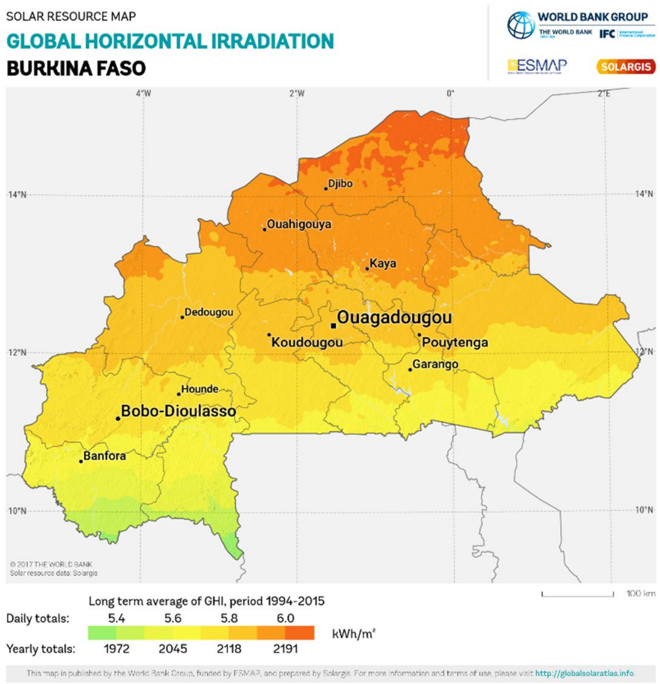
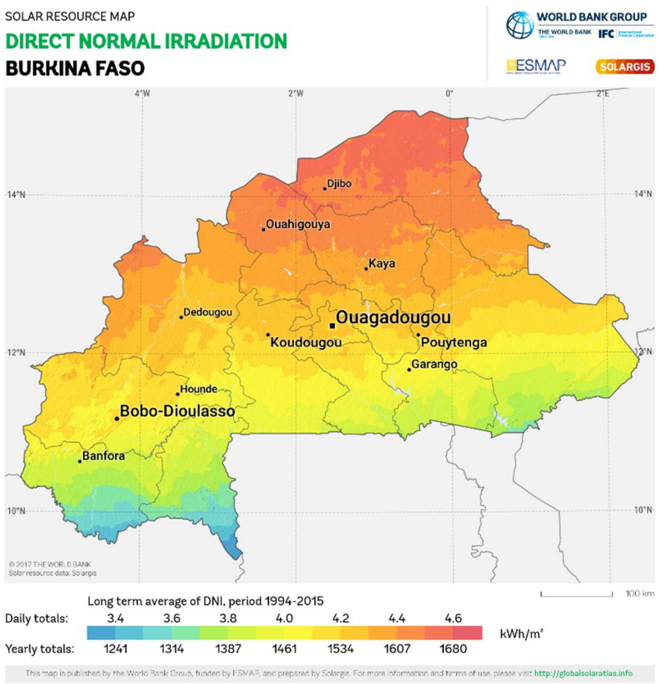
Burkina Faso





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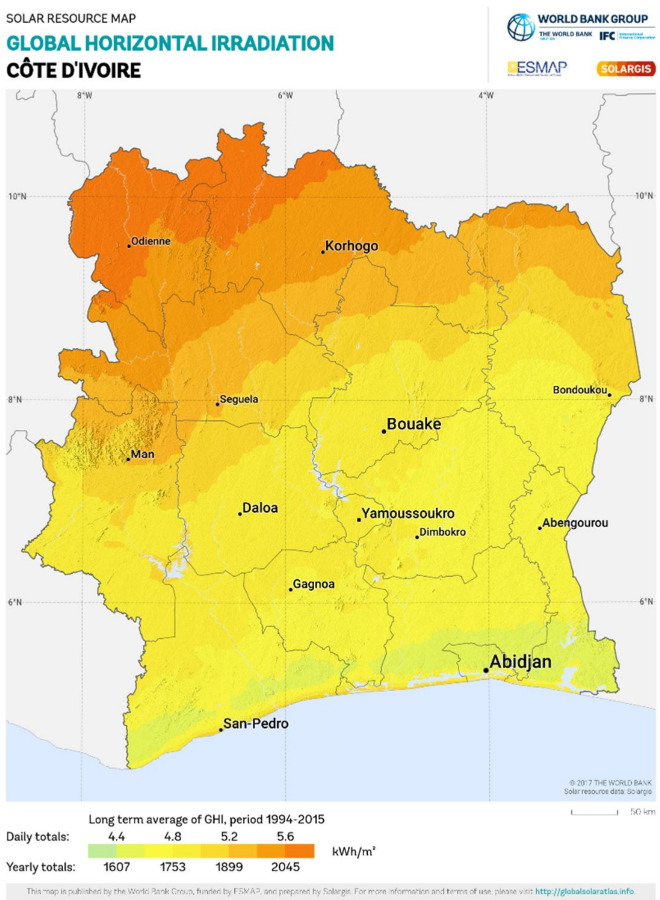
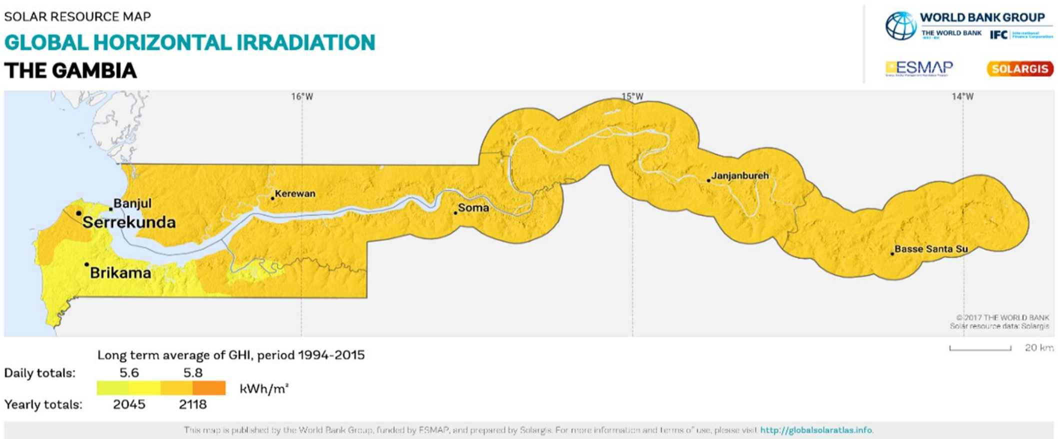
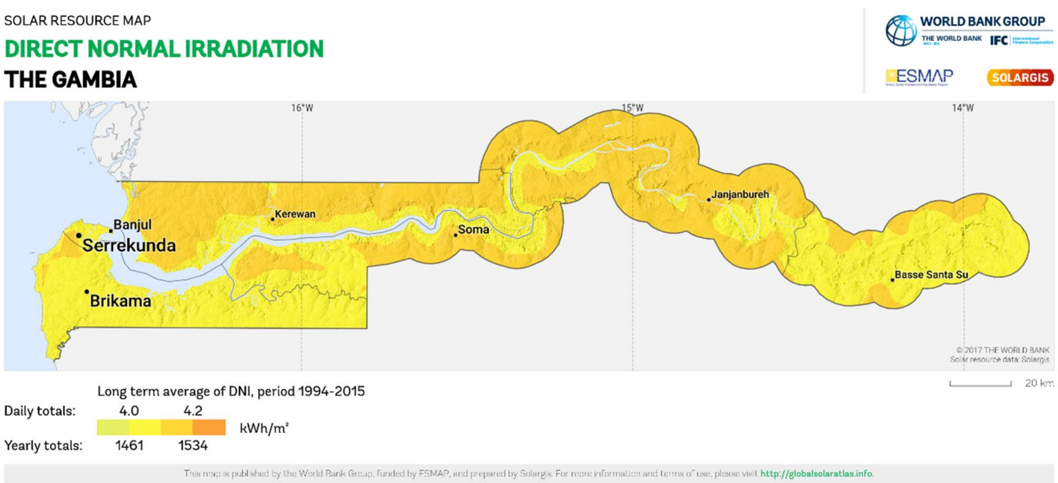
Côte d'Ivoire



Gambia





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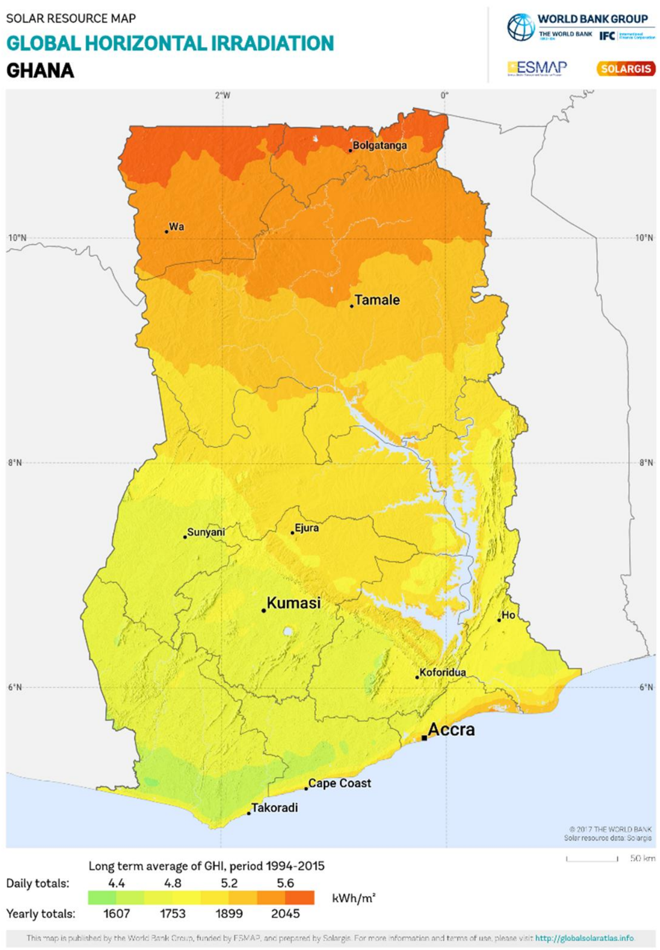
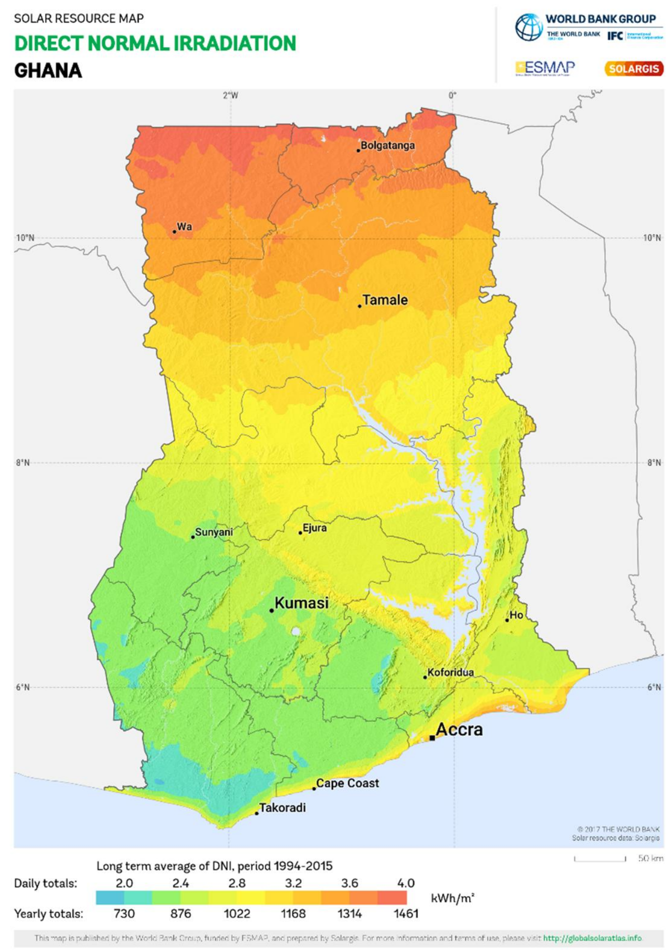
Ghana


SOLAR RESOURCE MAP
GLOBAL HORIZONTAL IRRADIATION
GHANA
WORLD BANK GROUP
ESMAP
SOLARGIS
2°W
0°
10°N
8°N
6°N
Bolgatanga
Wa
Tamale
Sunyani
Ejura
Kumasi
Ho
Koforidua
Accra
Cape Coast
Takoradi
© 2017 THE WORLD BANK
Solar resource data: Solargis
50 km
Long term average of GHI, period 1994-2015
Daily totals: 4.4 4.8 5.2 5.6
kWh/m²
Yearly totals: 1607 1753 1899 2045
This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit http://globalsolaratlas.info


SOLAR RESOURCE MAP
DIRECT NORMAL IRRADIATION
GHANA
WORLD BANK GROUP
ESMAP
SOLARGIS
2°W
0°
10°N
8°N
6°N
Bolgatanga
Wa
Tamale
Sunyani
Ejura
Kumasi
Ho
Koforidua
Accra
Cape Coast
Takoradi
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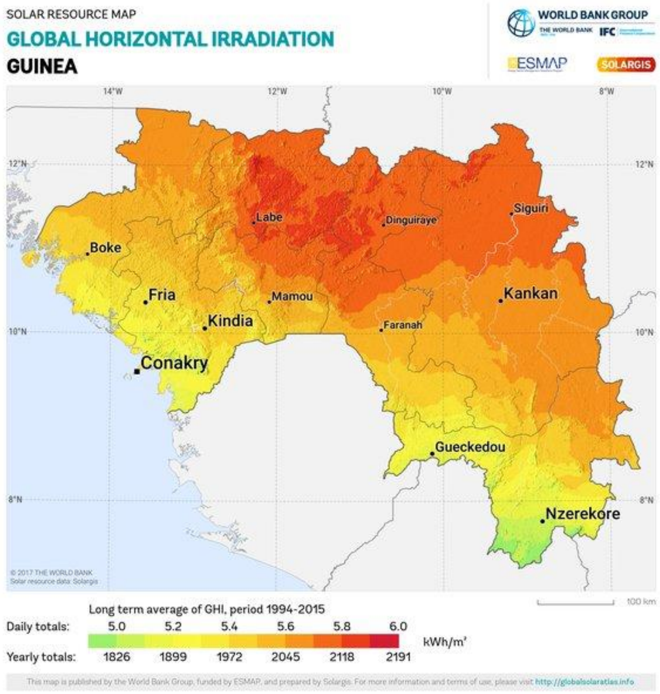
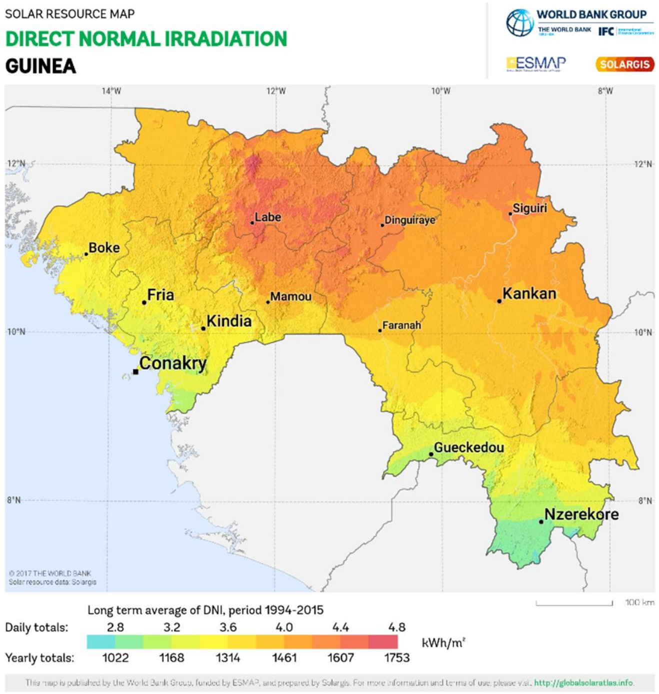
Solar resource data: Solargis
50 km
Long term average of DNI, period 1994-2015
Daily totals: 2.0 2.4 2.8 3.2 3.6 4.0
kWh/m²
Yearly totals: 730 876 1022 1168 1314 1461
This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit http://globalsolaratlas.info

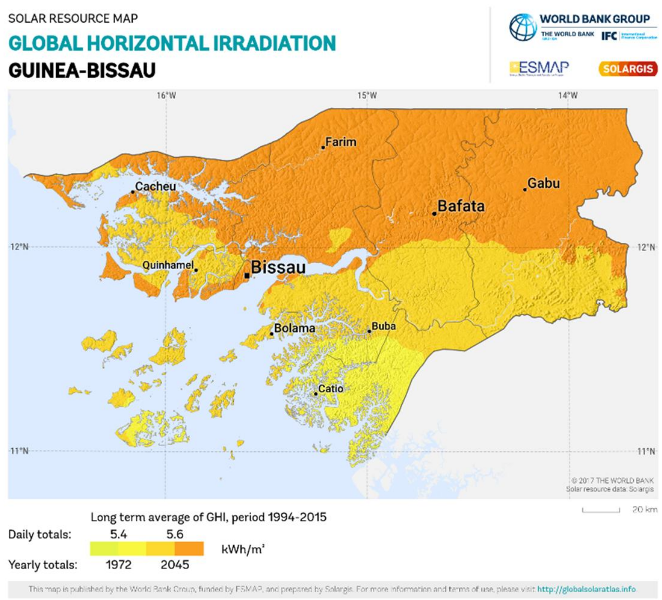
Guinea

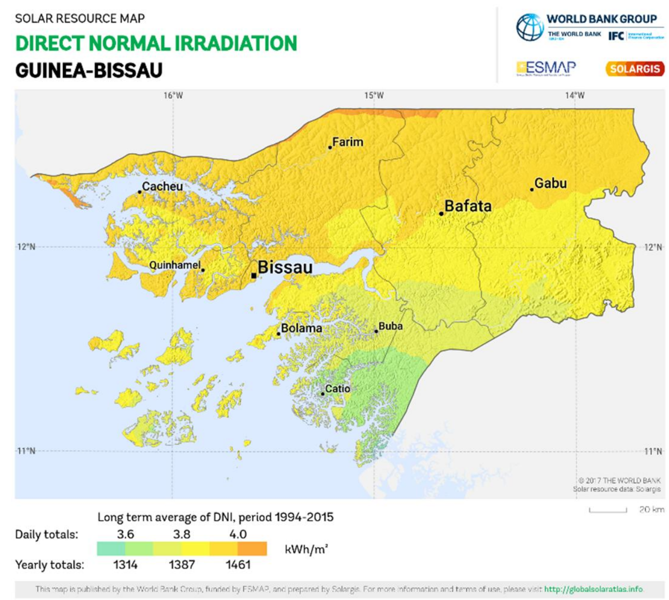




Final version

Guinea Bissau



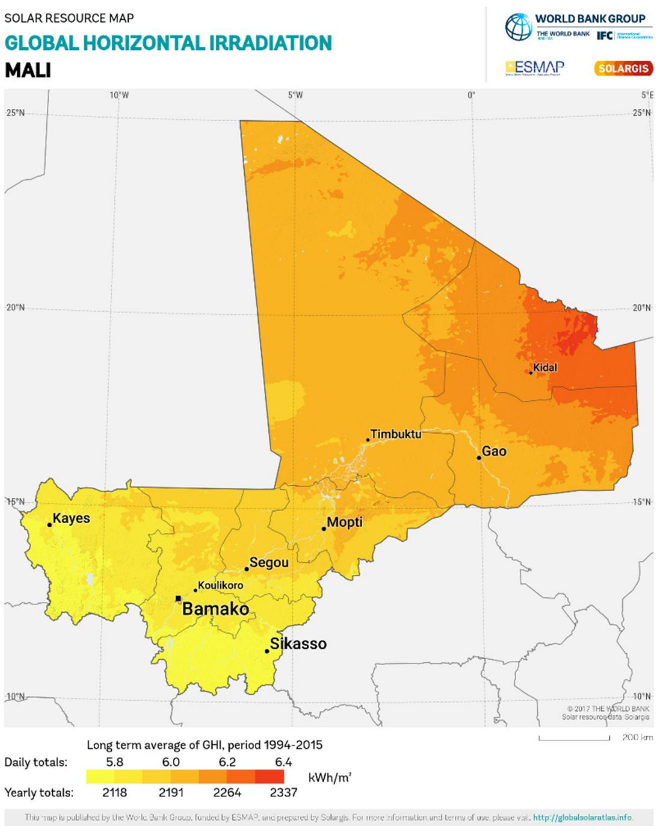


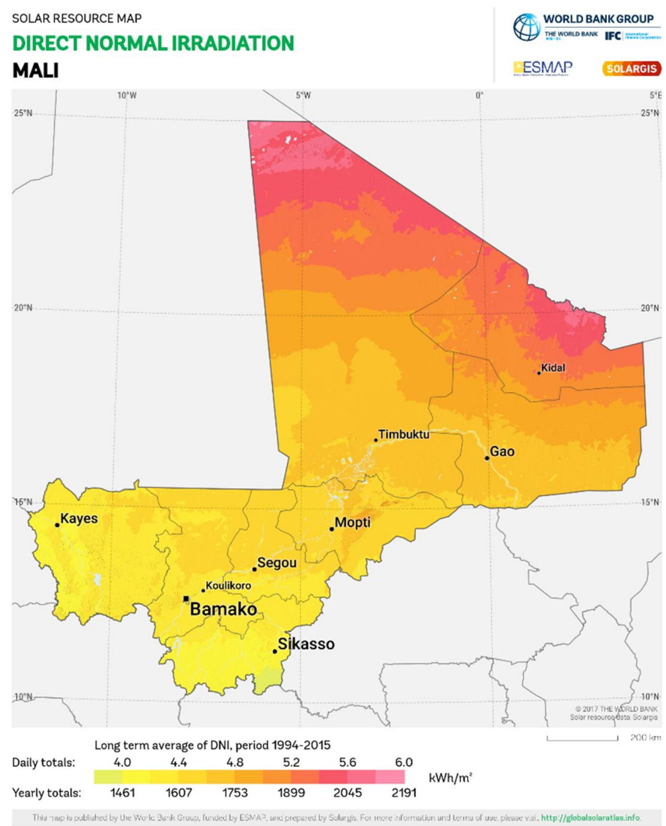
Final version

Liberia

Final version

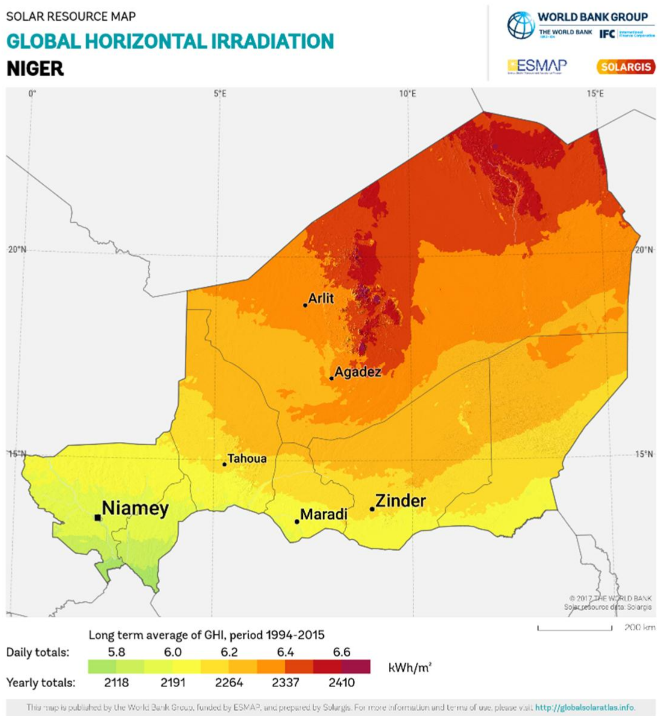
Mali

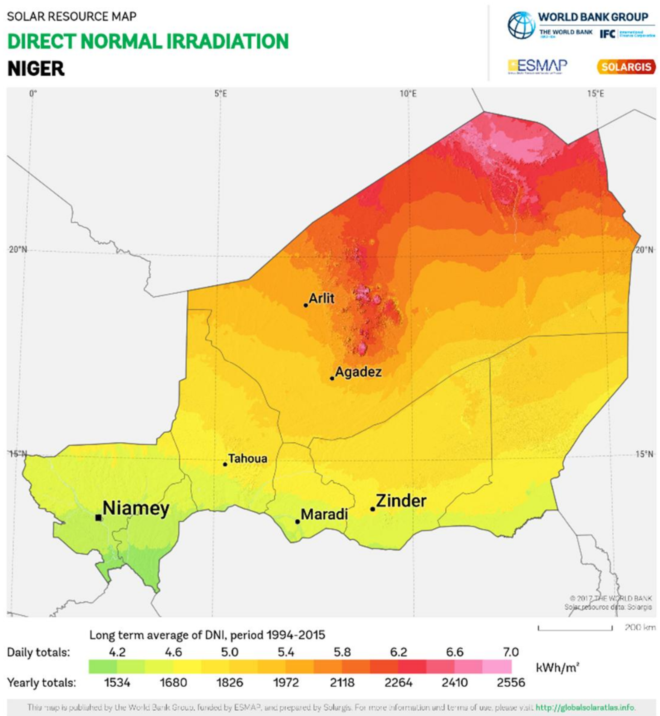




Final version

Niger





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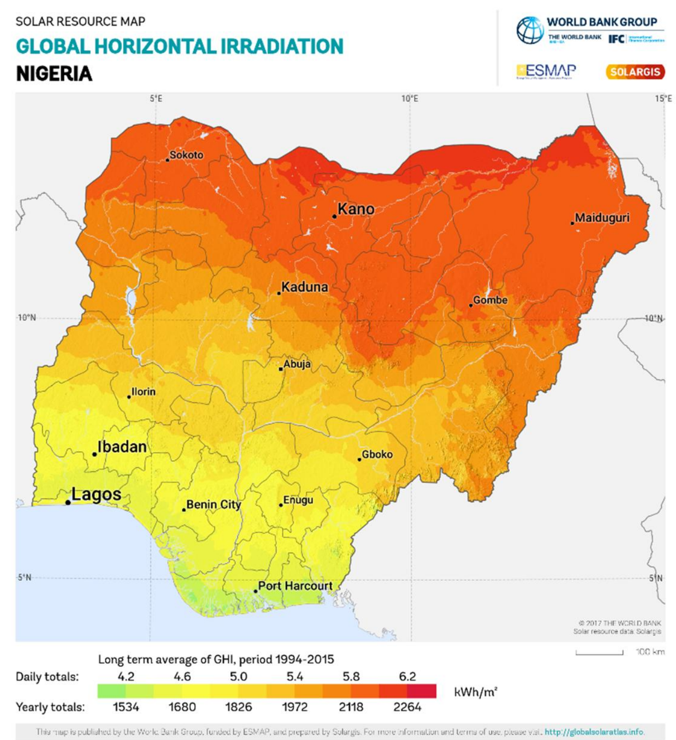
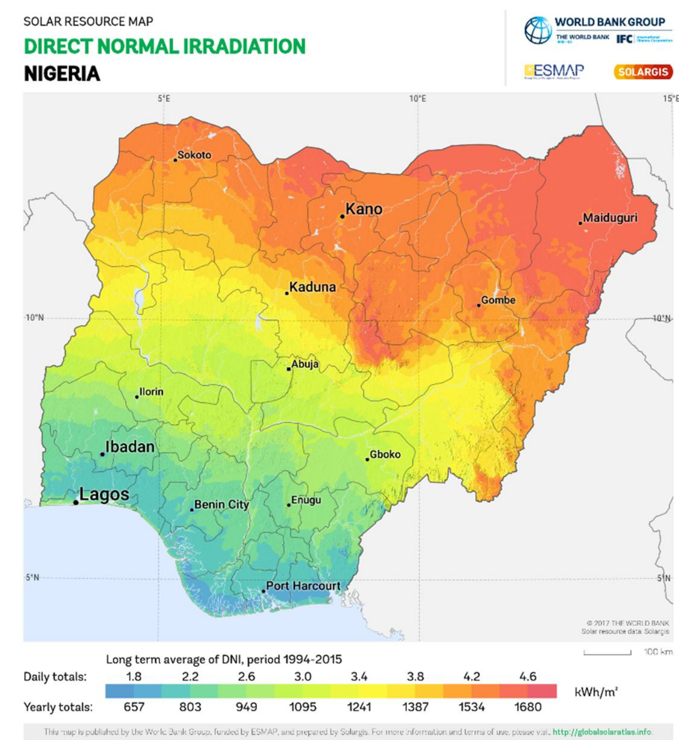
Nigeria





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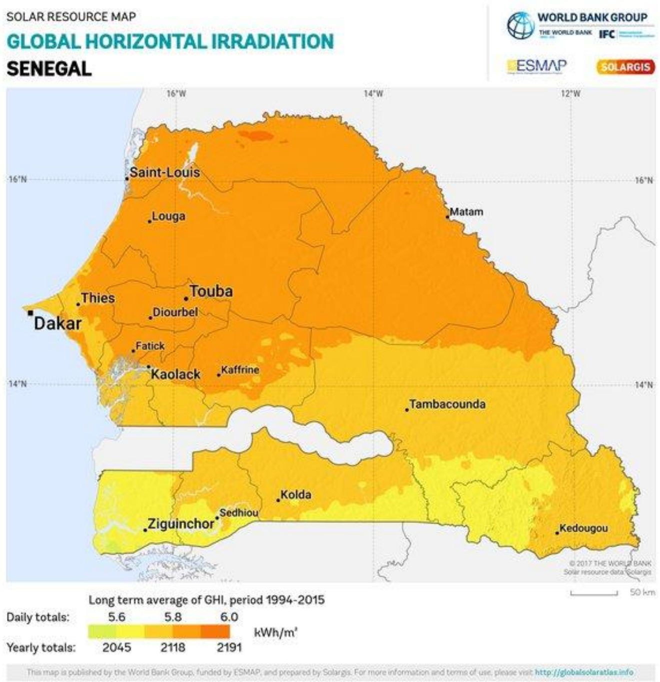
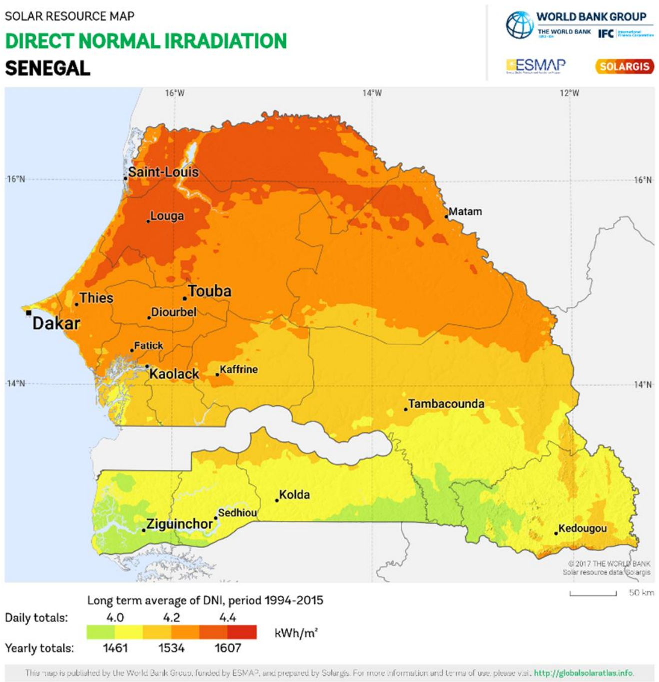
Senegal





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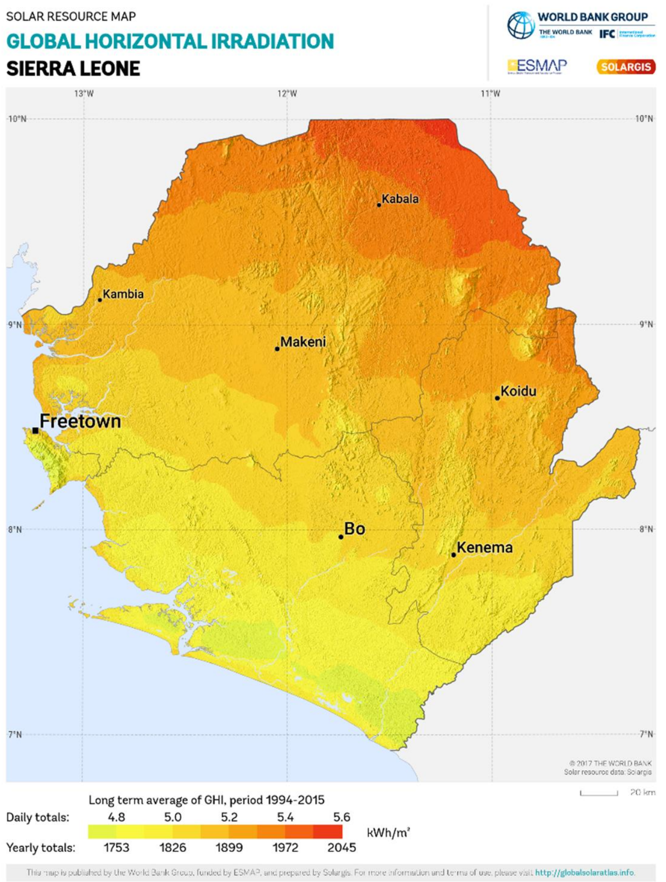
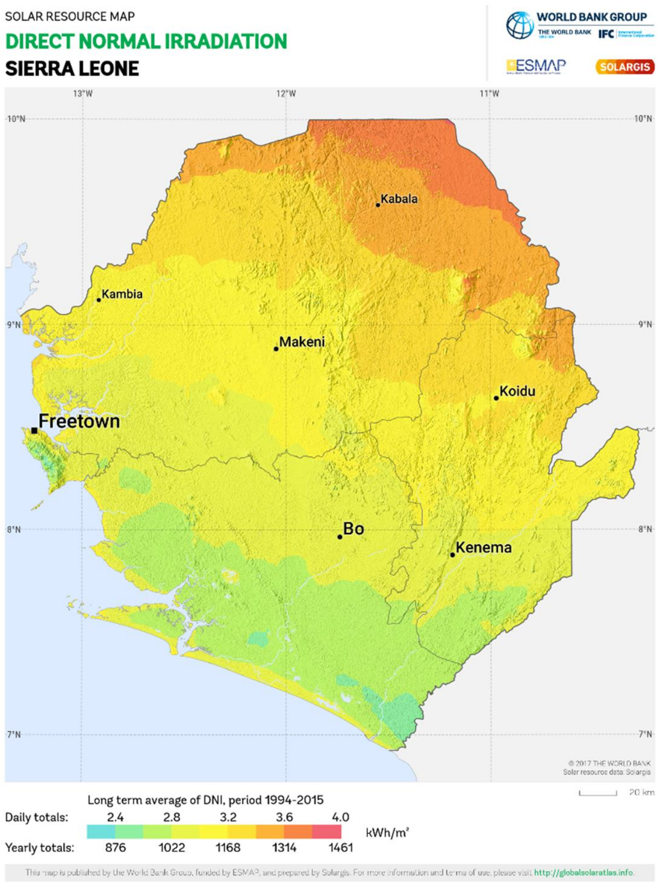
Sierra Leone





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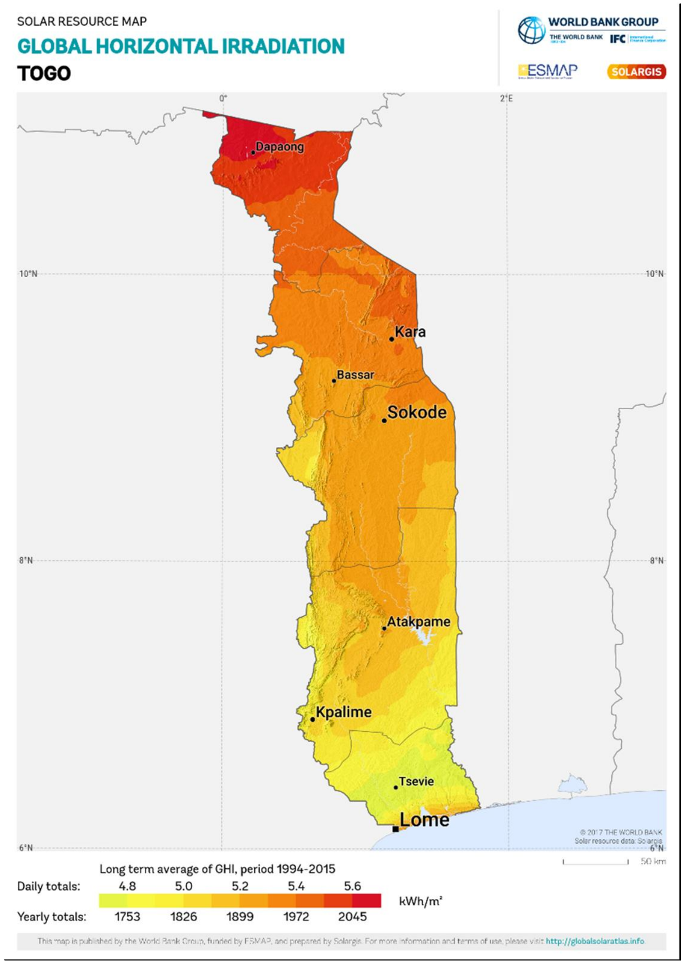
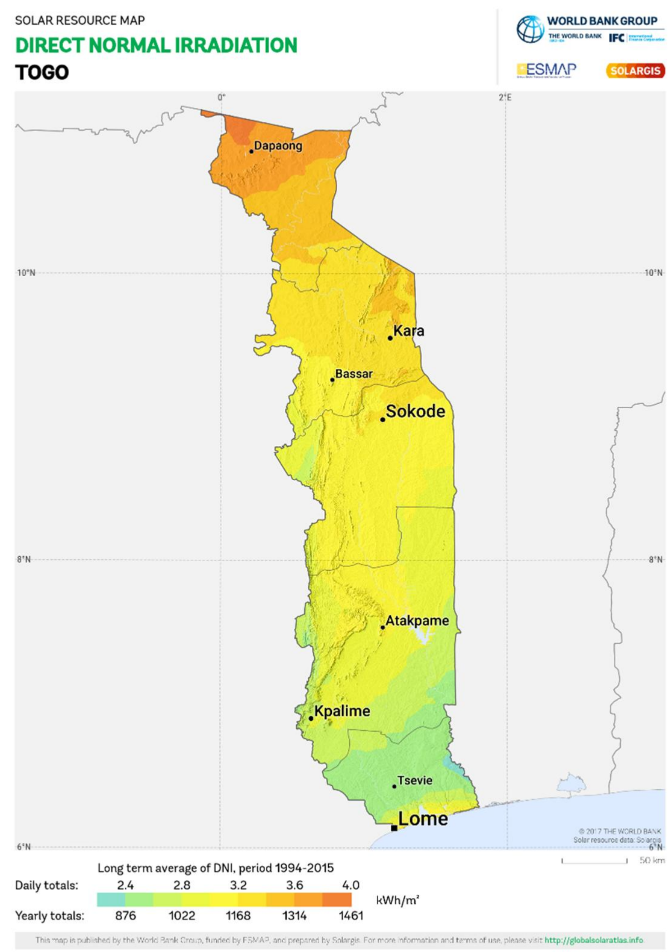
Togo





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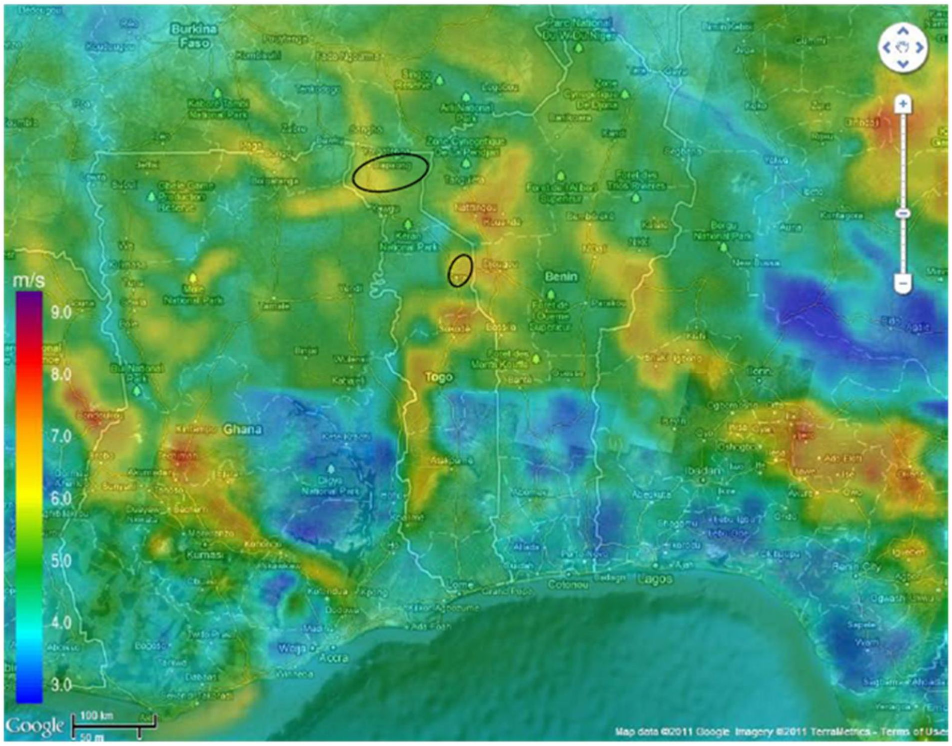
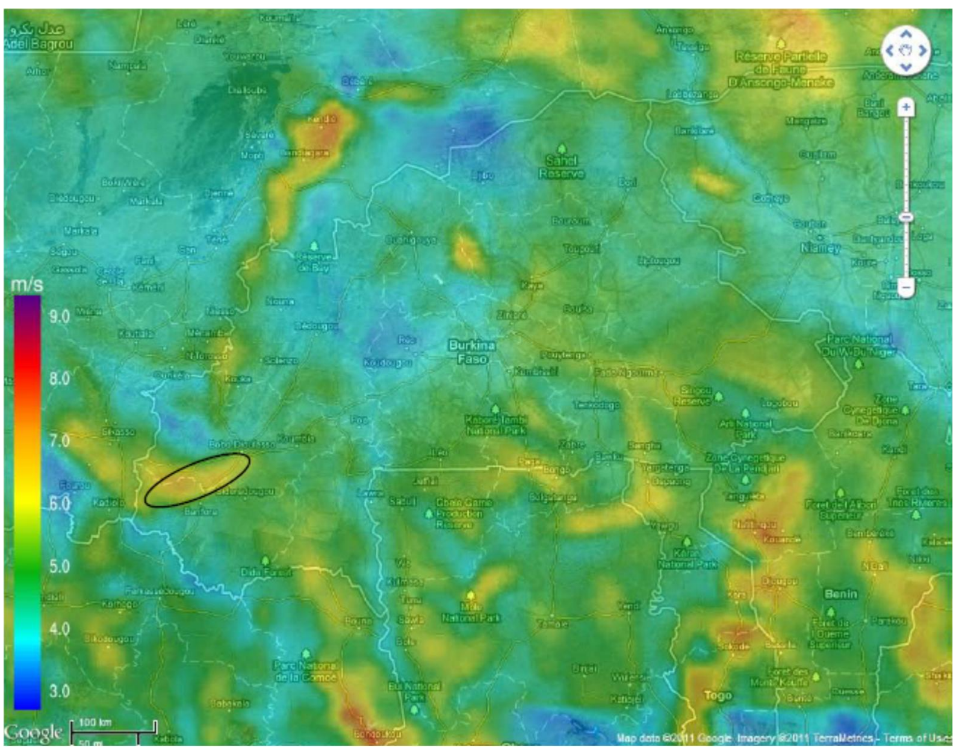
APPENDIX E : ZONES WITH HIGH WIND POTENTIAL PER COUNTRY

Final version

Benin and Togo



Burkina Faso



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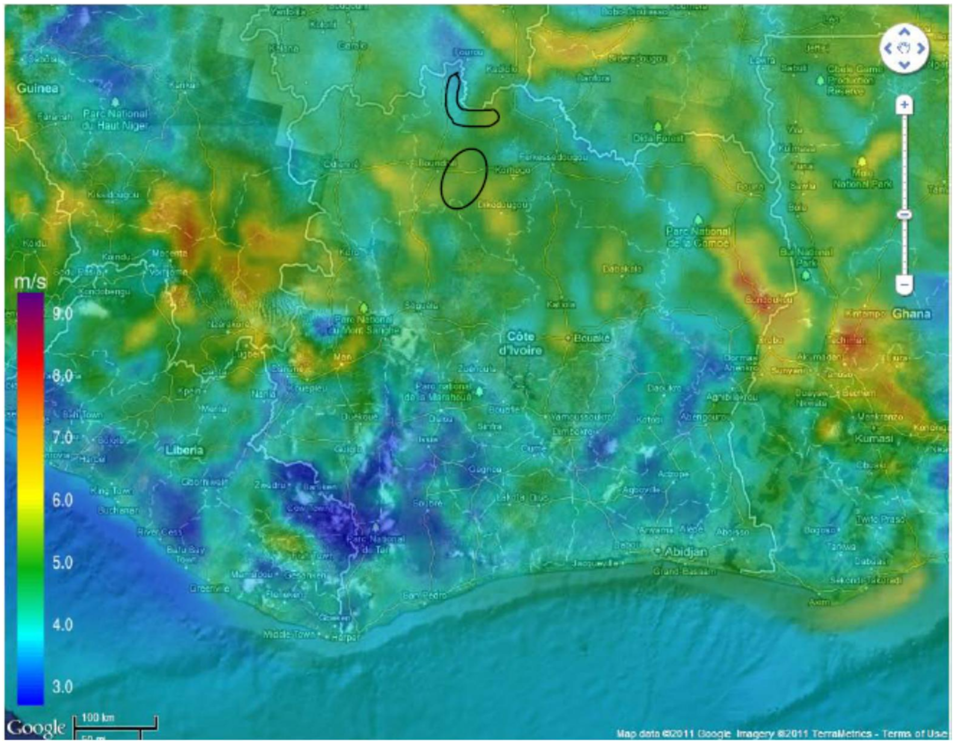
Côte d'Ivoire



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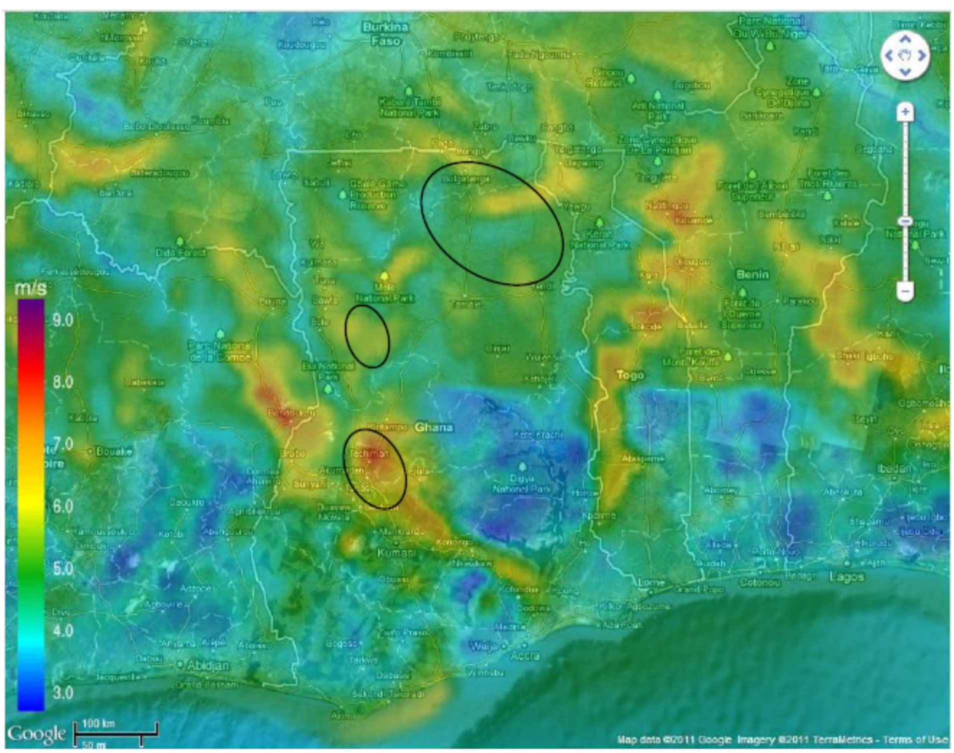
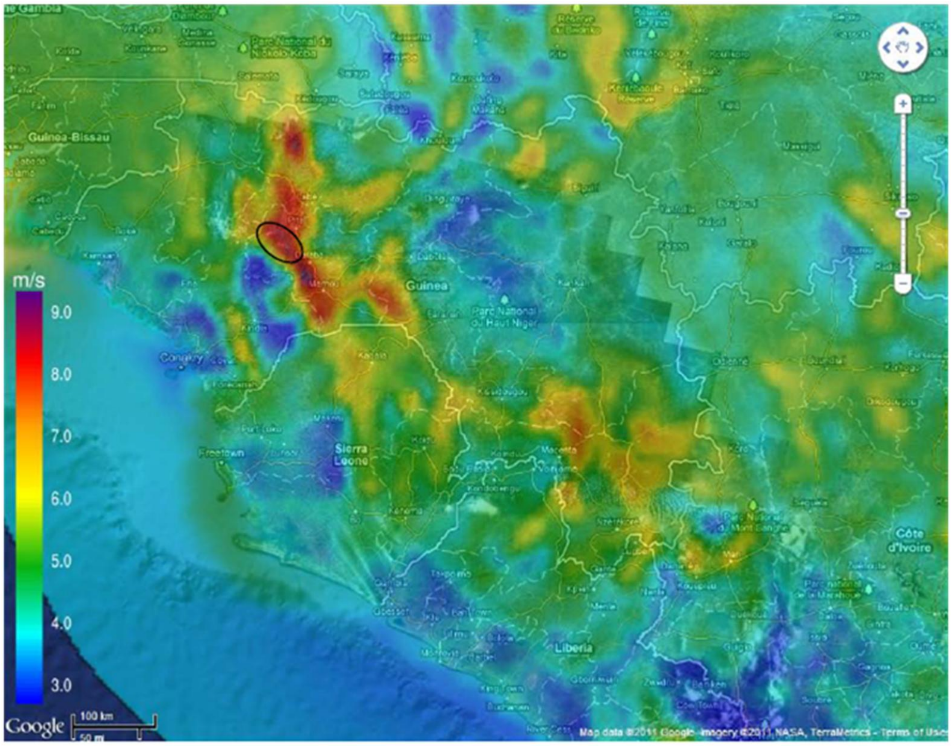
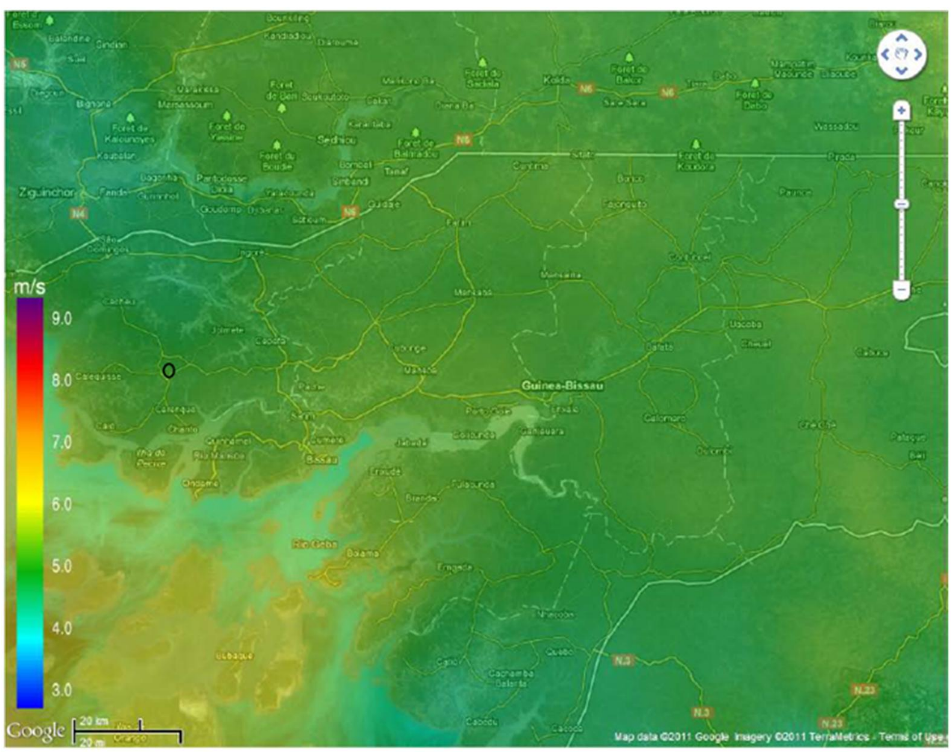


Guinea

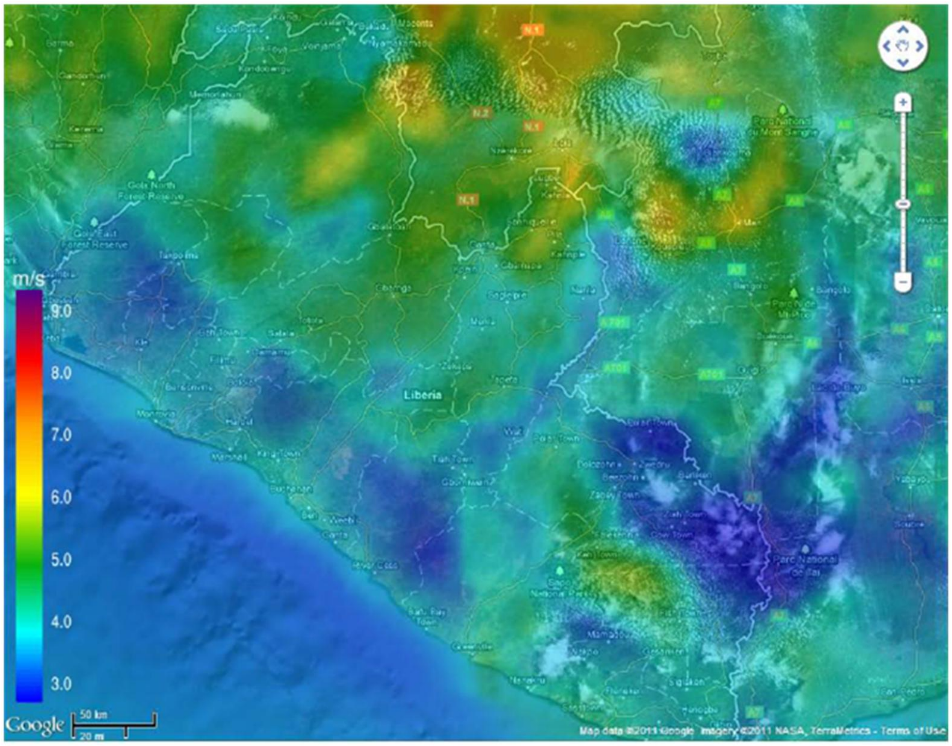


Guinea Bissau

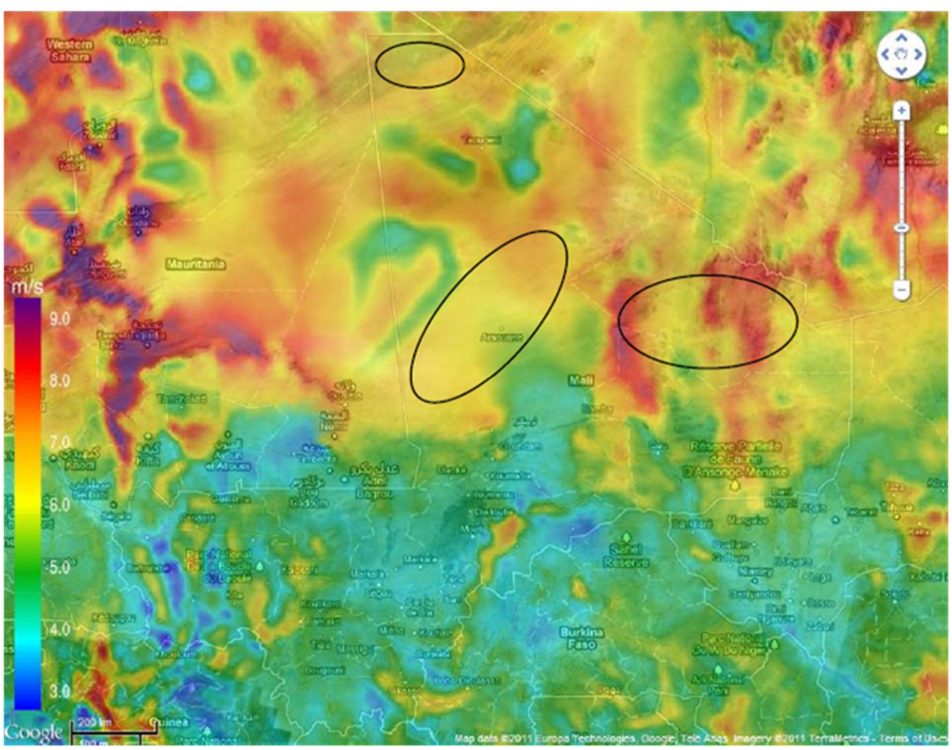


Final version

Liberia

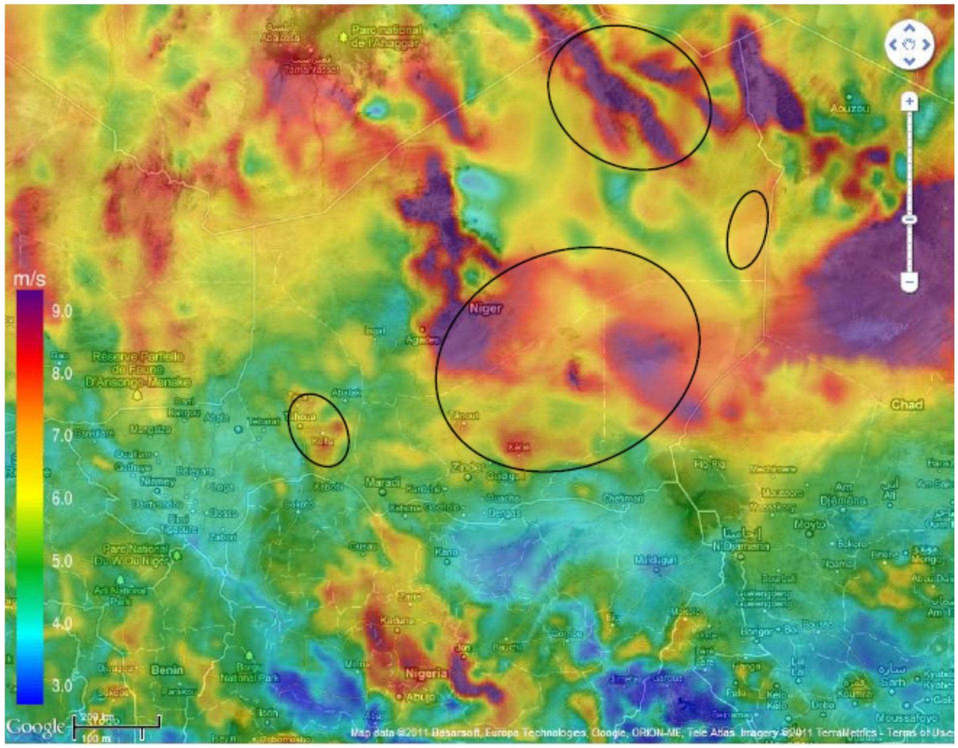


Mali



Final version

Niger



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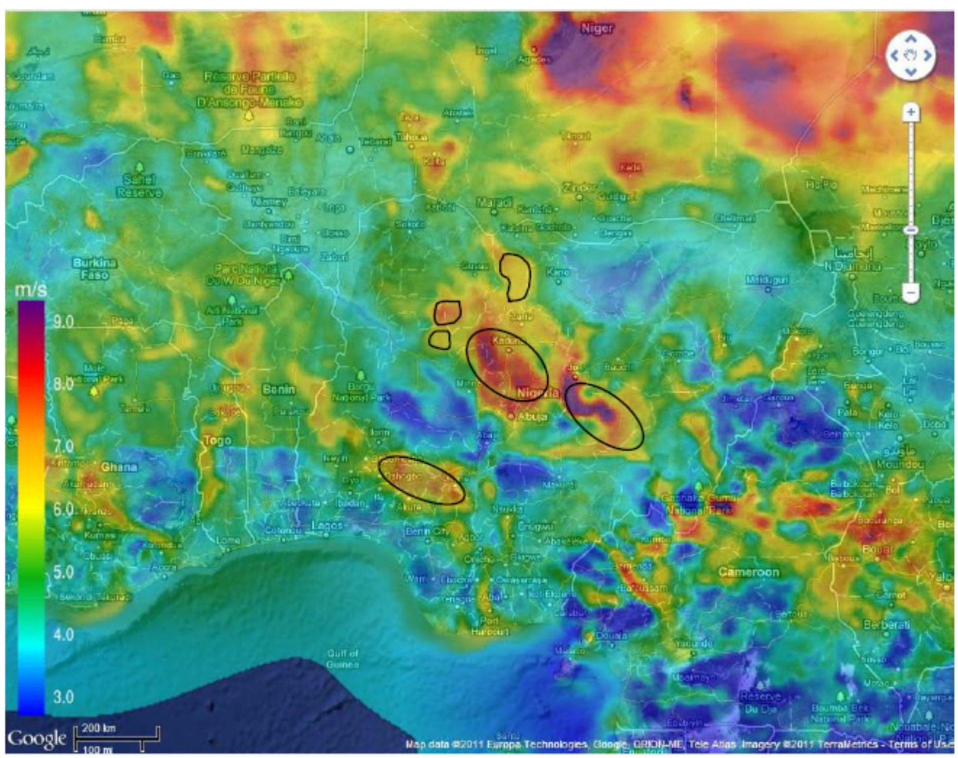

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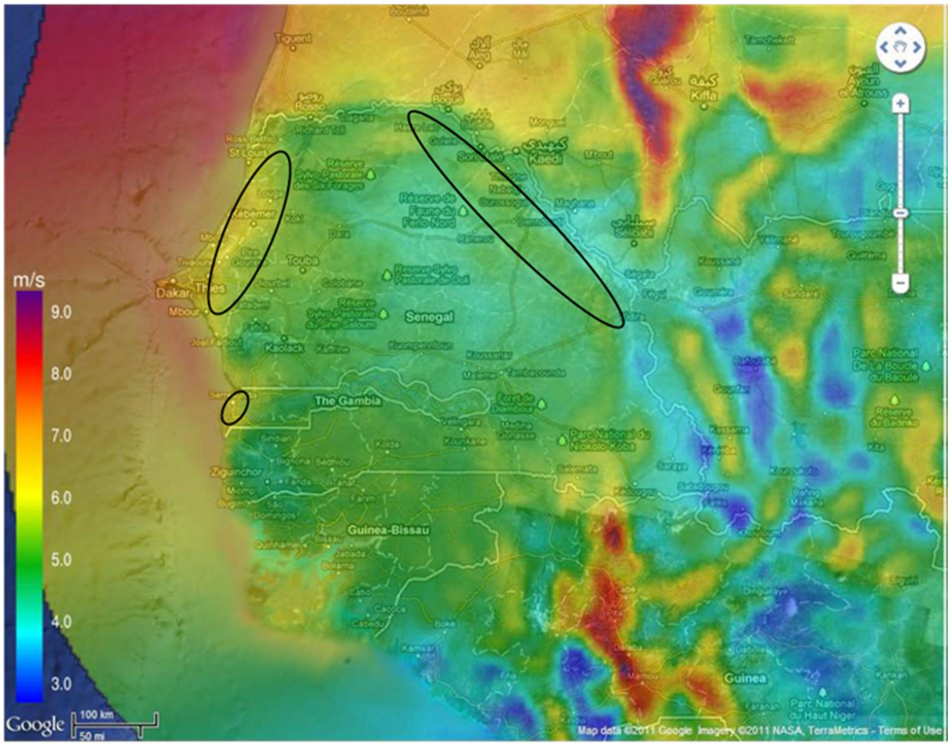
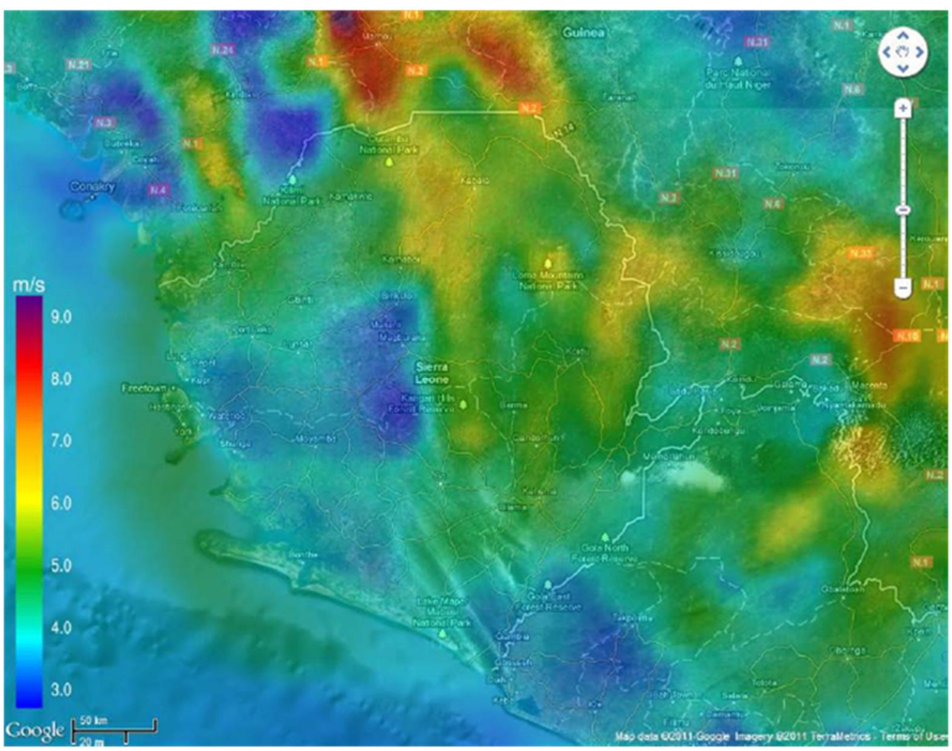
Senegal and Gambia



Sierra Leone



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APPENDIX F : THERMOFLOWS SCENARIOS

Final version

APPENDIX G : COMPARISON OF AVAILABLE THERMAL TECHNOLOGIES AND CHARACTERISTICS OF FOSSIL FUEL

Comparison of available thermal technologies

RECIPROCATING ENGINE (DIESEL, DUAL-FUEL & GASEOUS-FUEL) POWER GENERATION ORDERS, January – December 2016

Output Range (MW)	Units Ordered	Total Engine Output (MWe)	Type Of Generating Service			Engine Operating Speed Ranges (r/min)				Fuel					Western Europe	Eastern Europe, Russia & CIS	Middle East	Far East	Southeast Asia & Australia	Central Asia	North Africa	Central, West, East & South Africa	North America	Central America & Caribbean	South America
			Standby	Peaking	Contin-uous	Below 300	300 - 600	720 - 1000	Above 1000	Diesel Fuel	Heavy Fuel	Dual Fuel	Liquid Biofuel	Natural Gas											
0.50 to 1.00	11 006	7806	6800	188	3940	0	0	1	11 005	10 229	1	0	0	698	2229	282	1747	1332	1103	475	67	634	2259	221	657
1.01 to 2.00	11 077	15 529	6300	358	4419	0	0	12	11 065	9677	0	0	0	1372	2043	295	1941	2062	1506	229	43	718	1399	410	431
2.01 to 3.50	2761	6896	1976	207	578	0	0	17	2744	2510	0	0	0	247	607	50	121	622	150	25	7	22	1096	19	42
3.51 to 5.00	240	1047	47	0	193	0	0	23	217	60	1	0	0	179	67	41	15	23	14	14	13	0	51	1	1
5.01 to 7.50	47	284	6	0	41	0	0	43	4	29	6	6	0	6	2	0	9	10	5	5	0	0	7	1	8
7.51 to 10.00	97	893	2	0	95	0	0	95	2	9	11	40	0	37	12	0	5	2	25	11	0	11	1	4	26
10.01 to 15.00	18	244	0	0	18	0	0	18	0	0	18	0	0	0	0	0	0	0	8	0	0	10	0	0	0
15.01 to 20.00	141	2566	0	0	141	0	141	0	0	4	91	26	0	20	1	3	64	0	19	17	0	4	12	0	21
20.01 to 30.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30.01 and above	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	**25 387**	**35 266**	**15 130**	**754**	**9425**	**0**	**141**	**209**	**25 037**	**22 518**	**128**	**72**	**0**	**2559**	**4961**	**671**	**3902**	**4051**	**2830**	**776**	**130**	**1399**	**4825**	**656**	**1186**

STEAM TURBINE POWER GENERATION ORDERS, January – December 2016

Output Range (MW)	Units Ordered	Total Engine Output (MWe)	Type Of Generating Service			Steam Turbine Types					Western Europe	Eastern Europe, Russia & CIS	Middle East	Far East	Southeast Asia & Australia	Central Asia	North Africa	Central, West, East & South Africa	North America	Central America & Caribbean	South America
			Standby	Peaking	Contin-uous	Condensing	Non-Condensing	Reheat	Extraction	Induction											
0.0 to 1.00	4	2	0	0	4	0	4	0	0	0	0	0	0	0	1	0	0	0	3	0	0
1.01 to 5.00	11	19	0	0	11	2	9	0	0	0	0	0	0	0	10	0	0	0	0	0	1
5.01 to 10.00	5	42	0	0	5	4	1	0	1	0	2	0	0	0	1	0	0	0	1	0	0
10.01 to 30.00	9	155	0	0	9	8	1	0	4	0	1	0	3	1	0	0	2	0	2	0	0
30.01 to 60.00	13	562	0	1	3	11	0	0	4	4	2	0	1	1	2	4	0	0	2	1	0
60.01 to 120.00	6	490	0	2	4	6	0	2	0	3	0	0	1	0	0	0	0	2	2	0	1
120.01 to 200.00	16	2737	0	0	16	11	0	12	0	0	0	3	4	0	4	0	0	0	5	0	0
200.01 to 300.00	10	2423	0	0	10	8	0	4	2	0	0	2	2	2	0	0	2	0	2	0	0
300.01 to 500.00	7	1137	0	0	7	4	0	5	0	0	0	0	1	0	3	0	0	0	0	2	1
500.01 to 700.00	9	594	0	0	9	9	0	9	0	0	0	0	4	0	0	5	0	0	0	0	0
700.01 to 1000.00	5	4325	0	0	5	3	0	3	0	0	0	0	0	0	3	2	0	0	0	0	0
1000.01 and above	1	175	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Totals	**96**	**12 661**	**0**	**3**	**84**	**67**	**15**	**36**	**11**	**7**	**6**	**5**	**16**	**5**	**24**	**11**	**4**	**2**	**17**	**3**	**3**

GAS TURBINE POWER GENERATION ORDERS, January – December 2016

Output Range (MW)	Units Ordered	Total Engine Output (MWe)	Type Of Generating Service			Fuel				Western Europe	Eastern Europe, Russia & CIS	Middle East	Far East	Southeast Asia & Australia	Central Asia	North Africa	Central, West, East & South Africa	North America	Central America & Caribbean	South America
			Standby	Peaking	Contin-uous	Diesel Fuel	Heavy Fuel	Dual Fuel	Natural Gas											
1.00 to 2.00	67	86	60	0	7	28	26	7	6	1	0	0	65	1	0	0	0	0	0	0
2.01 to 3.50	47	125	41	0	6	15	15	13	4	0	4	0	43	0	0	0	0	0	0	0
3.51 to 5.00	49	176	37	0	10	10	23	6	7	0	3	0	39	0	0	0	0	5	0	0
5.01 to 7.50	50	293	2	0	46	2	0	7	39	6	3	16	8	1	0	0	6	8	0	0
7.51 to 10.00	30	214	0	0	17	0	0	1	16	6	0	0	6	0	0	0	0	5	0	0
10.01 to 15.00	19	243	0	1	18	0	0	0	19	8	0	3	5	0	0	0	0	0	3	0
15.01 to 20.00	20	286	1	0	11	0	0	4	8	0	2	0	4	0	0	0	0	5	0	1
20.01 to 30.00	12	302	0	0	12	0	0	7	5	3	0	2	2	0	0	0	0	5	0	0
30.01 to 60.00	135	5800	0	57	75	8	0	35	89	2	0	12	21	14	2	0	30	19	0	32
60.01 to 120.00	28	1719	0	2	17	0	0	4	15	0	0	2	15	1	2	0	0	4	0	4
120.01 to 180.00	11	601	0	5	6	0	1	1	9	0	4	0	2	0	0	0	5	0	0	0
180.01 and above	113	36 266	0	13	100	2	3	18	90	1	5	38	14	10	4	4	5	22	3	7
Totals	**581**	**46 111**	**141**	**78**	**325**	**65**	**68**	**103**	**307**	**27**	**21**	**73**	**224**	**27**	**8**	**4**	**46**	**73**	**6**	**44**

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Composition of fossil fuel

Natural Gas

The typical expected composition of natural gas at the delivery point of the plant to be considered is shown in the table below:

Composition	Composition requirements Mole Fraction %
Methane CH_4	88.75
Ethane C_2H_6	5.93
Propane C_3H_8	1.28
i-Butane C_4H_{10}	0.26
n-Butane C_4H_{10}	0.26
i-Pentane C_5H_{12}	0.09
n-Pentane C_5H_{12}	0.06
Hexane C_6H_{14}	0.06
CO_2	2.55
Nitrogen N_2	0.66
LHV (kCal/kg)	10 989

DDO et HFO

Since the HFO and DDO compositions have impacts on performance, maintenance frequency and emissions, this must be taken into account when choosing the fuel source.

Below are typical composition requirements:

Composition	Composition requirements
Viscosity	2 to 11 cSt @40°C
Injection viscosity	2.8 cSt (engine requirement)
Density	Max 900 kg/m³ @15°C
Water content	Max 0.3% Vol
Sulphur	Max 2% mass
Ash	Max 0.01% mass
Carbon Residue	Max 0.3
Flash point (PMCC)	Min 60°C
Hydrogen sulphide	Max 2 mg/kg

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Composition	Composition requirements
Acid number	Max 0.5 mg KOH/g
Oxidation stability	Max 25g/m³
Pour point	Max 6°C
Cetane Index	Min 35
Total sediment existent by hot filtration	Max 0.10% mass
Appearance	Clear and bright
Lubricity corrected wear scar diameter	Max 520 µm

Composition	Composition requirements
Paramètre	**Exigences**
Viscosity	Maximum 700 cSt at 50°C
Density	Maximum 1010 kg/m³ at 15°C
CCAI	Maximum 870
Water	Maximum 0,5 % Vol.
Sulphur	Maximum 4,5 % mass
Hydrogen sulphide	Maximum 2,00 mg/kg
Total acid number	Maximum 2,5 mg KOH/g
Ash content	Maximum 0,015 % mass
Vanadium	Maximum 450 mg/kg
Sodium	Maximum 100 mg/kg
Aluminium + silicon (total)	Maximum 60 mg/kg
Carbon Residue	Maximum 20 % mass
Asphaltenes	Maximum 14 % mass
Flash point (PMCC)	Minimum 60 °C
Pour point	Maximum 30 °C
Total Sediment existent aged	Maximum 0,10 % mass
Calcium	Maximum 30 mg/kg
Zinc	Maximum 15 mg/kg
Phosphorus	Maximum 15 mg/kg

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APPENDIX H: PARAMETERS OF EXISTING INTERCONNECTIONS

This section presents the parameters considered for the existing interconnections.

From Country	From Substation	To Country	To Substation	Voltage (kV)	Length (km)	Rated power (MVA)	R (% p.u.)	X (% p.u.)	B/2 (% p.u.)
Cote d'Ivoire	Ferkéssédougou 2_225	Mali	Sikasso RE_225	225	0	327	2.752	18.912	17.149
Cote d'Ivoire	Ferkéssédougou 1_225	Burkina Faso	Kodeni RE_225	225	0	327	2.576	17.699	16.050
Cote d'Ivoire	Riviera_225	Ghana	Prestea_225	225	210	327	2.439	16.759	15.022
Ghana	Aflao Ghana_161	Togo Benin	Lomé (Aflao) 1_161	161	0	128	0.273	0.626	0.137
Ghana	Asiekpe PST_161	Togo Benin	Lomé (Aflao) 1_161	161	0	128	3.940	8.890	1.935
Niger	Dosso_132	Nigeria	Birnin Kebbi_132	132	54	107.7	9.036	28.797	3.259
Niger	Gazaou_132	Nigeria	Katsina_132	132	0	82	8.470	18.330	1.705
Senegal	Bakel_225	Mali	Kayes_225	225	106	283	1.090	6.870	9.865
Senegal	Dagana_225	Mauritanie	Rosso_225	225	0	214	0.660	3.070	2.590
Togo Benin	Sakete_330	Nigeria	Ikeja_330	330	0	777	0.251	2.128	13.292
Togo Benin	Nangbéto_161	Togo Benin	Bohicon_161	161	0	178	4.320	13.270	2.850
Togo Benin	Momé Hagou_161	Togo Benin	Avakpa_161	161	0	128	4.050	10.530	2.000
Togo Benin	Kara_161	Togo Benin	Djougou_161	161	0	178	3.600	9.400	1.338
Togo Benin	Momé Hagou_161	Togo Benin	Maria Gleta 2_161	161	92	128	6.513	13.842	6.153

Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Côte d'Ivoire	LI	AKOUPE ZEUDJI-BINGERVILLE_400	48	ALM570 (2 conductor/phase)	2018-2022	-
Côte d'Ivoire	LI	BAKRE-BINGERVILLE_400	22	ALM570 (2 conductor/phase)	2018-2022	-
Côte d'Ivoire	LI	BAKRE-AKOUPE ZEUDJI_400	46	ALM570 (2 conductor/phase)	2018-2022	-
Côte d'Ivoire	LI	BAKRE-AZITO_400	10	ALM570 (2 conductor/phase)	2018-2022	-
Côte d'Ivoire	LI	AZITO-AKOUPE-ZEUDJI_400	52	ALM570 (2 conductor/phase)	2018-2022	-
Côte d'Ivoire	LI	BAKRE-BINGERVILLE_400	45	ALM570 (2 conductor/phase)	2018-2022	-
Côte d'Ivoire	LI	ANANI-BINGERVILLE 1_225	18	ALM570	2018-2022	-
Côte d'Ivoire	LI	ANANI-BINGERVILLE 2_225	18	ALM570	2018-2022	-
Côte d'Ivoire	LI	RIVIERA-BINGERVILLE_225	10	ALM570	2018-2022	-
Côte d'Ivoire	LI	BINGERVILLE-PRESTEA_225	200	ALM570	2018-2022	-
Côte d'Ivoire	LI	AKOUPE ZEUDJI-ABOBO 1_225	38	ALM570	2018-2022	-
Côte d'Ivoire	LI	AKOUPE ZEUDJI-ABOBO 2_225	38	ALM570	2018-2022	-
Côte d'Ivoire	LI	AKOUPE ZEUDJI-TAABO 1_225	132	ALM570	2018-2022	-
Côte d'Ivoire	LI	AKOUPE ZEUDJI-TAABO 2_225	132	ALM570	2018-2022	-
Côte d'Ivoire	LI	LABOA-BOUNDIALI_225	165	ALM570	2018-2022	-
Côte d'Ivoire	LI	BOUNDIALI-FERKE_225	152	ALM570	2018-2022	-
Côte d'Ivoire	LI	SEREBOU-BONDOUKOU_225	142	ALM570	2018-2022	-
Côte d'Ivoire	LI	BOUAKE2-SEREBOU_225	132	ALM570	2018-2022	-
Côte d'Ivoire	LI	AZITO-BAKRE_225	10	ALM570	2018-2022	-
Côte d'Ivoire	LI	VRIDI-BAKRE_225	5	ALM570	2018-2022	-
Côte d'Ivoire	LI	ADZOPE-AKOUPE-ZEUDJI_225	100	ALM570	2018-2022	-
Côte d'Ivoire	LI	SONGON-AKOUPE ZEUDJI_225	25	ALM570	2018-2022	-
Côte d'Ivoire	LI	ANYAMA-AKOUPE ZEUDJI_225	10	ALM570	2018-2022	-
Côte d'Ivoire	LI	BUYO-DUEKOUE_225	110	ALM570	2018-2022	-
Côte d'Ivoire	LI	DUEKOUE-MAN_225	86	ALM570	2018-2022	-
Côte d'Ivoire	LI	ZAGNE-TOULEPLEU_225	165	ALM570	2018-2022	-
Côte d'Ivoire	LI	SAN PEDRO-SOUBRE_225	128	ALM570	2018-2022	-
Côte d'Ivoire	LI	SOUBRE-BUYO_225	79	ALM570	2018-2022	-
Côte d'Ivoire	LI	DUEKOUE-ZAGNE_225	77	ALM570	2018-2022	-
Côte d'Ivoire	LI	SAN PEDRO 1-SAN PEDRO 2_225	10	ALM570	2018-2022	-
Côte d'Ivoire	LI	BOUNDIALI-TENGRELA_225	106	ALM570	2018-2022	-
Côte d'Ivoire	LI	TAABO-YAMOUSSOUKRO_225	80	ALM570	2018-2022	-
Côte d'Ivoire	LI	YAMOUSSOUKRO-KOSSOU_225	50	ALM570	2018-2022	-
Côte d'Ivoire	LI	KOSSOU-BOUAKE3_225	110	ALM570	2018-2022	-
Côte d'Ivoire	LI	BOUAKE3-BOUAKE2_225	10	ALM570	2018-2022	-
Côte d'Ivoire	LI	BUYO-DALOA_225	87	ALM570	2018-2022	-
Côte d'Ivoire	LI	SEREBOU-DABAKALA_225	67	ALM570	2018-2022	-
Côte d'Ivoire	LI	DABAKALA-KONG_225	98	ALM570	2018-2022	-
Côte d'Ivoire	LI	VRIDI-RIVIERA_225	18.3	ALM570	2018-2022	-

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Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Côte d'Ivoire	LI	ANYAMA-ADZOPE_225	100	ALM570	2018-2022	_
Côte d'Ivoire	LI	ATTAKRO-ADZOPE_225	75	ALM570	2018-2022	_
Côte d'Ivoire	LI	SAN PEDRO-SOUBRE_225	128	ALM570	2018-2022	_
Côte d'Ivoire	LI	KATIOLA-FERKE_225	12	ALM570	2018-2022	_
Côte d'Ivoire	LI	KONG-FERKE_225	85	ALM570	2018-2022	_
Côte d'Ivoire	LI	ZAGNE-TOULEPLEU_225	165	ALM570	2018-2022	_
Côte d'Ivoire	LI	SAN PEDRO 1-SAN PEDRO 2_225	10	ALM570	2018-2022	_
Côte d'Ivoire	LI	GRIBO-POPOLI-SAN PEDRO_225	3	ALM570	2018-2022	_
Côte d'Ivoire	LI	BOUNA-BONDOUKOU_90	180	ALM228	2018-2022	_
Côte d'Ivoire	LI	TANDA-AGNIBILEKRO_90	84	ALM228	2018-2022	_
Côte d'Ivoire	LI	TANDA-BONDOUKOU_90	52	ALM228	2018-2022	_
Côte d'Ivoire	LI	LABOA-TOUBA_90	65	ALM228	2018-2022	_
Côte d'Ivoire	LI	TOUBA-MAN_90	100	ALM228	2018-2022	_
Côte d'Ivoire	LI	DALOA-VAVOUA_90	57	ALM228	2018-2022	_
Côte d'Ivoire	LI	VAVOUA-ZUENOULA_90	56	ALM228	2018-2022	_
Côte d'Ivoire	LI	MANKONO-SEGUELA_90	71	ALM228	2018-2022	_
Côte d'Ivoire	LI	ZUENOULA-MANKONO_90	82	ALM228	2018-2022	_
Côte d'Ivoire	LI	BOUAKE1-BOUAKE3_90	20	ALM228	2018-2022	_
Côte d'Ivoire	LI	DAOUKRO-ATTAKRO_90	53	ALM228	2018-2022	_
Côte d'Ivoire	LI	SEREBOU-DAOUKRO_90	103	ALM228	2018-2022	_
Côte d'Ivoire	LI	AYAME 1-ABENGOUROU_90	156	ALM228	2018-2022	_
Côte d'Ivoire	LI	AYAME 1-AYAME 2_90	4	ALM228	2018-2022	_
Côte d'Ivoire	LI	LABOA-TOUBA_90	78	ALM228	2018-2022	_
Côte d'Ivoire	LI	MARABADIASSA-KATIOLA_90	39	ALM228	2018-2022	_
Côte d'Ivoire	LI	BOUAKE1-BOUAKE3_90	20	ALM228	2018-2022	_
Côte d'Ivoire	LI	YAMOUSSOUKRO1-YAMOUSSOUKRO2_90	7	ALM228	2018-2022	_
Côte d'Ivoire	LI	CENTRALE-PYLONE_90	N/A	ALM228	2018-2022	_
Côte d'Ivoire	LI	PYLONE-VERS KORHOGO_90	N/A	ALM228	2018-2022	_
Côte d'Ivoire	LI	TAABO-AGBOVILLE_90	118	ALM225	2018-2022	_
Côte d'Ivoire	LI	MANKONO-MARABADIASSA_90	57	ALM228	2018-2022	_
Côte d'Ivoire	LI	TOULEPLEU-MINE ITY_90	57	ALM228	2018-2022	_
Côte d'Ivoire	LI	SINGROBO-TAABO_90	3	ALM 228	2018-2022	_
Côte d'Ivoire	TF	400/225 AKOUPE ZEUDJI N°1	-	200 MVA	2018-2022	_
Côte d'Ivoire	TF	400/225 AKOUPE ZEUDJI N°2	-	200 MVA	2018-2022	_
Côte d'Ivoire	TF	400/225 SAN PEDRO2 N°1	-	200 MVA	2018-2022	_
Côte d'Ivoire	TF	400/225 SAN PEDRO2 N°2	-	200 MVA	2018-2022	_
Côte d'Ivoire	TF	400/225 BINGERVILLE N4	-	350 MVA	2018-2022	_
Côte d'Ivoire	TF	400/225 BINGERVILLE N5	-	350 MVA	2018-2022	_
Côte d'Ivoire	TF	400/225 BINGERVILLE N6	-	350 MVA	2018-2022	_
Côte d'Ivoire	TF	400/225 AKOUPE-ZEUDJI N1	-	350 MVA	2018-2022	_

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Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Côte d'Ivoire	TF	400/225 AKOUPE-ZEUDJI N2	-	350 MVA	2018-2022	-
Côte d'Ivoire	TF	400/225 BAKRE N1	-	350 MVA	2018-2022	-
Côte d'Ivoire	TF	400/225 BAKRE N2	-	350 MVA	2018-2022	-
Côte d'Ivoire	TF	400/225 SAN PEDRO N1	-	200 MVA	2018-2022	-
Côte d'Ivoire	TF	400/225 SAN PEDRO N2	-	200 MVA	2018-2022	-
Côte d'Ivoire	TF	330/225 BINGERVILLE N1	-	350 MVA	2018-2022	-
Côte d'Ivoire	TF	330/225 BINGERVILLE N2	-	350 MVA	2018-2022	-
Côte d'Ivoire	TF	330/225 BINGERVILLE N3	-	350 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 AKOUPE ZEUDJI N°1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 AKOUPE ZEUDJI N°2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/93 (4) LABOA N°2	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BOUNDIALI	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BOUNDIALI	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BONDOUKOU N1	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BONDOUKOU N2	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 YOPOUGON1 N°1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 YOPOUGON1 N°2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 TREICHVILLE N°1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 TREICHVILLE N°2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 (1) ABOBO N°1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 (1) ABOBO N°2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 (1) ABOBO N°3	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 (1) ABOBO N°4	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BONDOUKOU N°1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BONDOUKOU N°2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 SEREBOU N°1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 SEREBOU N°2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 TOULEPLEU	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 (2) SAN PEDRO 1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 DIVO	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/93 SEREBOU N°1	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/93 SEREBOU N°2	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/93 BONDOUKOU N°1	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/93 BONDOUKOU N°2	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/93 (2) MAN N°2	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/93 (2) SOUBRE N°2	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 (3)TAABO N°1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 (3)TAABO N°2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 SAN PEDRO N°1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 SAN PEDRO N°2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/93 (5) BUYO N°2	-	70 MVA	2018-2022	-

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Côte d'Ivoire	TF	225/90 YAMOUSSOUKRO2 N°1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 YAMOUSSOUKRO2 N°2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BOUAKE3 N°1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BOUAKE3 N°2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/93 (6)KOSSOU N°2	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 DALOA	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 GAGNOA N°1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 GAGNOA N°2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/93 FERKE	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/93 BOUAKE 2 N°2	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 FERKE N1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 FERKE N2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 MAN	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BOUAKE 2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 LABOA	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BUYO	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BOUNDIALI	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BIA-SUD N1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BIA-SUD N2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 ATTAKRO N1	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 ATTAKRO N2	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 KATIOLA N1	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 KATIOLA N2	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 KORHOGO N1	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 KORHOGO N2	-	70 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 YAMOUSSOUKRO N1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 YAMOUSSOUKRO N2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BOUAKE3 N1	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 BOUAKE3 N2	-	100 MVA	2018-2022	-
Côte d'Ivoire	TF	225/90 DALOA N1	-	100 MVA	2018-2022	-
Côte d'Ivoire	SVC	SVC FERKE - 225 kV	-	50 MVAr	2018	-
Côte d'Ivoire	SVC	SVC MAN - 225 kV	-	50 MVAr	2019	-
Côte d'Ivoire	SVC	SVC BONDOUKOU - 90 kV	-	50 MVAr	2020	-
Côte d'Ivoire	REAC	Reactor BONDOUKOU - 90 kV	-	50 MVAr	2019	Number of taps?
Côte d'Ivoire	REAC	Capacitor DABOU – 90kV	-	7.2 MVAr	2018	3 taps?
Côte d'Ivoire	REAC	Capacitor DALOA - 90 kV	-	14.4 MVAr	2019	6 taps?
Côte d'Ivoire	REAC	Capacitor TOUBA - 90 kV	-	14.4 MVAr	2019	6 taps?
Côte d'Ivoire	REAC	Capacitor BOUNA - 90 kV	-	4.8 MVAr	2021	2 taps?
Côte d'Ivoire	REAC	Capacitor ADZOPE - 90 kV	-	7.2 MVAr	2021	3 taps?
Côte d'Ivoire	REAC	Capacitor DIVO - 90 kV	-	12 MVAr	2020	5 taps?
Côte d'Ivoire	REAC	Capacitor SEGUELA - 90 kV	-	4.8 MVAr	2020	2 taps?

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Côte d'Ivoire	REAC	Capacitor TONGON - 90 kV	-	4.8 MVAr	2020	2 taps?
Côte d'Ivoire	REAC	Capacitor YOPOUGON1-90kV	-	7.2 MVAr	2018	30 kV connection; 3 taps?
Côte d'Ivoire	REAC	Capacitor YOPOUGON1-90kV	-	7.2 MVAr	2018	15 kV connection; 3 taps?
Côte d'Ivoire	REAC	Capacitor ZAGNE - 90 kV	-	12 MVAr	2020	5 taps?
Ghana	LI	Prestea-Kumasi 330 kV	N/A	-	2018	-
Ghana	LI	Aboadze-Dunkwa-Kumasi-Kintampo-Tamale-Bolgatanga 330 kV	N/A	-	2019	-
Ghana	LI	Sunyani-Berekum 161 kV	N/A	-	2018	-
Ghana	LI	Asawinso-Juabeso-Mim 161 kV	N/A	-	2018 or 2019?	-
Ghana	LI	Break-in of 161kV Akosombo-Nkawkaw line at Tafo	N/A	-	2019	How far is the break-in?
Ghana	LI	Upgrade of Achimota-Acrra East-Volta lines (2)	-	213 to 488 MVA	2019	-
Ghana	TF	Upgrade transformers in Tarkwa, Akwatia, KoNogo, Asawinso, Asiekpe, Tamales, New Tarkwa, Sunyani, New Tema, Cape Coast, Kpandu et Winneba.	-	-	2019	Size of transformers?
Ghana	REAC	Dunkwa, Kumasi, Bolgatanga reactors	-	-	2019	-
Ghana	SS	New Pokuase Substation 330 kV on Aboadze-Volta	-	-	2019	-
Ghana	SS	New Accra Substation?	-	-	2018	Connection?
Ghana	SS	New Substation GIS at Accra Central	-	-	2019	Same project as Accra?
Mali	LI	Sikasso-Bougouni-Bamako 225 kV	N/A	-	2020	Single/Double circuit?
Mali	LI	225 kV Bamako Loop	N/A	-	2021	Single/Double circuit?
Mali	LI	Duplicate of Manantali-Bamako	-	-	2021	-
Mali	LI	Reinforcement Manantali-Kayes	-	-	N/A	-
Burkina Faso	LI	Double circuit line Kossodo-Poste Ouaga Est- Poste Patte d'Oie - 90 kV	N/A	-	2019	-
Burkina Faso	LI	Kossodo-Zigniaré 90 kV	25	-	2019	-
Burkina Faso	LI	Upgrade to 90 kV of line Zagtouli-Koudougou	100	-	2019	-
Burkina Faso	LI	Kaya-Zigniaré 90 kV double circuit	70	-	2019	-
Burkina Faso	LI	Pa- Diebougou 90 kV	N/A	-	N/A	-
Burkina Faso	LI	Wona-Dedougou 90 kV	60	-	2019	-
Burkina Faso	LI	Zano-Koupela 132 kV	55	-	2019	-
Burkina Faso	LI	PA-Houndé 90 kV	36	-	2018	-
Burkina Faso	TF	Ouga I 90/15 kV	-	40 MVA	2018	Zagtouli Solar Project
Burkina Faso	TF	Poste Haoundé 90/11.5 kV	-	-	2018	Transformer info?
Burkina Faso	TF	Zano 132/33 kV	-	40 MVA	2018	-
Togo-Benin	LI	Davié-Notsé_161	54.5	178.5 MVA	2025	-
Togo-Benin	LI	Davié-Légbassito_161 n°1	14	178.5 MVA	2018	-
Togo-Benin	LI	Davié-Légbassito_161 n°2	14	178.5 MVA	2018	-

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Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Togo-Benin	LI	Notsé-Atakpamé_161	70	178.5 MVA	2025	-
Togo-Benin	LI	Atakpamé-Kara_161	250	178.5 MVA	2025	-
Togo-Benin	LI	Kara-Bandjeli_161	75	178.5 MVA	2022	-
Togo-Benin	LI	Kara-Mango_161	164	178.5 MVA	2020	-
Togo-Benin	LI	Mango-Dapaong_161	78	178.5 MVA	2020	-
Togo-Benin	LI	Porga-Tangieta-Natitingou_161	110	178.5 MVA	2022	-
Togo-Benin	LI	Bembereke-Kandi_161	114	178.5 MVA	2018	-
Togo-Benin	LI	Kandi-Guene-Malanville_161	90	178.5 MVA	2018	-
Togo-Benin	LI	Onigbolo-Parakou_161 n°1	280	178.5 MVA	2018	-
Togo-Benin	LI	Onigbolo-Parakou_161 n°2	280	178.5 MVA	2018	-
Togo-Benin	LI	Dapaong-Mandouri 161	N/A	178.5 MVA	2020	-
Togo-Benin	LI	Atakpamé-Lomé 161	N/A	178.5 MVA	2021	-
Togo-Benin	LI	Notse-Adjarala	N/A	128 MVA	N/A	-
Togo-Benin	LI	Adjarala-Ava n°2	N/A	128 MVA	N/A	-
Togo-Benin	TF	ATAKPAME – T3_161 / ATAKPAME – T3_20	-	16 MVA	2019	-
Togo-Benin	TF	BANDJELI – T1_161 / BANDJELI – T1_34	-	20 MVA	2022	-
Togo-Benin	TF	BANDJELI – T2_161 / BANDJELI – T2_34	-	20 MVA	2022	-
Togo-Benin	TF	BEMBEREKE – T1_161 / BEMBEREKE – T1_34	-	20 MVA	2018	-
Togo-Benin	TF	BEMBEREKE – T2_161 / BEMBEREKE – T2_34	-	20 MVA	2018	-
Togo-Benin	TF	BLITTA – T1_161 / BLITTA – T1_34	-	20 MVA	2022	-
Togo-Benin	TF	BLITTA – T2_161 / BLITTA – T2_34	-	20 MVA	2022	-
Togo-Benin	TF	CINKASSE - T1_161 / CINKASSE - T1_0.4	-	16 MVA	2022	-
Togo-Benin	TF	DAPAONG -T1_161 / DAPAONG - T1_22	-	16 MVA	2022	-
Togo-Benin	TF	DAPAONG -T2_161 / DAPAONG - T2_34,5	-	16 MVA	2022	-
Togo-Benin	TF	KANDI – T1_161 / KANDI – T1_34	-	20 MVA	2018	-
Togo-Benin	TF	KANDI – T2_161 / KANDI – T2_34	-	20 MVA	2018	-
Togo-Benin	TF	LEGBASSITO – TR1_161 / LEGBASSITO – TR1_20	-	50 MVA	2018	-
Togo-Benin	TF	LEGBASSITO – TR2_161 / LEGBASSITO – TR2_20	-	50 MVA	2018	-
Togo-Benin	TF	MALANVILLE – T1_161 / MALANVILLE – T1	-	20 MVA	2018	-
Togo-Benin	TF	MANGO – TR1_161 / MANGO – TR1_20	-	20 MVA	2020	-
Togo-Benin	TF	MANGO – TR2_161 / MANGO – TR2_20	-	20 MVA	2020	-
Togo-Benin	TF	NATITINGOU – T1_161 / NATITINGOU –T1_20	-	20 MVA	2022	-
Togo-Benin	TF	NOTSE – T1_161 / NOTSE – T1_33	-	12.5 MVA	2025	-
Togo-Benin	TF	PORGA – T1_161 / PORGA – T1_20	-	20 MVA	2022	-
Togo-Benin	TF	TANGUIETA – T1_161 / TANGUIETA – T1_20	-	20 MVA	2022	-
Gambia	TF	Brikama 225/30 kV	-	2 x 50 MVA	2021	OMVG
Guinea Bissau	TF	Bissau 225/30 kV	-	3 x 20 MVA	2021	OMVG

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Guinea	LI	Linsan-Fomi 225 kV	N/A	250 MVA	2020	Double circuit?
Guinea	LI	Linsan – Kisougoudou 225 kV (Guinea Loop)	N/A	-	N/A	Double circuit?
Guinea	LI	Kisigoudou – N'Zérékoré 225 kV (Guinea Loop)	N/A	-	N/A	Double circuit?
Guinea	LI	Maneah-Linsan 225 kV	N/A	-	N/A	Double circuit?
Guinea	TF	Linsan 225/110 kV	-	2 x 75 MVA	2021	OMVG
Guinea	TF	N'Zérékore 225/110 kV	-	40 MVA	2020	CLSG
Niger	LI	Salkadmana-Niamey 330 kV	400	760 MVA	2022	-
Niger	LI	Kandadji- Niamey 132 kV	190	107.7 MVA	2022	-
Niger	LI	Salkadmana-Tahoua-Malbaza 132 kV	60+260	107.7 MVA	2020	-
Niger	LI	Niamey-Zabori 330 kV (Dorsale Nord)	N/A	760 MVA	2022	Single circuit?
Niger	LI	Reinforcement HV grid Niamey?	N/A	-	2020	Which lines?
Senegal	LI	Tanaf-Ziguichor 225 kV	N/A	-	N/A	-
Senegal	LI	Mbour-Kayar_225	N/A	-	2018	-
Senegal	LI	Mbour-Kayar_225	N/A	-	2018	-
Senegal	LI	OLAM-Sendou_225	N/A	-	2018	-
Senegal	LI	Mbour-OLAM_225	N/A	-	2018	-
Senegal	LI	Sendou-Kounoune_225	12	348 MVA	2018	-
Senegal	LI	Sendou-Kounoune_225	12	348 MVA	2018	-
Senegal	LI	Tobene-Kounoune_225	53	348 MVA	2018	-
Senegal	LI	Tobene-Kounoune_225	53	348 MVA	2019	-
Senegal	LI	Fatick-SAPCO_225	N/A	-	2018	-
Senegal	LI	SAPCO-MBOUR_225	N/A	-	2018	-
Senegal	LI	Fatick-Kaolack_225	40	348 MVA	2020	-
Senegal	LI	Africa Energy-Tobene_225	30	-	2020	-
Senegal	LI	Africa Energy-Tobene_225	30	-	2020	-
Senegal	LI	Mboro-Tobene_225	200	348 MVA	2020	-
Senegal	LI	Mboro-Tobene_225	200	348 MVA	2020	-
Senegal	LI	Bakel-Tambacounda_225	N/A	-	2021	-
Senegal	LI	Cap Des Biches-Kounoune_90	6.5	86 MVA	2020	-
Senegal	LI	Hann-Patte d'Oie_90	1.2	81.80 MVA	2020	-
Senegal	LI	Hann-Patte d'Oie_90	1.2	81.80 MVA	2026	-
Senegal	LI	Hann-Patte d'Oie_90	1.2	-	2030	-
Senegal	REAC	Reactance KAOLACK 225 kV	-	20 MVAr	N/A	-
Senegal	REAC	Reactance TOUBA 225 kV	-	25 MVAr	N/A	-
Senegal	REAC	Reactance KOUNOUNE 225 kV	-	25 MVAr	N/A	-
Sierra Leone	TF	Kamakwie 225/33 kV	-	40 MVA	2020	CLSG
Sierra Leone	TF	Yiben 225/33 kV	-	40 MVA	2020	CLSG
Sierra Leone	TF	Bumbuna 225/161 kV	-	2 x 70 MVA	2020	CLSG
Sierra Leone	TF	Bikongore 225/33 kV	-	40 MVA	2020	CLSG
Sierra Leone	TF	Kenema 225/33 kV	-	40 MVA	2020	CLSG

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Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Liberia	TF	Mano 225/33 kV	-	40 MVA	2020	CLSG
Liberia	TF	Monrovia 225/33 kV	-	70 MVA	2020	CLSG
Liberia	TF	Buchanan 225/33 kV	-	40 MVA	2020	CLSG
Liberia	TF	Yekepa 225/33 kV	-	40 MVA	2020	CLSG
Mauritania	LI	Noukchott-Nouadhibou 225 kV	N/A	-	2020	Double circuit?
Mauritania	LI	Noukchott-St LYess- Tobene 225 kV	N/A	-	2020	Double circuit?
Nigeria	LI	Owerri-Ahoada-Yenegoa 1x132kv circuit	N/A	N/A	2020	-
Nigeria	LI	Alaoji-Umuahia 2x132kV circuits	N/A	N/A	2020	-
Nigeria	LI	Mbalano-Okigwe 1x132kv circuit	N/A	N/A	2020	-
Nigeria	LI	2nd Benin-Onitsha 1x330kv circuit	N/A	N/A	2020	-
Nigeria	LI	3rd Benin - Onitsha 2x330KV circuits	N/A	N/A	2020	-
Nigeria	LI	Onitsha - Oba - Nnewi - Ideato-Okigwe 2x132kv circuits	N/A	N/A	2020	-
Nigeria	LI	Nsukka - Ayangba 2x132KV circuits	N/A	N/A	2020	-
Nigeria	LI	Owerri - Abo Mbaise 2x132KV circuits	N/A	N/A	2020	-
Nigeria	LI	Onitsha-Ifitedunu 2x132kV circuits	N/A	N/A	2020	-
Nigeria	LI	Umuahia-Ohafia 1x132kV circuit	N/A	N/A	2020	-
Nigeria	LI	Umuahia - Mbalano 1x132kV circuit	N/A	N/A	2020	-
Nigeria	LI	Ohafia - Arochukwu 1x132kV circuit	N/A	N/A	2020	-
Nigeria	LI	Abakaliki - Amasiri 2x132kV circuits	N/A	N/A	2020	-
Nigeria	LI	Ugwuaji-Nnenwe 2x132kV circuits	N/A	N/A	2020	-
Nigeria	LI	Nnenwe-Mpu 2x132kV circuits	N/A	N/A	2020	-
Nigeria	LI	Akure-Ado Ekiti 1x132kv circuit	N/A	N/A	2020	-
Nigeria	LI	Tline Ikeja West - Ayobo 2x132kV circuits	N/A	N/A	2020	-
Nigeria	LI	Benin North-Oshogbo 2x330KV circuits - 1 circuit LILO at New Akure substation	N/A	N/A	2020	-
Nigeria	LI	New Abeokuta - Igboora - Lanlate 2x132kv circuits - Tee-off at Igboora- Igangan	N/A	N/A	2020	-
Nigeria	LI	Ganmo -Ogbomosho 2x132kV circuits	N/A	N/A	2020	-
Nigeria	LI	Ikorodu - Odogunyan - Shagamu 2x132kV circuits	N/A	N/A	2020	-
Nigeria	LI	Omotosho-Epe-Aja 2x330KV circuits.	N/A	N/A	2020	-
Nigeria	LI	Oshogbo- Ede 2x132KV circuits	N/A	N/A	2020	-
Nigeria	LI	Erukan - Omotosho 2x330KV circuits	N/A	N/A	2020	-
Nigeria	LI	Obajana-Okeagbe 2x132kV circuits	N/A	N/A	2020	-
Nigeria	LI	Owerri-Ahoada-Yenegoa 2x132kv circuits	N/A	N/A	2020	-
Nigeria	LI	Afam-Port Harcourt 2x132kV circuits - LILO at Port Harcourt main TS	N/A	N/A	2020	-
Nigeria	LI	3rd Benin - Onitsha 2x330KV circuits	N/A	N/A	2020	-
Nigeria	LI	2nd Benin-Onitsha 1x330kv circuit	N/A	N/A	2020	-
Nigeria	LI	Afam IV - Afam II 1x132kV circuit	N/A	N/A	2020	-

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Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Nigeria	LI	Alscon - Ibom Power 2x132kV circuits	N/A	N/A	2020	-
Nigeria	LI	Obudu - Ogoja 2x132KV circuits	N/A	N/A	2020	-
Nigeria	LI	Yenagoa - Oporoma 2x132kv circuits	50	N/A	2020	-
Nigeria	LI	Delta-Port Harcourt 2x330kV circuits	N/A	N/A	2020	-
Nigeria	TF	330/132/33kV at Onitsha and Benin.	-	150 MVA	2020	-
Nigeria	TF	132/33kv at Aboh -Mbaise	-	2 x 60 MVA	2020	-
Nigeria	TF	330/132KV at Olorunsogo	-	2 x 150 MVA	2020	provisional
Nigeria	TF	330/132/33kV at Onitsha	-	150 MVA	2020	second additional unit?
Nigeria	TF	132/33kV at Ukpilla, Edo State	-	60 MVA	2020	-
Nigeria	TF	Amukpe	-	1x30/40MVA	2020	-
Nigeria	TF	330/132/33kV at Afam TS for rehabilitation	-	1 x 150MVA	2020	-
Nigeria	SS	Substations Imo - Rivers - Bayelsa States	-	N/A	2020	-
Nigeria	SS	Umuahia	-	2x30/40MVA, 132/33kV	2020	-
Nigeria	SS	Ideato	-	2x60 MVA, 132/33 kV	2020	-
Nigeria	SS	Arochukwu	-	2x30/40MVA, 132/33kV	2020	-
Nigeria	SS	Okigwe	-	2x30/40MVA 132/33kV	2020	-
Nigeria	SS	Ohafia	-	2x30/40MVA 132/33kV	2020	-
Nigeria	SS	Mbalano.	-	2x30/40MVA 132/33kV	2020	-
Nigeria	SS	Nnewi	-	2x60 MVA 132kV	2020	-
Nigeria	SS	Oba	-	2x60 MVA, 132/33 kV	2020	-
Nigeria	SS	Ifitedunu	-	2 x 60MVA 132/33kV	2020	-
Nigeria	SS	Amasiri, Afikpo	-	2x60MVA,132/33kV	2020	-
Nigeria	SS	Mpu	-	2x60MVA,132/33kV	2020	-
Nigeria	SS	Nnenwe	-	2x60MVA, 132/33kV	2020	-
Nigeria	SS	Odogunyan	-	2 x 60MVA, 132/33kV	2020	-
Nigeria	SS	Ayobo	-	2 x 60MVA, 132/33kV	2020	-
Nigeria	SS	New Akure	-	2X150MVA,330/132KV + 2x60MVA, 132/33kV	2020	-
Nigeria	SS	Ogbomosho	-	2 x60MVA 132/33kV	2020	-
Nigeria	SS	Lanlate	-	2x30/40 MVA, 132/33 kV	2020	-
Nigeria	SS	Igangan	-	2x60MVA 132/33KV	2020	-
Nigeria	SS	Ede	-	2X60MVA	2020	voltage levels ?
Nigeria	SS	Omotosho	-	2x 150MVA, 330/132KV + 2x60MVA, 132/33kV	2020	-
Nigeria	SS	Okeagbe, Ondo State	-	2x60MVA 132/33kV	2020	-
Nigeria	SS	Ose LGA Headquarters, Ondo State	-	2x60MVA, 132/33kV	2020	-
Nigeria	SS	Calabar	-	2x150MVA, 330/132/33kV	2020	-
Nigeria	SS	Ughelli Power Plant	-	1x60MVA	2020	-
Nigeria	SS	Ogoja	-	2x30/40MVA, 132/33kV	2020	-

Final version

Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Nigeria	SS	Oporoma	-	2x 60MVA, 132/33KV	2020	-

Final version

APPENDIX I: TECHNICAL PARAMETERS OF GENERATION UNITS

This section presents the technical parameters of the existing and decided generation units for each country. The parameters in red indicates assumptions taken to fill gaps and/or ambiguities in the collected data. In these cases, the following values have been considered:

- 0.85 lagging and 0.95 leading power factor for thermal and hydro units, 0.95 leading and lagging power factor for renewable energy sources;
- Sub-transient reactance of 20 % p.u. for conventional units (If no similar unit is present) and 100 % p.u. for renewable energy sources (no contribution to short circuit current).

Benin

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Akpakpa - Aggreko	existing	Thermal	Akpakpa_15	38.89	15.00	35.00	16.95	20.00	-3.00	16.95	35.00
Akpakpa - SBEE	existing	Thermal	Akpakpa_15	35.29	15.00	30.00	2.90	20.00	-9.86	18.59	12.00
CAI -TAG BID	existing	Thermal	TB TAG BID_15.8	87.50	15.75	70.00	12.59	20.00	-27.30	52.50	70.00
Gbegamey - Aggreko	existing	Thermal	Gbegamey Aggreko_15	17.78	15.00	16.00	9.92	20.00	-5.26	9.92	16.00
Maria Gleta - Aggreko	existing	Thermal	Aggreko Maria Gleta_15.8	63.33	15.75	57.00	31.00	20.00	-16.43	31.00	50.00
Maria Gleta - TAG CEB	existing	Thermal	Maria Gleta TAG CEB_15.8	29.41	15.75	25.00	14.00	20.00	-8.22	15.49	24.00
Natitingou - SBEE G1-3	existing	Thermal	Natitingou SBEE Diesel_15	6.66	15.00	6.00	1.94	20.00	-1.97	2.90	6.00
Natitingou - SBEE G4-6	existing	Thermal	Natitingou SBEE Diesel_15	6.66	15.00	6.00	2.90	20.00	-1.97	2.90	6.00
Parakou - MRI	existing	Thermal	Parakou Thermal_15	18.89	15.00	17.00	8.23	20.00	-5.59	8.23	17.00
Parakou SBEE G1-3	existing	Thermal	Parakou Thermal_15	28.11	15.00	25.30	12.25	20.00	-8.32	12.25	14.00
Porto-Novo G1-4	existing	Thermal	Porto-Novo_15	8.89	15.00	8.00	1.94	20.00	-2.63	3.87	8.00
Porto-Novo G5-6	existing	Thermal	Porto-Novo_15	4.44	15.00	4.00	3.87	20.00	-1.31	1.94	4.00
Vedoko - MRI	existing	Thermal	Vedoko_15	28.89	15.00	26.00	15.49	20.00	-8.55	12.59	26.00
Yéripao	existing	Hydro	N/A	0.53	15.00	0.48	37.50	20.00	-0.23	0.23	0.48
Maria Gleta - TAG BID	decided	Thermal	N/A	62.50	15.75	50.00	52.50	20.00	-19.50	37.50	50.00

Final version

Burkina Faso

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
BOBO II G1	existing	Thermal	BOBO II G1_5.5	4.75	5.50	3.80	2.85	14.00	-0.38	2.85	3.40
BOBO II G2	existing	Thermal	BOBO II G2_5.5	4.75	5.50	3.80	2.85	14.00	-0.38	2.85	3.40
BOBO II G3	existing	Thermal	BOBO II G3_5.5	4.75	5.50	3.80	2.85	14.00	-0.38	2.85	3.40
BOBO II G4	existing	Thermal	BOBO II G4_5.5	4.75	5.50	3.80	2.85	14.00	-0.38	2.85	3.40
BOBO II G5	existing	Thermal	BOBO II G5_5.5	4.75	5.50	3.80	2.85	14.00	-0.38	2.85	3.40
BOBO II G6	existing	Thermal	BOBO II G6_11	15.60	11.00	12.50	9.33	15.60	-4.00	7.50	10.00
BOBO II G7	existing	Thermal	BOBO II G7_11	15.60	11.00	12.50	9.33	15.60	-4.00	7.50	10.00
BOBO II G8	existing	Thermal	BOBO II G8_11	15.60	11.00	12.50	9.33	15.60	-4.00	7.50	10.00
BOBO II G9	existing	Thermal	BOBO II G9_11	15.60	11.00	12.50	9.33	15.60	-4.00	7.50	10.00
Dedougou	existing	Thermal	N/A	6.68	N/A	5.68	3.52	20.00	-1.87	3.52	4.40
Dori	existing	Thermal	N/A	5.14	N/A	4.37	2.71	20.00	-1.44	2.71	3.00
Gaoua	existing	Thermal	N/A	2.82	N/A	2.40	1.49	20.00	-0.79	1.49	1.90
Komsilga G1	existing	Thermal	Komsilga G1_11	22.50	11.00	18.00	11.16	15.60	-5.92	11.16	14.00
Komsilga G2	existing	Thermal	Komsilga G2_11	15.00	11.00	12.50	9.33	15.60	-4.00	7.50	11.00
Komsilga G3	existing	Thermal	Komsilga G3_11	15.00	11.00	12.50	9.33	15.60	-4.00	7.50	11.00
Komsilga G4	existing	Thermal	Komsilga G4_11	15.00	11.00	12.50	9.33	15.60	-4.00	7.50	11.00
Komsilga G5	existing	Thermal	Komsilga G5_11	15.00	11.00	12.50	9.33	15.60	-4.00	7.50	11.00
Komsilga G6	existing	Thermal	Komsilga G6_11	15.00	11.00	12.50	9.33	15.60	-4.00	7.50	11.00
Komsilga G7	existing	Thermal	Komsilga G7_11	15.00	11.00	12.50	9.33	15.60	-4.00	7.50	11.00
Kossodo G1	existing	Thermal	Kossodo G1_11	4.75	11.00	3.80	2.85	13.50	-1.25	2.85	3.50
Kossodo G2	existing	Thermal	Kossodo G2_11	8.00	11.00	6.46	4.50	18.10	-2.12	4.84	5.10
Kossodo G3	existing	Thermal	Kossodo G3_11	8.00	11.00	6.46	4.50	18.10	-2.12	4.84	5.10
Kossodo G4	existing	Thermal	Kossodo G4_11	10.04	11.00	8.00	6.00	17.50	-2.63	6.00	6.40

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Kossodo G5	existing	Thermal	Kossodo G5_11	10.04	11.00	8.00	7.20	17.50	-0.80	6.00	6.40
Kossodo G6	existing	Thermal	Kossodo G6_11	22.50	11.00	18.00	13.50	15.60	-1.80	13.50	14.00
Kossodo G7	existing	Thermal	Kossodo G7_11	10.04	11.00	8.00	6.00	17.50	-2.63	6.00	6.40
Kossodo G8	existing	Thermal	Kossodo G8_11	10.04	11.00	8.00	6.00	17.50	-2.63	6.00	6.40
Ouaga 1 G1	existing	Thermal	Ouaga 1 G1_6.3	3.38	6.30	2.70	2.02	13.00	-0.89	2.02	2.50
Ouaga 1 G2	existing	Thermal	Ouaga 1 G2_6.3	3.38	6.30	2.70	2.02	13.00	-0.89	2.02	2.50
Ouaga 2 G1	existing	Thermal	Ouaga 2 G1_5.5	6.50	5.50	5.20	3.90	25.00	-1.71	3.90	3.40
Ouaga 2 G2	existing	Thermal	Ouaga 2 G2_5.5	6.50	5.50	5.20	3.90	25.00	-1.71	3.90	3.40
Ouaga 2 G3	existing	Thermal	Ouaga 2 G3_5.5	6.50	5.50	5.20	3.90	25.00	-1.71	3.90	3.40
Ouaga 2 G4	existing	Thermal	Ouaga 2 G4_5.5	10.00	5.50	8.00	6.00	28.30	-2.63	6.00	5.30
Ouaga 2 G5	existing	Thermal	Ouaga 2 G5_5.5	10.00	5.50	8.00	6.00	28.30	-2.63	6.00	5.30
Ouaga 2 G6	existing	Thermal	Ouaga 2 G6_15	4.00	15.00	3.20	2.40	15.00	-1.05	2.40	2.10
Ouahigouya	existing	Thermal	N/A	6.12	N/A	5.20	3.22	20.00	-1.71	3.22	3.70
Bagre G1	existing	Hydro	Bagre G1_6.6	8.80	6.60	8.00	3.66	20.60	-3.66	3.66	8.00
Bagre G2	existing	Hydro	Bagre G1_6.6	8.80	6.60	8.00	3.66	20.60	-3.66	3.66	8.00
Kompienga G1	existing	Hydro	Kompienga G1_6.6	7.70	6.60	7.00	3.39	22.00	-3.39	3.39	7.00
Kompienga G2	existing	Hydro	Kompienga G1_6.6	7.70	6.60	7.00	3.39	22.00	-3.39	3.39	7.00
Niofila G1	existing	Hydro	Niofila G1_0.4	0.55	0.40	0.50	0.23	20.00	-0.20	0.23	0.50
Niofila G2	existing	Hydro	Niofila G1_0.4	0.55	0.40	0.50	0.23	20.00	-0.20	0.23	0.50
Niofila G3	existing	Hydro	Niofila G1_0.4	0.55	0.40	0.50	0.23	20.00	-0.20	0.23	0.50
Sol Zagtouli 1	existing	PV	Sol Zagtouli 1_15	34.70	11.00	33.00	10.70	100.00	-3.30	10.70	33.00
Solaire Ziga	existing	PV	N/A	1.16	N/A	1.10	0.36	100.00	-0.36	0.36	1.10
Tourni G1	existing	Hydro	Niofila G1_0.4	0.27	0.40	0.25	0.10	20.00	0.00	0.10	0.25
Tourni G2	existing	Hydro	Niofila G1_0.4	0.27	0.40	0.25	0.10	20.00	0.00	0.10	0.25

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Fada Extension	decided	Thermal	Fada Extension _6.6	9.00	11.00	7.50	4.65	20.00	-2.47	4.65	6.75
Kossodo	decided	Thermal	N/A	58.82	11.00	50.00	30.99	20.00	-16.43	30.99	50.00
Samendeni	decided	Hydro	N/A	3.25	N/A	2.76	1.71	20.00	-0.91	1.71	2.76

Côte d'Ivoire

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
AGGREKO 1 CI	existing	Thermal	Aggreko 1 CI_0.4	43.75	0.40	35.00	26.25	16.00	-26.26	26.25	35.00
AGGREKO 2 CI	existing	Thermal	Aggreko 1 CI_0.4	37.50	0.40	30.00	22.50	16.00	-22.50	22.50	30.00
AGGREKO 3 CI	existing	Thermal	Aggreko 3 CI_0.4	43.75	0.40	35.00	26.25	16.00	-26.25	26.25	35.00
AGGREKO 4 CI	existing	Thermal	Aggreko 4 CI_0.4	62.50	0.40	50.00	37.50	18.00	-37.50	37.50	50.00
AGGREKO 5 CI	existing	Thermal	Aggreko 5 CI_0.4	62.50	0.40	50.00	37.50	18.00	-37.50	37.50	50.00
Azito Tag 1	existing	Thermal	Azito Tag 1_15.8	210.00	15.75	152.00	144.90	20.00	-80.00	120.00	148.00
Azito Tag 2	existing	Thermal	Azito Tag 2_15.8	210.00	15.75	152.00	144.90	20.00	-80.00	120.00	148.00
Azito TAV	existing	Thermal	Azito TAV_15.8	210.00	15.75	168.00	126.00	20.00	-80.00	120.00	168.00
Ciprel Tag 10	existing	Thermal	Ciprel Tag 1_11	143.53	11.00	122.00	75.61	20.00	-40.10	75.61	117.00
Ciprel Tag 5	existing	Thermal	Ciprel Tag 5_11	43.10	11.00	34.50	25.80	19.90	-14.85	23.00	33.00
Ciprel Tag 6	existing	Thermal	Ciprel Tag 6_11	43.10	11.00	34.50	25.80	19.90	-14.85	23.00	33.00
Ciprel Tag 7	existing	Thermal	Ciprel Tag 7_11	43.10	11.00	34.50	25.80	19.90	-14.85	23.00	33.00
Ciprel Tag 8	existing	Thermal	Ciprel Tag 8_11	130.59	11.00	111.00	68.79	20.00	-36.48	68.79	111.00
Ciprel Tag 9	existing	Thermal	Ciprel Tag 9_11	130.59	11.00	111.00	68.79	20.00	-36.48	68.79	111.00
Ciprel TAV	existing	Thermal	Ciprel TAV_15	130.59	15.00	111.00	68.79	20.00	-36.48	68.79	111.00
Vridi1 Tag 1	existing	Thermal	Vridi1 Tag 1_11	26.50	11.00	21.20	11.55	18.80	-9.00	17.00	21.20
Vridi1 Tag 2	existing	Thermal	Vridi1 Tag 1_11	26.50	11.00	21.20	11.55	18.80	-9.00	17.00	21.20
Vridi1 Tag 3	existing	Thermal	Vridi1 Tag 3_11	26.50	11.00	21.20	11.55	18.80	-9.00	17.00	21.20
Vridi1 Tag 4	existing	Thermal	Vridi1 Tag 3_11	26.50	11.00	21.20	11.55	18.80	-9.00	17.00	21.20
Ayame1 G1	existing	Hydro	Ayame1 G1_5.5	12.00	5.50	10.56	5.69	22.00	0.00	0.00	9.63
Ayame1 G2	existing	Hydro	Ayame1 G2_5.5	12.00	5.50	10.56	5.69	22.00	0.00	0.00	9.63
Ayame2 G1	existing	Hydro	Ayame2 G1_5.5	19.00	5.50	15.20	11.40	22.50	0.00	0.00	15.50

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Ayame2 G2	existing	Hydro	Ayame2 G2_5.5	19.00	5.50	15.20	11.40	22.50	0.00	0.00	15.50
Buyo G1	existing	Hydro	Buyo G1_10.5	61.00	10.50	55.00	26.58	20.50	-31.00	30.00	55.00
Buyo G2	existing	Hydro	Buyo G2_10.5	61.00	10.50	55.00	26.58	20.50	-31.00	30.00	55.00
Buyo G3	existing	Hydro	Buyo G3_10.5	61.00	10.50	55.00	26.58	20.50	-31.00	30.00	55.00
Faye G1	existing	Hydro	Faye G1_5.5	2.75	5.50	2.50	1.14	22.00	-0.25	1.14	2.50
Faye G2	existing	Hydro	Faye G1_5.5	2.75	5.50	2.50	1.14	22.00	-0.25	1.14	2.50
Kossou G1	existing	Hydro	Kossou G1_17	61.60	17.00	58.50	19.20	23.10	-17.00	23.00	58.50
Kossou G2	existing	Hydro	Kossou G2_17	61.60	17.00	58.50	19.20	23.10	-17.00	23.00	58.50
Kossou G3	existing	Hydro	Kossou G3_17	61.60	17.00	58.50	19.20	23.10	-17.00	23.00	58.50
Soubre G1	existing	Hydro	Soubre G1_10.5	105.88	10.50	90.00	55.77	19.53	-55.77	55.77	90.00
Soubre G2	existing	Hydro	Soubre G2_10.5	105.88	10.50	90.00	55.77	19.53	-55.77	55.77	90.00
Soubre G3	existing	Hydro	Soubre G3_10.5	105.88	10.50	90.00	55.77	19.53	-55.77	55.77	90.00
Taabo G1	existing	Hydro	Taabo G1_13.8	78.00	13.80	70.20	34.00	26.70	-20.00	25.00	70.20
Taabo G2	existing	Hydro	Taabo G2_13.8	78.00	13.80	70.20	34.00	26.70	-20.00	0.00	70.20
Taabo G3	existing	Hydro	Taabo G3_13.8	78.00	13.80	70.20	34.00	26.70	-20.00	25.00	70.20
Azito 4 G1	decided	Thermal	Azito 4 G1_15.8	106.00	15.75	90.00	56.00	20.00	-29.60	56.00	90.00
Azito 4 G2	decided	Thermal	Azito 4 G2_15.8	106.00	15.75	90.00	56.00	20.00	-26.90	56.00	90.00
Azito 4 TAV	decided	Thermal	Azito 4 TAV_15.8	125.00	15.75	100.00	75.00	20.00	-32.90	75.00	100.00
Ciprel V TAG 1	decided	Thermal	Ciprel V TAG 1_11	162.50	11.00	130.00	97.50	19.00	-42.73	80.57	120.00
Ciprel V TAG 2	decided	Thermal	Ciprel V TAG 1_11	162.50	11.00	130.00	97.50	19.00	-42.73	80.57	120.00
Ciprel V TAV	decided	Thermal	Ciprel V TAV_11	162.50	11.00	130.00	97.50	19.00	-42.73	80.57	110.00
Gribopopoli G1	decided	Hydro	Gribopopoli G1_10.5	65.80	10.50	56.00	34.71	20.50	-18.40	34.71	51.00
Gribopopoli G2	decided	Hydro	Gribopopoli G2_10.5	65.80	10.50	56.00	34.71	20.50	-18.40	34.71	51.00
Korhogo	decided	PV	N/A	21.05	N/A	20.00	6.57	100.00	-6.57	6.57	20.00
Poro Power	decided	PV	N/A	52.63	N/A	50.00	16.43	100.00	-16.43	16.43	50.00

Final version

Gambia

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Brikama I G1	existing	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Brikama I G2	existing	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Brikama I G3	existing	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Brikama I G4	existing	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Brikama I G5	existing	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Brikama I G6	existing	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Brikama II Wartsila	existing	Thermal	N/A	10.59	N/A	9.00	5.58	20.00	-2.96	5.58	0.00
Kotu G1	existing	Thermal	N/A	3.53	N/A	3.00	1.86	20.00	-0.99	1.86	3.00
Kotu G2	existing	Thermal	N/A	3.53	N/A	3.00	1.86	20.00	-0.99	1.86	0.00
Kotu G3	existing	Thermal	N/A	4.00	N/A	3.40	2.11	20.00	-1.12	2.11	5.50
Kotu G4	existing	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Kotu G6	existing	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Kotu G7	existing	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Kotu G8	existing	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Kotu G9	existing	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Brikama I G6 Rehabilitation	decided	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Brikama II Wartsila Rehabilitation	decided	Thermal	N/A	9.41	N/A	8.00	4.96	20.00	-2.63	4.96	8.00
Brikama III G1	decided	Thermal	N/A	11.76	N/A	10.00	6.20	20.00	-3.29	6.20	10.00
Brikama III G2	decided	Thermal	N/A	11.76	N/A	10.00	6.20	20.00	-3.29	6.20	10.00
Kotu Expansion G1	decided	Thermal	N/A	7.53	N/A	6.40	3.97	20.00	-2.10	3.97	5.50
Brikama Solar	decided	PV	N/A	10.53	N/A	10.00	3.29	100.00	-3.29	3.29	10.00

Final version

Ghana

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
AKSA	existing	Thermal	AKSA G1_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G1_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G1_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G1_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G2_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G2_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G2_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G2_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G3_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G3_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G3_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G3_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G4_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G4_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G4_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA G4_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AKSA	existing	Thermal	AKSA_13.8	22.62	15.00	18.10	13.00	23.50	-6.00	13.00	18.10
AMERI	existing	Thermal	AMERI_13.8	31.25	13.80	25.00	15.50	14.80	-12.11	15.50	23.00
AMERI	existing	Thermal	AMERI_13.8	31.25	13.80	25.00	15.50	14.80	-12.11	15.50	23.00
AMERI	existing	Thermal	AMERI_13.8	31.25	13.80	25.00	15.50	14.80	-12.11	15.50	23.00
AMERI	existing	Thermal	AMERI_13.8	31.25	13.80	25.00	15.50	14.80	-12.11	15.50	23.00
AMERI	existing	Thermal	AMERI_13.8	31.25	13.80	25.00	15.50	14.80	-12.11	15.50	23.00
AMERI	existing	Thermal	AMERI_13.8	31.25	13.80	25.00	15.50	14.80	-12.11	15.50	23.00
AMERI	existing	Thermal	AMERI_13.8	31.25	13.80	25.00	15.50	14.80	-12.11	15.50	23.00
AMERI	existing	Thermal	AMERI_13.8	31.25	13.80	25.00	15.50	14.80	-12.11	15.50	23.00
AMERI	existing	Thermal	AMERI_13.8	31.25	13.80	25.00	15.50	14.80	-12.11	15.50	23.00
AMERI	existing	Thermal	AMERI_13.8	31.25	13.80	25.00	15.50	14.80	-12.11	15.50	23.00
CENIT	existing	Thermal	CENIT_13.8	141.75	14.40	126.00	65.00	17.90	-50.00	65.00	115.00
Karpower ship I	existing	Thermal	Karpower ship I -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Karpower ship I	existing	Thermal	Karpower ship I -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -3_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -3_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -3_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -3_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -3_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -3_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -4_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -4_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -4_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -4_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -4_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship I	existing	Thermal	Karpower ship I -4_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship II	existing	Thermal	Karpower ship II -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship II	existing	Thermal	Karpower ship II -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship II	existing	Thermal	Karpower ship II -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship II	existing	Thermal	Karpower ship II -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship II	existing	Thermal	Karpower ship II -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship II	existing	Thermal	Karpower ship II -1_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship II	existing	Thermal	Karpower ship II -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship II	existing	Thermal	Karpower ship II -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship II	existing	Thermal	Karpower ship II -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship II	existing	Thermal	Karpower ship II -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Karpower ship II	existing	Thermal	Karpower ship II -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Karpower ship II	existing	Thermal	Karpower ship II -2_13.8	23.00	13.80	18.30	13.70	14.80	-6.00	9.00	18.30
Kpone TPP	existing	Thermal	Kpone TPP1_13.8	130.00	13.80	110.00	68.00	16.40	-53.00	68.00	100.00
Kpone TPP	existing	Thermal	Kpone TPP2_13.8	130.00	13.80	110.00	68.00	16.40	-53.00	68.00	100.00
SuNo Asogli 1	existing	Thermal	SuNo Asogli 1-1_13.8	36.30	13.80	29.00	21.75	14.80	-14.00	21.75	29.00
SuNo Asogli 1	existing	Thermal	SuNo Asogli 1-2_13.8	36.30	13.80	29.00	21.75	14.80	-14.00	21.75	29.00
SuNo Asogli 1	existing	Thermal	SuNo Asogli 1-3_13.8	36.30	13.80	29.00	21.75	14.80	-14.00	21.75	29.00
SuNo Asogli 1	existing	Thermal	SuNo Asogli 1-4_13.8	36.30	13.80	29.00	21.75	14.80	-14.00	21.75	29.00
SuNo Asogli 1	existing	Thermal	SuNo Asogli 1-5_13.8	36.30	13.80	29.00	21.75	14.80	-14.00	21.75	29.00
SuNo Asogli 1	existing	Thermal	SuNo Asogli 1-6_13.8	36.30	13.80	29.00	21.75	14.80	-14.00	21.75	29.00
SuNo Asogli 2	existing	Thermal	SuNo Asogli 2 G1_13.8	150.00	13.80	120.00	85.00	17.90	-50.00	85.00	120.00
SuNo Asogli 2	existing	Thermal	SuNo Asogli 2 G2_13.8	150.00	13.80	120.00	85.00	17.90	-50.00	85.00	120.00
SuNo Asogli 2	existing	Thermal	SuNo Asogli 2 G3_13.8	150.00	13.80	120.00	85.00	17.90	-50.00	85.00	120.00
TAPCo	existing	Thermal	TAPCo 1_13.8	137.50	13.80	110.00	82.50	21.40	-40.00	68.00	110.00
TAPCo	existing	Thermal	TAPCo 2_13.8	137.50	13.80	110.00	82.50	21.40	-40.00	68.00	110.00
TAPCo	existing	Thermal	TAPCo 3_13.8	137.50	13.80	110.00	82.50	22.00	-40.00	68.00	110.00
TICo	existing	Thermal	TICo 1_13.8	137.50	13.80	110.00	82.50	21.40	-40.00	68.00	110.00
TICo	existing	Thermal	TICo 2_13.8	137.50	13.80	110.00	82.50	21.40	-40.00	68.00	110.00
TICo	existing	Thermal	TICo_13.8	137.50	13.80	120.00	82.50	22.00	-40.00	68.00	110.00
TT1PP	existing	Thermal	TT1PP_13.8	141.75	14.40	126.00	65.00	17.90	-50.00	65.00	100.00
TT2PP	existing	Thermal	TT1PP Generation_161	15.18	11.00	12.90	7.99	17.10	-4.24	7.99	11.70
TT2PP	existing	Thermal	TT1PP Generation_161	15.18	11.00	12.90	7.99	17.10	-4.24	7.99	11.70
TT2PP	existing	Thermal	TT1PP Generation_161	9.29	11.00	7.90	4.90	17.10	-2.60	4.90	7.20
TT2PP	existing	Thermal	TT1PP Generation_161	9.29	11.00	7.90	4.90	17.10	-2.60	4.90	7.20
TT2PP	existing	Thermal	TT1PP Generation_161	9.29	11.00	7.90	4.90	17.10	-2.60	4.90	7.20
Akosombo	existing	Hydro	Akosombo 1_14.4	211.18	14.40	179.50	111.24	21.00	-59.00	111.24	150.00
Akosombo	existing	Hydro	Akosombo 2_14.4	211.18	14.40	179.50	111.24	21.00	-59.00	111.24	150.00
Akosombo	existing	Hydro	Akosombo 3_14.4	211.18	14.40	179.50	111.24	21.00	-59.00	111.24	150.00
Akosombo	existing	Hydro	Akosombo 4_14.4	211.18	14.40	179.50	111.24	21.00	-59.00	111.24	150.00
Akosombo	existing	Hydro	Akosombo 5_14.4	211.18	14.40	179.50	111.24	21.00	-59.00	111.24	150.00
Akosombo	existing	Hydro	Akosombo 6_14.4	211.18	14.40	179.50	111.24	21.00	-59.00	111.24	150.00
Bui	existing	Hydro	Bui 1_14.4	147.80	14.40	133.00	64.40	27.00	-35.00	64.40	114.00
Bui	existing	Hydro	Bui 2_14.4	147.80	14.40	133.00	64.40	27.00	-35.00	64.40	114.00

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Bui	existing	Hydro	Bui 3_14.4	147.80	14.40	133.00	64.40	27.00	-35.00	64.40	114.00
Kpong	existing	Hydro	Kpong 1_13.8	51.00	13.80	45.90	22.00	27.00	-15.00	22.00	36.00
Kpong	existing	Hydro	Kpong 2_13.8	51.00	13.80	45.90	22.00	27.00	-15.00	22.00	36.00
Kpong	existing	Hydro	Kpong 3_13.8	51.00	13.80	45.90	22.00	27.00	-15.00	22.00	36.00
Kpong	existing	Hydro	Kpong 4_13.8	51.00	13.80	45.90	22.00	27.00	-22.00	22.00	36.00
Winneba Solar	existing	PV	Winneba A_34.5	21.05	34.50	20.00	6.57	100.00	-6.57	6.57	20.00
Navrongo Solar	existing	PV	Navrongo_34.5	2.63	34.50	2.5	0.80	100.00	-0.80	0.80	2.5
CEN power	decided	Thermal	CEN power GT1_14.4	133.00	13.80	120.00	58.00	21.40	-40.00	58.00	113.00
CEN power	decided	Thermal	CEN power GT2_14.4	133.00	13.80	120.00	58.00	21.40	-40.00	58.00	113.00
CEN power	decided	Thermal	CEN power ST1_14.4	133.00	13.80	120.00	58.00	21.40	-40.00	58.00	113.00
Kpone ST	decided	Thermal	Kpone ST_13.8	130.00	13.80	120.00	68.00	16.40	-53.00	68.00	100.00

Guinea

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
G-Energie G1	exist.	Thermal	Kaloum_20 kV	25.0	11.50	21.25	13.17	17.90	-7.90	15.81	18.50
G-Energie G2	exist.	Thermal	Kaloum_20 kV	25.0	11.50	21.25	13.17	17.90	-7.90	15.81	18.50
Kaloum 1 G1	exist.	Thermal	Kaloum_20 kV	5.076	11.00	4.06	3.04	12.90	-1.83	3.65	3.7
Kaloum 1 G2	exist.	Thermal	Kaloum_20 kV	5.076	11.00	4.06	3.04	12.90	-1.83	3.65	3.7
Kaloum 1 G3	exist.	Thermal	Kaloum_20 kV	5.076	11.00	4.06	3.04	12.90	-1.83	3.65	3.7
Kaloum 1 G4	exist.	Thermal	Kaloum_20 kV	5.076	11.00	4.06	3.04	12.90	-1.83	3.65	3.7
Kaloum 1 G5	exist.	Thermal	Kaloum_20 kV	5.076	11.00	4.06	3.04	12.90	-1.83	3.65	3.7
Kaloum 1 G6	exist.	Thermal	Kaloum_20 kV	5.076	11.00	4.06	3.04	12.90	-1.83	3.65	3.7
Kaloum 2 G1	exist.	Thermal	Kaloum_20 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	7.5
Kaloum 2 G2	exist.	Thermal	Kaloum_20 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	7.5
Kaloum 2 G3	exist.	Thermal	Kaloum_20 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	7.5

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Kaloum 3 G1	exist.	Thermal	Kaloum_20 kV	14.0	6.30	11.2	8.4	28.70	-5.04	10.08	10.00
Kaloum 3 G2	exist.	Thermal	Kaloum_20 kV	14.0	6.30	11.2	8.4	28.70	-5.04	10.08	10.00
Kaloum 3 G3	exist.	Thermal	Kaloum_20 kV	14.0	6.30	11.2	8.4	28.70	-5.04	10.08	10.00
Kaloum 3 G4	exist.	Thermal	Kaloum_20 kV	14.0	6.30	11.2	8.4	28.70	-5.04	10.08	10.00
Kaloum 5 G1	exist.	Thermal	Kaloum_20 kV	13.75	11.00	11.0	8.25	25.90	-4.95	9.9	10.00
Kaloum 5 G2	exist.	Thermal	Kaloum_20 kV	13.75	11.00	11.0	8.25	25.90	-4.95	9.9	10.00
Kaloum 5 G3	exist.	Thermal	Kaloum_20 kV	13.75	11.00	11.0	8.25	25.90	-4.95	9.9	10.00
Kipé G1	exist.	Thermal	Kipé_20 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
Kipé G2	exist.	Thermal	Kipé_20 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
Kipé G3	exist.	Thermal	Kipé_20 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
Kipé G4	exist.	Thermal	Kipé_20 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
Kipé G5	exist.	Thermal	Kipé_20 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
Kipé G6	exist.	Thermal	Kipé_20 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
ENDEAVOR	decidé	Thermal	ENDEAVOR_110 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
ENDEAVOR	decidé	Thermal	ENDEAVOR_110 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
ENDEAVOR	decidé	Thermal	ENDEAVOR_110 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
ENDEAVOR	decidé	Thermal	ENDEAVOR_110 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
ENDEAVOR	decidé	Thermal	ENDEAVOR_110 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
ENDEAVOR	decidé	Thermal	ENDEAVOR_110 kV	10.935	11.00	8.74	6.56	15.30	-3.94	7.87	6.50
Baneah G1	exist.	Hydro	Baneah _15 kV	2.78	3.15	2.50	1.21	18.50	-0.73	1.45	1.8
Baneah G2	exist.	Hydro	Baneah _15 kV	2.78	3.15	2.50	1.21	18.50	-0.73	1.45	1.8
Donkea G1	exist.	Hydro	Donkea _110 kV	8.50	6.30	7.50	3.71	18.00	-2.22	4.45	7.00
Donkea G2	exist.	Hydro	Donkea _110 kV	8.50	6.30	7.50	3.71	18.00	-2.22	4.45	7.00
Garafiri G1	exist.	Hydro	Garafiri _110 kV	31.50	5.65	25.00	16.59	21.10	-9.96	19.91	25.00
Garafiri G2	exist.	Hydro	Garafiri _110 kV	31.50	5.65	25.00	16.59	21.10	-9.96	19.91	25.00

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Garafiri G3	exist.	Hydro	Garafiri _110 kV	31.50	5.65	25.00	16.59	21.10	-9.96	19.91	25.00
Grandes Chutes G1	exist.	Hydro	Grandes Chutes _60 kV	6.30	3.30	5.04	3.78	25.00	-2.27	4.54	4.5
Grandes Chutes G2	exist.	Hydro	Grandes Chutes _60 kV	6.30	3.30	5.04	3.78	25.00	-2.27	4.54	4.5
Grandes Chutes G3	exist.	Hydro	Grandes Chutes _60 kV	11.0	5.50	8.80	6.6	29.40	-3.96	7.92	8.0
Grandes Chutes G4	exist.	Hydro	Grandes Chutes _60 kV	11.0	5.50	8.80	6.6	29.40	-3.96	7.92	8.0
Kaleta G1	exist.	Hydro	Kaleta _225 kV	92.00	10.50	78.2	48.46	19.00	-29.08	58.16	78.2
Kaleta G2	exist.	Hydro	Kaleta _225 kV	92.00	10.50	78.2	48.46	19.00	-29.08	58.16	78.2
Kaleta G3	exist.	Hydro	Kaleta _225 kV	92.00	10.50	78.2	48.46	19.00	-29.08	58.16	78.2
Kinkon G1	exist.	Hydro	Kinkon _30 kV	1.00	6.30	0.80	0.6	14.18	-0.36	0.72	0.80
Kinkon G2	exist.	Hydro	Kinkon _30 kV	1.00	6.30	0.80	0.6	14.18	-0.36	0.72	0.80
Kinkon G3	exist.	Hydro	Kinkon _30 kV	1.00	6.30	0.80	0.6	14.18	-0.36	0.72	0.80
Kinkon G4	exist.	Hydro	Kinkon _30 kV	1.00	6.30	0.80	0.6	14.18	-0.36	0.72	0.80
Amaria G1	decid.	Hydro	Amaria _225 kV	88.24	13.8	75.00	46.48	19.00	-27.89	55.78	75.00
Amaria G2	decid.	Hydro	Amaria _225 kV	88.24	13.8	75.00	46.48	19.00	-27.89	55.78	75.00
Amaria G3	decid.	Hydro	Amaria _225 kV	88.24	13.8	75.00	46.48	19.00	-27.89	55.78	75.00
Amaria G4	decid.	Hydro	Amaria _225 kV	88.24	13.8	75.00	46.48	19.00	-27.89	55.78	75.00
Souapiti G1	decid.	Hydro	Souapiti _225 kV	140.00	13.80	112.50	73.75	20.00	-36.98	83.30	112.50
Souapiti G2	decid.	Hydro	Souapiti _225 kV	140.00	13.80	112.50	73.75	20.00	-36.98	83.30	112.50
Souapiti G3	decid.	Hydro	Souapiti _225 kV	140.00	13.80	112.50	73.75	20.00	-36.98	83.30	112.50
Souapiti G4	decid.	Hydro	Souapiti _225 kV	140.00	13.80	112.50	73.75	20.00	-36.98	83.30	112.50
Sougéta	decid.	RES	Souguéta_30 kV	31.58	N/A	30.00	9.86	100.00	-9.86	9.86	2.50
Khoummaguély	decid.	RES	Khoummaguély_110 kV	42.11	N/A	40.00	13.15	100.00	-13.15	13.15	20.00

Final version

Guinea Bissau

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Aggreko Rental GB	existing	Thermal	N/A	15.00	N/A	15.00	9.30	20.00	-4.93	9.30	15.00
BADEA Diesel	decided	Thermal	N/A	23.53	N/A	20.00	12.39	20.00	-6.57	12.39	20.00
Bor BOAD	decided	Thermal	N/A	17.65	N/A	15.00	9.30	20.00	-4.93	9.30	15.00
BOAD Solar GB	decided	PV	N/A	23.53	N/A	20.00	6.57	100.00	-6.57	6.57	20.00

Liberia

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Bushrod	existing	Thermal	Monrovia_33	17.65	33.00	22.60	2.50	20.00	-2.50	2.50	4.00
Bushrod II	decided	Thermal	Monrovia_33	56.47	33.00	48.00	29.75	20.00	-15.78	29.75	48.00
Mont Coffee G1	decided	Hydro	Mont Coffee G1_10.5	25.00	10.50	20.00	15.00	21.00	-2.00	15.00	16.50
Mont Coffee G2	decided	Hydro	Mont Coffee G2_10.5	25.00	10.50	20.00	15.00	21.00	-2.00	15.00	16.50
Mont Coffee G3	decided	Hydro	Mont Coffee G3_10.5	25.00	10.50	20.00	15.00	21.00	-2.00	15.00	16.50
Mont Coffee G4	decided	Hydro	Mont Coffee G4_10.5	25.00	10.50	20.00	15.00	21.00	-2.00	15.00	16.50

Mali

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
AGGREKO Balingue	existing	Thermal	AGGREKO Balingue_11	37.50	11.00	30.00	22.50	20.00	-9.86	22.50	30
AGGREKO Kati	existing	Thermal	AGGREKO Kati_11	37.50	11.00	30.00	22.50	20.00	-9.86	22.50	22
Aggreko Dakar	existing	Thermal	APR Dakar_30	47.00	30.00	40.00	24.68	20.00	-13.15	24.68	40

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Balingue BID Extension G5	existing	Thermal	Balingue BID G1_15	14.38	15.00	11.50	8.80	20.00	-3.78	8.80	8.1
Balingue BID Extension G6	existing	Thermal	Balingue BID G1_15	14.38	15.00	11.50	8.80	20.00	-3.78	8.80	8.1
Balingue BID G1	existing	Thermal	Balingue BID G1_15	15.00	15.00	12.15	8.80	20.00	-3.99	8.80	8.45
Balingue BID G2	existing	Thermal	Balingue BID G1_15	15.00	15.00	12.15	8.80	20.00	-3.99	8.80	8.45
Balingue BID G3	existing	Thermal	Balingue BID G1_15	15.00	15.00	12.15	8.80	20.00	-3.99	8.80	8.45
Balingue BID G4	existing	Thermal	Balingue BID G1_15	15.00	15.00	12.15	8.80	20.00	-3.99	8.80	8.45
Balingue G1	existing	Thermal	Balingue BID G1_15	17.65	15.00	15.00	9.30	15.70	-4.93	9.30	6.46
Balingue G2	existing	Thermal	Balingue BID G1_15	17.65	15.00	15.00	9.30	15.70	-4.93	9.30	6.46
Balingue G3	existing	Thermal	Balingue BID G1_15	17.65	15.00	15.00	9.30	15.70	-4.93	9.30	6.46
Balingue G4	existing	Thermal	Balingue BID G1_15	17.65	15.00	15.00	9.30	15.70	-4.93	9.30	4.94
Dar Salam TAC	existing	Thermal	Dar Salam TAC_11	26.96	11.00	24.60	11.03	16.70	-8.09	11.03	24.6
Aggreko Darsalam	existing	Thermal	GPS Darsalam_11	13.75	11.00	11.00	8.25	20.00	-3.62	8.25	11
SES Koutiala	existing	Thermal	SES Koutiala_11	12.50	11.00	10.00	7.50	20.00	-3.29	7.50	10
SES Sikasso	existing	Thermal	SES Sikasso_11	12.50	11.00	10.00	7.50	20.00	-3.29	7.50	10
Felou G1	existing	Hydro	Felou G1_11	25.00	11.00	21.50	15.00	27.00	-7.07	15.00	20
Felou G2	existing	Hydro	Felou G2_11	25.00	11.00	21.50	15.00	27.00	-7.07	15.00	20
Felou G3	existing	Hydro	Felou G3_11	25.00	11.00	21.50	15.00	27.00	-7.07	15.00	20
Manantali G1	existing	Hydro	Manantali G1_11	47.06	11.00	40.00	24.79	20.00	-13.15	24.79	40
Manantali G2	existing	Hydro	Manantali G2_11	47.06	11.00	40.00	24.79	20.00	-13.15	24.79	40
Manantali G3	existing	Hydro	Manantali G3_11	47.06	11.00	40.00	24.79	20.00	-13.15	24.79	40
Manantali G4	existing	Hydro	Manantali G4_11	47.06	11.00	40.00	24.79	20.00	-13.15	24.79	40
Manantali G5	existing	Hydro	Manantali G5_11	47.06	11.00	40.00	24.79	20.00	-13.15	24.79	40
Selingue G1	existing	Hydro	Selingue G1_8.7	13.60	8.66	12.15	6.84	27.00	-3.99	6.84	11.75
Selingue G2	existing	Hydro	Selingue G1_8.7	13.60	8.66	12.15	6.84	27.00	-3.99	6.84	11.75
Selingue G3	existing	Hydro	Selingue G1_8.7	13.60	8.66	12.15	6.84	27.00	-3.99	6.84	11.75

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Selingue G4	existing	Hydro	Selingue G1_8.7	13.60	8.66	12.15	6.84	27.00	-3.99	6.84	11.75
Sotuba 1 G1	existing	Hydro	Sotuba 1 G1_2	3.40	2.00	2.85	3.50	33.00	-0.94	3.50	2.85
Sotuba 1 G2	existing	Hydro	Sotuba 1 G1_2	3.40	2.00	2.85	3.50	33.00	-0.57	3.50	2.85
Albatros	decided	Thermal	N/A	115.00	11.00	92.00	69.00	20.00	-30.24	69.00	92.00
Kenie G1	decided	Hydro	Kenie G1_15.5	16.47	15.50	14.00	8.63	27.00	-4.60	8.63	14.00
Kenie G2	decided	Hydro	Kenie G2_15.5	16.47	15.50	14.00	8.63	27.00	-4.60	8.63	14.00
Kenie G3	decided	Hydro	Kenie G3_15.5	16.47	15.50	14.00	8.63	27.00	-4.60	8.63	14.00
Segou - SCATEC Solar	decided	PV	SCATEC Solar_8.7	34.70	8.66	33.00	10.72	100.00	-10.80	10.72	33.00
Segou - Solar Kita	decided	PV	Kita_225	52.60	11.00	50.00	16.33	100.00	-16.00	16.33	50.00

Niger

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Agadez	exist.	Thermal	N/A	2.22	N/A	1.89	1.17	14.80	-0.62	1.17	1.40
Aggreko 1A	exist.	Thermal	Aggreko 1A_20	2.82	0.40	2.40	1.80	14.80	-0.79	1.80	2.40
Aggreko 1A	exist.	Thermal	Aggreko 1A_20	3.53	0.40	3.00	0.96	14.80	-0.99	0.96	3.00
Aggreko 1A	exist.	Thermal	Aggreko 1A_20	2.82	0.40	2.40	1.80	14.80	-0.79	1.80	2.40
Aggreko 1A	exist.	Thermal	Aggreko 1A_20	3.53	0.40	3.00	0.96	14.80	-0.99	0.96	3.00
Aggreko 1B	exist.	Thermal	Aggreko 1A_20	2.82	0.40	2.40	1.80	14.80	-0.79	1.80	2.40
Aggreko 1B	exist.	Thermal	Aggreko 1A_20	3.53	0.40	3.00	0.96	14.80	-0.99	0.96	3.00
Aggreko 1B	exist.	Thermal	Aggreko 1A_20	2.82	0.40	2.40	1.80	14.80	-0.79	1.80	2.40
Aggreko 1B	exist.	Thermal	Aggreko 1A_20	3.53	0.40	3.00	0.96	14.80	-0.99	0.96	3.00
Aggreko 2	exist.	Thermal	Niamey 2D-2_20	3.53	0.40	3.00	0.96	14.80	-0.99	0.96	3.00
Aggreko 2	exist.	Thermal	Niamey 2D-2_20	2.82	0.40	2.40	1.80	14.80	-0.79	1.80	2.40

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Aggreko 2	exist.	Thermal	Niamey 2D-2_20	3.53	0.40	3.00	0.96	14.80	-0.99	0.96	3.00
Aggreko 2	exist.	Thermal	Niamey 2D-2_20	2.82	0.40	2.40	1.80	14.80	-0.79	1.80	2.40
Diffa	exist.	Thermal	N/A	8.88	N/A	7.55	4.68	14.80	-2.48	4.68	6.66
Gaya	exist.	Thermal	N/A	0.34	N/A	0.29	0.18	14.80	-0.10	0.18	0.20
Gaya	exist.	Thermal	N/A	0.59	N/A	0.50	0.31	14.80	-0.17	0.31	0.42
Gorou Banda	exist.	Thermal	Goroubanda_11	23.53	11.00	20.00	15.00	14.80	-6.57	15.00	20.00
Gorou Banda	exist.	Thermal	Goroubanda_11	23.53	11.00	20.00	15.00	14.80	-6.57	15.00	20.00
Gorou Banda	exist.	Thermal	Goroubanda_11	23.53	11.00	20.00	15.00	14.80	-6.57	15.00	20.00
Gorou Banda	exist.	Thermal	Goroubanda_11	23.53	11.00	20.00	15.00	14.80	-6.57	15.00	20.00
Goudel	exist.	Thermal	Goudel G1_20	18.12	11.00	15.40	9.54	14.80	-5.06	9.54	12.60
Goudel	exist.	Thermal	Goudel G2_20	11.76	5.65	10.00	6.20	14.80	-3.29	6.20	9.00
Malbaza	exist.	Thermal	Malbaza_20	1.51	0.40	1.28	0.79	14.80	-0.42	0.79	0.75
Malbaza	exist.	Thermal	Malbaza_20	1.29	0.40	1.10	0.68	14.80	-0.36	0.68	0.80
Malbaza	exist.	Thermal	Malbaza_20	7.53	0.40	6.40	3.97	14.80	-2.10	3.97	6.00
Maradi	exist.	Thermal	Maradi_20	0.86	0.40	0.73	0.45	14.80	-0.24	0.45	0.70
Maradi	exist.	Thermal	Maradi_20	1.78	5.50	1.51	0.94	14.80	-0.50	0.94	1.20
Maradi	exist.	Thermal	Maradi_20	4.94	5.50	4.20	2.60	14.80	-1.38	2.60	3.40
Niamey 2	exist.	Thermal	Niamey 2D-2_20	13.53	10.50	11.50	7.13	22.00	-3.78	7.13	9.00
Niamey 2	exist.	Thermal	Niamey 2D-2_20	14.12	10.50	12.00	7.44	14.80	-3.94	7.44	9.00
Sonichar	exist.	Thermal	N/A	22.12	N/A	18.80	11.65	14.80	-6.18	11.65	18.80
Sonichar	exist.	Thermal	N/A	22.12	N/A	18.80	11.65	14.80	-6.18	11.65	18.80
Tahoua	exist.	Thermal	N/A	3.00	N/A	2.55	1.58	14.80	-0.84	1.58	1.50
Tahoua	exist.	Thermal	N/A	1.19	N/A	1.01	0.62	14.80	-0.33	0.62	0.80
Zinder	exist.	Thermal	Zinder_20	3.76	5.50	3.19	1.98	22.00	-1.05	1.98	2.60
Zinder	exist.	Thermal	Zinder_20	4.71	5.50	4.00	2.48	22.00	-1.31	2.48	3.20

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Gorou Banda 2	decid.	Thermal	Goroubanda_11	23.53	11.00	20.00	15.00	14.80	-6.57	15.00	20.00
Salkadamna	decid.	Thermal	Salkadamna_11	58.82	11.00	50.00	30.99	14.80	-16.43	30.99	50.00
Salkadamna	decid.	Thermal	Salkadamna G2_11	58.82	11.00	50.00	30.99	14.80	-16.43	30.99	50.00
Salkadamna	decid.	Thermal	Salkadamna G3_11	58.82	11.00	50.00	30.99	14.80	-16.43	30.99	50.00
Salkadamna	decid.	Thermal	Salkadamna G4_11	58.82	11.00	50.00	30.99	14.80	-16.43	30.99	50.00
Sonichar	decid.	Thermal	N/A	80.94	N/A	68.80	42.64	14.80	-22.61	42.64	68.80
Gorou Banda PV	decid.	PV	Goroubanda_11	21.05	11.00	20.00	6.57	100.00	-6.57	6.57	20.00

Final version

Nigeria

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
AES Ebute barge	exist.	Thermal	AES Ebute barge_10.5	38.60	10.50	31.00	23.17	20.00	-3.09	23.17	31.00
AES Ebute barge	exist.	Thermal	AES Ebute barge_10.5	38.60	10.50	31.00	23.17	20.00	-3.09	23.17	31.00
AES Ebute barge	exist.	Thermal	AES Ebute barge_10.5	38.60	10.50	31.00	23.17	20.00	-3.09	23.17	31.00
AES Ebute barge	exist.	Thermal	AES Ebute barge_10.5	39.50	10.50	31.00	23.70	20.00	-3.16	23.70	31.00
AES Ebute barge	exist.	Thermal	AES Ebute barge_10.5	39.50	10.50	31.00	23.70	20.00	-3.16	23.70	31.00
AES Ebute barge	exist.	Thermal	AES Ebute barge_10.5	39.50	10.50	31.00	23.70	20.00	-3.16	23.70	31.00
AES Ebute barge	exist.	Thermal	AES Ebute barge_10.5	40.50	10.50	31.00	27.34	20.00	-3.64	27.34	31.00
AES Ebute barge	exist.	Thermal	AES Ebute barge_10.5	40.50	10.50	31.00	27.34	20.00	-3.64	27.34	31.00
AES Ebute barge	exist.	Thermal	AES Ebute barge_10.5	40.50	10.50	31.00	27.34	20.00	-3.64	27.34	31.00
Afam IV	exist.	Thermal	Afam IV_10.5	94.00	11.50	75.00	56.25	20.00	-24.65	56.25	0.00
Afam IV	exist.	Thermal	Afam IV_10.5	94.00	11.50	75.00	56.25	20.00	-24.65	56.25	0.00
Afam IV	exist.	Thermal	Afam IV_11.5	94.00	11.50	75.00	56.25	20.00	-24.65	56.25	0.00
Afam IV	exist.	Thermal	Afam IV_11.5	94.00	11.50	75.00	56.25	20.00	-24.65	56.25	0.00
Afam IV	exist.	Thermal	Afam IV_11.5	94.00	11.50	75.00	56.25	20.00	-24.65	56.25	0.00
Afam IV	exist.	Thermal	Afam IV_11.5	94.00	11.50	75.00	56.25	20.00	-24.65	56.25	0.00
Afam V	exist.	Thermal	Afam V_15.8	162.70	11.50	138.30	85.00	20.00	-45.00	85.00	0.00
Afam V	exist.	Thermal	Afam V_15.8	162.70	11.50	138.30	85.00	20.00	-45.00	85.00	0.00
Afam VI	exist.	Thermal	N/A	176.00	11.50	166.00	90.00	20.00	-50.00	90.00	150.00
Afam VI	exist.	Thermal	N/A	176.00	11.50	166.00	90.00	20.00	-50.00	90.00	150.00
Afam VI	exist.	Thermal	N/A	176.00	11.50	166.00	90.00	20.00	-50.00	90.00	150.00
Afam VI	exist.	Thermal	N/A	270.59	11.50	230.00	142.54	20.00	-75.60	90.00	200.00
Alaogi NIPP	exist.	Thermal	Alaogi NIPP_15	141.25	15.00	120.00	60.00	20.00	-39.44	60.00	120.00
Alaogi NIPP	exist.	Thermal	Alaogi NIPP_15	141.25	15.00	120.00	60.00	20.00	-39.44	60.00	120.00

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Alaogi NIPP	exist.	Thermal	Alaogi NIPP_15	141.25	15.00	120.00	60.00	20.00	-39.44	60.00	120.00
Alaogi NIPP	exist.	Thermal	Alaogi NIPP_15	141.25	15.00	120.00	60.00	16.40	-39.44	60.00	120.00
Calabar / Odukpani NIPP	exist.	Thermal	Calabar / Odukpani NIPP_15	141.25	15.00	113.00	84.40	20.00	-56.30	84.40	113.00
Calabar / Odukpani NIPP	exist.	Thermal	Calabar / Odukpani NIPP_15	141.25	15.00	113.00	84.40	20.00	-56.30	84.40	0.00
Calabar / Odukpani NIPP	exist.	Thermal	Calabar / Odukpani NIPP_15	141.25	15.00	113.00	84.40	20.00	-56.30	84.40	0.00
Calabar / Odukpani NIPP	exist.	Thermal	Calabar / Odukpani NIPP_15	141.25	15.00	113.00	84.40	20.00	-56.30	84.40	0.00
Calabar / Odukpani NIPP	exist.	Thermal	Calabar / Odukpani NIPP_15	141.25	15.00	113.00	84.40	20.00	-56.30	84.40	0.00
Delta II	exist.	Thermal	Delta II_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta II	exist.	Thermal	Delta II_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta II	exist.	Thermal	Delta II_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta II	exist.	Thermal	Delta II_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta II	exist.	Thermal	Delta II_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta II	exist.	Thermal	Delta II_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta III	exist.	Thermal	Delta III_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta III	exist.	Thermal	Delta III_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta III	exist.	Thermal	Delta III_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta III	exist.	Thermal	Delta III_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta III	exist.	Thermal	Delta III_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta III	exist.	Thermal	Delta III_11.5	25.00	11.50	24.00	14.87	20.00	-7.89	14.87	12.26
Delta IV	exist.	Thermal	Delta IV_11.5	117.65	11.50	100.00	60.00	20.00	-30.00	60.00	60.64
Delta IV	exist.	Thermal	Delta IV_11.5	117.65	11.50	100.00	60.00	20.00	-30.00	60.00	60.64
Delta IV	exist.	Thermal	Delta IV_11.5	117.65	11.50	100.00	60.00	20.00	-30.00	60.00	60.64
Delta IV	exist.	Thermal	Delta IV_11.5	117.65	11.50	100.00	60.00	20.00	-30.00	60.00	60.64
Delta IV	exist.	Thermal	Delta IV_11.5	117.65	11.50	100.00	60.00	20.00	-30.00	60.00	60.64

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Delta IV	exist.	Thermal	Delta IV_11.5	117.65	11.50	100.00	60.00	20.00	-30.00	60.00	60.64
Egbin	exist.	Thermal	Egbin_16	246.00	16.00	220.00	106.55	20.00	-72.31	106.55	147.00
Egbin	exist.	Thermal	Egbin_16	246.00	16.00	220.00	106.55	20.00	-72.31	106.55	147.00
Egbin	exist.	Thermal	Egbin_16	246.00	16.00	220.00	106.55	20.00	-72.31	106.55	147.00
Egbin	exist.	Thermal	Egbin_16	246.00	16.00	220.00	106.55	20.00	-72.31	106.55	147.00
Egbin	exist.	Thermal	Egbin_16	246.00	16.00	220.00	106.55	20.00	-72.31	106.55	147.00
Egbin	exist.	Thermal	Egbin_16	246.00	16.00	220.00	106.55	20.00	-72.31	106.55	147.00
Gbarain - GT2 NIPP	exist.	Thermal	Gbarain - GT2 NIPP_15	141.25	15.00	113.00	84.40	20.00	-56.30	84.40	113.00
Geregu FGN1	exist.	Thermal	Geregu FGN1_15.8	174.00	10.50	138.00	85.00	20.00	-45.00	85.00	138.00
Geregu FGN1	exist.	Thermal	Geregu FGN1_15.8	174.00	10.50	138.00	85.00	20.00	-45.00	85.00	138.00
Geregu FGN1	exist.	Thermal	Geregu FGN1_15.8	174.00	10.50	138.00	85.00	20.00	-45.00	85.00	138.00
Geregu NIPP1	exist.	Thermal	Geregu NIPP1_15.8	175.00	10.50	145.00	85.00	20.00	-70.00	85.00	145.00
Geregu NIPP1	exist.	Thermal	Geregu NIPP1_15.8	175.00	10.50	145.00	85.00	20.00	-70.00	85.00	145.00
Geregu NIPP1	exist.	Thermal	Geregu NIPP1_15.8	175.00	10.50	145.00	85.00	20.00	-70.00	85.00	145.00
Ibom 1	exist.	Thermal	Ibom 1_11.5	46.00	11.50	39.00	24.00	20.00	-20.00	24.00	32.00
Ibom 1	exist.	Thermal	Ibom 1_11.5	46.00	11.50	39.00	24.00	20.00	-20.00	24.00	32.00
Ibom 1	exist.	Thermal	Ibom 1_15	141.25	15.00	113.00	60.00	20.00	-40.00	60.00	90.00
Ihovbor (Eyaen)	exist.	Thermal	Ihovbor (Eyaen)_15	141.25	15.00	150.00	60.00	20.00	-40.00	60.00	113.00
Ihovbor (Eyaen)	exist.	Thermal	Ihovbor (Eyaen)_15	141.25	15.00	150.00	60.00	20.00	-40.00	60.00	113.00
Ihovbor (Eyaen)	exist.	Thermal	Ihovbor (Eyaen)_15	141.25	15.00	150.00	60.00	20.00	-40.00	60.00	113.00
Okpai	exist.	Thermal	Okpai_15.8	176.47	11.50	150.00	92.96	20.00	-49.30	92.96	150.00
Okpai	exist.	Thermal	Okpai_15.8	176.47	11.50	150.00	92.96	20.00	-49.30	92.96	150.00
Okpai	exist.	Thermal	Okpai_15.8	176.47	11.50	150.00	92.96	20.00	-49.30	92.96	150.00
Olorunsogo 1	exist.	Thermal	Olorunsogo 1_10.5	52.30	10.50	42.10	31.40	14.80	-12.00	31.40	36.63
Olorunsogo 1	exist.	Thermal	Olorunsogo 1_10.5	52.30	10.50	42.10	31.40	14.80	-12.00	31.40	36.63

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Olorunsogo 1	exist.	Thermal	Olorunsogo 1_10.5	52.30	10.50	42.10	31.40	14.80	-12.00	31.40	36.63
Olorunsogo 1	exist.	Thermal	Olorunsogo 1_10.5	52.30	10.50	42.10	31.40	14.80	-12.00	31.40	36.63
Olorunsogo 1	exist.	Thermal	Olorunsogo 1_10.5	52.30	10.50	42.10	31.40	14.80	-12.00	31.40	36.63
Olorunsogo 1	exist.	Thermal	Olorunsogo 1_10.5	52.30	10.50	42.10	31.40	14.80	-12.00	31.40	36.63
Olorunsogo 1	exist.	Thermal	Olorunsogo 1_10.5	52.30	10.50	42.10	31.40	14.80	-12.00	31.40	36.63
Olorunsogo 1	exist.	Thermal	Olorunsogo 1_10.5	52.30	10.50	42.10	31.40	14.80	-12.00	31.40	36.63
Olorunsogo 2	exist.	Thermal	Olorunsogo 2_15	150.00	10.50	120.00	70.50	20.00	-25.00	70.50	78.88
Olorunsogo 2	exist.	Thermal	Olorunsogo 2_15	150.00	10.50	120.00	70.50	20.00	-25.00	70.50	78.88
Olorunsogo 2	exist.	Thermal	N/A	150.00	10.50	120.00	70.50	20.00	-25.00	70.50	78.88
Olorunsogo 2	exist.	Thermal	Olorunsogo 2_15	150.00	10.50	120.00	70.50	20.00	-25.00	70.50	78.88
Olorunsogo 2	exist.	Thermal	Olorunsogo 2_15	150.00	10.50	120.00	70.50	20.00	-25.00	70.50	78.88
Olorunsogo 2	exist.	Thermal	N/A	150.00	10.50	120.00	70.50	20.00	-25.00	70.50	78.88
Omoku IPP G1	exist.	Thermal	Omoku IPP G1_11.5	29.41	11.50	25.00	15.49	20.00	-8.22	15.49	25.00
Omoku IPP G2	exist.	Thermal	Omoku IPP G2_11.5	29.41	11.50	25.00	15.49	20.00	-8.22	15.49	25.00
Omoku IPP G3	exist.	Thermal	N/A	29.41	11.50	25.00	15.49	20.00	-8.22	15.49	25.00
Omoku IPP G4	exist.	Thermal	N/A	29.41	11.50	25.00	15.49	20.00	-8.22	15.49	0.00
Omoku IPP G5	exist.	Thermal	N/A	29.41	11.50	25.00	15.49	20.00	-8.22	15.49	0.00
Omoku IPP G6	exist.	Thermal	N/A	29.41	11.50	25.00	15.49	20.00	-8.22	15.49	0.00
Omotosho 1	exist.	Thermal	Omotosho 1_10.5	49.41	10.50	42.00	26.03	20.00	-13.80	26.03	42.00
Omotosho 1	exist.	Thermal	Omotosho 1_10.5	49.41	10.50	42.00	26.03	20.00	-13.80	26.03	42.00
Omotosho 1	exist.	Thermal	Omotosho 1_10.5	49.41	10.50	42.00	26.03	20.00	-13.80	26.03	42.00
Omotosho 1	exist.	Thermal	Omotosho 1_10.5	49.41	10.50	42.00	26.03	20.00	-13.80	26.03	42.00
Omotosho 1	exist.	Thermal	Omotosho 1_10.5	49.41	10.50	42.00	26.03	20.00	-13.80	26.03	42.00
Omotosho 1	exist.	Thermal	Omotosho 1_10.5	49.41	10.50	42.00	26.03	20.00	-13.80	26.03	42.00
Omotosho 1	exist.	Thermal	Omotosho 1_10.5	49.41	10.50	42.00	26.03	20.00	-13.80	26.03	42.00

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Omotosho 1	exist.	Thermal	Omotosho 1_10.5	49.41	10.50	42.00	26.03	20.00	-13.80	26.03	42.00
Omotosho 2 NIPP	exist.	Thermal	Omotosho 2 NIPP_15	148.24	10.50	126.00	78.09	20.00	-41.41	78.09	126.00
Omotosho 2 NIPP	exist.	Thermal	Omotosho 2 NIPP_15	148.24	10.50	126.00	78.09	20.00	-41.41	78.09	126.00
Omotosho 2 NIPP	exist.	Thermal	Omotosho 2 NIPP_15	148.24	10.50	126.00	78.09	20.00	-41.41	78.09	126.00
Omotosho 2 NIPP	exist.	Thermal	Omotosho 2 NIPP_15	148.24	10.50	126.00	78.09	20.00	-41.41	78.09	126.00
Paras Energy	exist.	Thermal	N/A	11.25	11.00	9.00	6.75	14.00	-2.96	6.75	9.00
Paras Energy	exist.	Thermal	N/A	11.25	11.00	9.00	6.75	14.00	-2.96	6.75	9.00
Paras Energy	exist.	Thermal	N/A	11.25	11.00	9.00	6.75	27.00	-2.96	6.75	9.00
Paras Energy	exist.	Thermal	N/A	11.25	11.00	9.00	6.75	27.00	-2.96	6.75	9.00
Paras Energy	exist.	Thermal	N/A	11.25	11.00	9.00	6.75	14.00	-2.96	6.75	9.00
Paras Energy	exist.	Thermal	N/A	11.25	11.00	9.00	6.75	14.00	-2.96	6.75	9.00
Rivers IPP	exist.	Thermal	N/A	224.71	10.50	191.00	118.37	19.00	-62.78	118.37	160.00
Sapele	exist.	Thermal	Sapele _15.8	134.00	15.75	88.00	54.54	20.00	-28.92	54.54	54.54
Sapele	exist.	Thermal	Sapele _15.8	134.00	15.75	88.00	54.54	20.00	-28.92	54.54	54.54
Sapele	exist.	Thermal	Sapele _15.8	134.00	15.75	88.00	54.54	20.00	-28.92	54.54	54.54
Sapele	exist.	Thermal	Sapele _15.8	134.00	15.75	88.00	54.54	20.00	-28.92	54.54	54.54
Sapele	exist.	Thermal	Sapele _15.8	134.00	15.75	88.00	54.54	20.00	-28.92	54.54	54.54
Sapele	exist.	Thermal	Sapele _15.8	134.00	15.75	88.00	54.54	20.00	-28.92	54.54	54.54
Sapele Ogorode 1	exist.	Thermal	Sapele Ogorode 1_15	141.25	15.00	113.00	84.75	20.00	-37.14	84.75	113.00
Sapele Ogorode 1	exist.	Thermal	Sapele Ogorode 1_15	141.25	15.00	113.00	84.75	20.00	-37.14	84.75	0.00
Sapele Ogorode 1	exist.	Thermal	Sapele Ogorode 1_15	141.25	15.00	113.00	84.75	20.00	-37.14	84.75	0.00
Sapele Ogorode 1	exist.	Thermal	Sapele Ogorode 1_15	141.25	15.00	113.00	84.75	20.00	-37.14	84.75	0.00
Trans Amadi G1-4	exist.	Thermal	N/A	117.65		100.00	61.97	20.00	-32.87	61.97	75.00
Jebba	exist.	Hydro	Jebba_16	119.00	16.00	101.00	49.00	24.00	-30.00	49.00	84.00
Jebba	exist.	Hydro	Jebba_16	119.00	16.00	101.00	49.00	20.00	-30.00	49.00	84.00

Final version

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Jebba	exist.	Hydro	Jebba_16	119.00	16.00	101.00	49.00	20.00	-30.00	49.00	84.00
Jebba	exist.	Hydro	Jebba_16	119.00	16.00	101.00	49.00	20.00	-30.00	49.00	84.00
Jebba	exist.	Hydro	Jebba_16	119.00	16.00	101.00	49.00	20.00	-30.00	49.00	84.00
Jebba	exist.	Hydro	Jebba_16	119.00	16.00	101.00	49.00	20.00	-30.00	49.00	84.00
Kainji G10	exist.	Hydro	Kainji G1_16	94.12	16.00	80.00	49.58	20.00	-26.29	49.58	40.00
Kainji G11	exist.	Hydro	Kainji G11_16	117.65	16.00	100.00	61.97	20.00	-32.87	61.97	50.00
Kainji G12	exist.	Hydro	Kainji G12_16	117.65	16.00	100.00	61.97	20.00	-32.87	61.97	50.00
Kainji G5	exist.	Hydro	Kainji G5_16	141.18	16.00	120.00	74.37	20.00	-39.44	74.37	0.00
Kainji G6	exist.	Hydro	Kainji G6_16	141.18	16.00	120.00	74.37	20.00	-39.44	74.37	0.00
Kainji G7	exist.	Hydro	Kainji G7_16	94.12	16.00	80.00	49.58	20.00	-26.29	49.58	40.00
Kainji G8	exist.	Hydro	Kainji G8_16	94.12	16.00	80.00	49.58	20.00	-26.29	49.58	40.00
Kainji G9	exist.	Hydro	Kainji G9_16	94.12	16.00	80.00	49.58	20.00	-26.29	49.58	40.00
Shiroro	exist.	Hydro	Shiroro_15.7	176.50	15.65	150.00	100.00	20.00	-70.00	100.00	150.00
Shiroro	exist.	Hydro	Shiroro_15.7	176.50	15.65	150.00	100.00	20.00	-70.00	100.00	100.00
Shiroro	exist.	Hydro	Shiroro_15.7	176.50	15.65	150.00	100.00	20.00	-70.00	100.00	100.00
Shiroro	exist.	Hydro	Shiroro_15.7	176.50	15.65	150.00	100.00	20.00	-70.00	100.00	100.00
Egbema 1 NIPP	decid.	Thermal	Egbema 1 NIPP_15	141.25	15.00	113.00	84.40	20.00	-56.30	84.40	113.00
Egbema 1 NIPP	decid.	Thermal	Egbema 1 NIPP_15	141.25	15.00	113.00	84.40	20.00	-56.30	84.40	113.00
Egbema 1 NIPP	decid.	Thermal	Egbema 1 NIPP_15	141.25	15.00	113.00	84.40	20.00	-56.30	84.40	113.00
Gbarain - Ubie 1	decid.	Thermal	Gbarain - Ubie 1_15	141.25	15.00	113.00	84.40	20.00	-56.30	84.40	113.00
Omoku NIPP	decid.	Thermal	Omoku NIPP_15	141.25	15.00	113.00	84.75	20.00	-11.30	84.75	113.00
Omoku NIPP	decid.	Thermal	Omoku NIPP_15	141.25	15.00	113.00	84.75	20.00	-11.30	84.75	113.00
Gurara G1-2	decid.	Hydro	N/A	35.29	11.50	30.00	33.54	20.00	-9.86	33.54	30.00
Kaduna IPP	decid.	Thermal	N/A	252.94	N/A	215.00	133.25	20.00	-70.67	133.25	215.00
Alaoji 2 + NIPP	decid.	Thermal	N/A	335.29	N/A	285.00	176.63	21.00	-93.67	176.63	285.00

Final version

Senegal

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Bel Air C6	exist.	Thermal	Belair_15	16.45	15.00	16.50	10.23	20.00	-5.42	10.23	15.00
Bel Air C6	exist.	Thermal	Belair_15	16.45	15.00	16.50	10.23	20.00	-5.42	10.23	15.00
Bel Air C6	exist.	Thermal	Belair_15	16.45	15.00	16.50	10.23	20.00	-5.42	10.23	15.00
Bel Air C6	exist.	Thermal	Belair_15	16.45	15.00	16.50	10.23	20.00	-5.42	10.23	15.00
Bel Air C6	exist.	Thermal	Belair_15	16.45	15.00	16.50	10.23	20.00	-5.42	10.23	15.00
Bel Air C6	exist.	Thermal	Belair_15	16.45	15.00	16.50	10.23	20.00	-5.42	10.23	15.00
Boutoute 1	exist.	Thermal	Zuiguinchor_225	22.12	225.00	18.80	11.65	20.00	-6.18	11.65	18.80
Boutoute 2	exist.	Thermal	Zuiguinchor_225	12.50	225.00	10.00	7.50	20.00	-3.29	7.50	10.00
Cap des Biches - IPP Contour Global	exist.	Thermal	Cap des Biches - IPP Contour Global G1_11	19.29	11.00	16.40	10.16	22.10	-5.39	10.16	16.40
Cap des Biches - IPP Contour Global	exist.	Thermal	Cap des Biches - IPP Contour Global G2_11	19.29	11.00	16.40	10.16	22.10	-5.39	10.16	16.40
Cap des Biches - IPP Contour Global	exist.	Thermal	Cap des Biches - IPP Contour Global G3_11	19.29	11.00	16.40	10.16	22.10	-5.39	10.16	16.40
Cap des Biches - IPP Contour Global	exist.	Thermal	Cap des Biches - IPP Contour Global G4_11	19.29	11.00	16.40	10.16	22.10	-5.39	10.16	16.40
Cap des Biches - IPP Contour Global	exist.	Thermal	Cap des Biches - IPP Contour Global G5_11	19.29	11.00	16.40	10.16	22.10	-5.39	10.16	16.40
Cap des Biches C4	exist.	Thermal	Cap des Biches C4 G1_11.5	24.71	11.50	21.00	13.01	20.00	-6.90	13.01	17.50
Cap des Biches C4	exist.	Thermal	Cap des Biches C4 G2_11.5	24.71	11.50	21.00	13.01	20.00	-6.90	13.01	17.50
Cap des Biches C4	exist.	Thermal	Cap des Biches C4 G3_11.5	27.06	11.50	23.00	14.25	20.00	-7.56	14.25	20.00
Cap des Biches C4	exist.	Thermal	Cap des Biches C4 G4_11.5	17.65	11.50	15.00	9.30	20.00	-4.93	9.30	13.00
Cap des Biches C4	exist.	Thermal	Cap des Biches C4 G5_11.5	17.65	11.50	15.00	9.30	20.00	-4.93	9.30	13.00
Kaolack / Kahone	exist.	Thermal	Kaolack / Kahone_15	17.65	15.00	15.00	9.30	20.00	-4.93	9.30	15.00
Kaolack / Kahone	exist.	Thermal	Kaolack / Kahone_15	17.65	15.00	15.00	9.30	20.00	-4.93	9.30	15.00
Kaolack / Kahone	exist.	Thermal	Kaolack / Kahone G3_15	17.65	15.00	15.00	9.30	20.00	-4.93	9.30	15.00
Kaolack / Kahone	exist.	Thermal	Kaolack / Kahone G4_15	17.65	15.00	15.00	9.30	20.00	-4.93	9.30	15.00

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Kaolack / Kahone	exist.	Thermal	Kaolack / Kahone G5_15	17.65	15.00	15.00	9.30	20.00	-4.93	9.30	15.00
Kaolack / Kahone	exist.	Thermal	Kaolack / Kahone G5_15	17.65	15.00	15.00	9.30	20.00	-4.93	9.30	15.00
Kounoune	exist.	Thermal	Kounoune_15	50.59	15.00	43.00	26.65	20.00	-14.13	26.65	43.00
Tobene IPP	exist.	Thermal	Tobene IPP 1_15	24.71	15.00	21.00	13.01	22.10	-6.90	13.01	21.00
Tobene IPP	exist.	Thermal	Tobene IPP 2_15	24.71	15.00	21.00	13.01	22.10	-6.90	13.01	21.00
Tobene IPP	exist.	Thermal	Tobene IPP 3_15	24.71	15.00	21.00	13.01	22.10	-6.90	13.01	21.00
Tobene IPP	exist.	Thermal	Tobene IPP 4_15	24.71	15.00	21.00	13.01	22.10	-6.90	13.01	21.00
Tobene IPP	exist.	Thermal	Tobene IPP 5_15	24.71	15.00	21.00	13.01	22.10	-6.90	13.01	21.00
Bokhol	exist.	PV	Dagana_30	21.05	30.00	20.00	6.57	100.00	-6.57	6.00	20.00
Malicounda	exist.	PV	Touba_225	23.16	225.00	22.00	7.23	100.00	-7.23	7.23	11.00
Mékhé - Senergy PV	exist.	PV	Mékhé - Senergy PV _30	31.58	30.00	30.00	9.86	100.00	-9.86	9.53	29.00
Mérina Dakhar - Tenergy PV	exist.	PV	Mérina Dakhar - Tenergy PV_30	31.58	30.00	30.00	9.86	100.00	-9.86	6.57	20.00
Sendou IPP CES	decid.	Thermal	Sendou IPP CES _6.6	135.29	6.66	115.00	71.27	27.60	-37.80	71.27	115.00
Diass PV	decid.	PV	Diass_30	15.79	30.00	15.00	4.93	100.00	-4.93	4.93	15.00
Sakal EDS-Eximag PV	decid.	PV	Sakal_225	21.05	225.00	20.00	6.57	100.00	-6.57	6.57	20.00

Final version

Sierra Leone

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Bumbuna	exist.	Hydro	Bumbuna G1_13.8	32.50	13.80	25.00	18.75	21.00	-2.50	18.75	25.00
Bumbuna	exist.	Hydro	Bumbuna G2_13.8	32.50	13.80	25.00	18.75	21.00	-2.50	18.75	25.00
Bumbuna II	decid.	Hydro	Bumbuna_10.3	85.88	13.80	73.00	45.24	20.00	-23.99	45.24	73.00
Bankasoka, Charlotte, Makali	exist.	Hydro	Kenema_33	6.25	33.00	5.00	9999.00	20.00	-0.50	3.75	5.00
Freetown	exist.	Thermal	Freetown_161	43.53	33.00	37.00	22.93	20.00	-12.16	22.93	37.00
Dodo	exist.	Hydro	Kenema_33	7.50	33.00	6.00	4.50	27.00	-0.60	4.50	6.00

Togo

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Kara	exist.	Thermal	Kara_15	17.78	15.00	16.00	7.75	20.00	-5.26	7.75	4.00
Lomé - Contour Global	exist.	Thermal	Contour Global Gen_15	18.47	15.00	16.62	8.05	15.50	-5.46	8.05	15.00
Lomé - Contour Global	exist.	Thermal	Contour Global Gen_15	18.47	15.00	16.62	8.05	15.50	-5.46	8.05	15.00
Lomé - Contour Global	exist.	Thermal	Contour Global Gen_15	18.47	15.00	16.62	8.05	15.50	-5.46	8.05	15.00
Lomé - Contour Global	exist.	Thermal	Contour Global Gen_15	18.47	15.00	16.62	8.05	15.50	-5.46	8.05	15.00
Lomé - Contour Global	exist.	Thermal	Contour Global Gen_15	18.47	15.00	16.62	8.05	15.50	-5.46	8.05	15.00
Lomé - Contour Global	exist.	Thermal	Contour Global Gen_15	18.47	15.00	16.62	8.05	15.50	-5.46	8.05	15.00
Lomé CEET	exist.	Thermal	Lome CEET_15	18.82	15.00	16.00	0.23	20.00	-5.26	9.92	5.00
Lomé Port - TAG CEB	exist.	Thermal	Lomé Port TAG CEB_15	25.00	15.00	16.00	15.00	21.00	-9.00	15.00	5.00
Sokodé	exist.	Thermal	Sokode Diesel_15	4.44	15.00	4.00	1.94	20.00	-1.31	1.94	1.50
Nangbéto	exist.	Hydro	Nangbéto 1_10.3	38.59	10.30	32.80	20.33	18.50	-15.00	20.33	32.80
Nangbéto	exist.	Hydro	Nangbéto 2_10.3	38.59	10.30	32.80	20.33	18.50	-15.00	20.33	32.80

Unit Name	Status	Type	Connection node	Nominal power (MVA)	Nominal voltage (kV)	Nominal active power (MW)	Nominal reactive power (Mvar)	Sub-transient reactance (% p.u.)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Max. active power (MW)
Lomé	decid.	Thermal	N/A	47.06	N/A	40.00	24.79	20.00	-13.15	24.79	40.00

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APPENDIX J: LIST OF NATIONAL PROJECTS PLANNED

Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Côte d'Ivoire	LI	AKOUPE ZEUDJI-BINGERVILLE_400	50	ALM570 (2 conductor/phase)	2018-2022	
Côte d'Ivoire	LI	BAKRE-AKOUPE ZEUDJI_400	46	ALM570 (2 conductor/phase)	2018-2022	
Côte d'Ivoire	LI	BAKRE-AZITO_400	10	ALM570 (2 conductor/phase)	2018-2022	
Côte d'Ivoire	LI	AZITO-AKOUPE-ZEUDJI_400	52	ALM570 (2 conductor/phase)	2018-2022	
Côte d'Ivoire	LI	BAKRE-BINGERVILLE_400	45	ALM570 (2 conductor/phase)	2018-2022	
Côte d'Ivoire	LI	AKOUPE ZEUDJI-SAN PEDRO_400	330	Biterne ALM570 (2 conductor/phase)	2021	
Côte d'Ivoire	LI	ANANI-BINGERVILLE 1_225	18	ALM570	2018-2022	
Côte d'Ivoire	LI	ANANI-BINGERVILLE 2_225	18	ALM570	2018-2022	
Côte d'Ivoire	LI	RIVIERA-BINGERVILLE_225	10	ALM570	2018-2022	
Côte d'Ivoire	LI	BINGERVILLE-PRESTEA_225	200	ALM570	2018-2022	
Côte d'Ivoire	LI	AKOUPE ZEUDJI-ABOBO 1_225	38	ALM570	2018-2022	
Côte d'Ivoire	LI	AKOUPE ZEUDJI-ABOBO 2_225	38	ALM570	2018-2022	
Côte d'Ivoire	LI	AKOUPE ZEUDJI-TAABO 1_225	132	ALM570	2018-2022	
Côte d'Ivoire	LI	AKOUPE ZEUDJI-TAABO 2_225	132	ALM570	2018-2022	
Côte d'Ivoire	LI	LABOA-BOUNDIALI_225	165	ALM570	2018-2022	
Côte d'Ivoire	LI	BOUNDIALI-FERKE_225	152	ALM570	2018-2022	
Côte d'Ivoire	LI	SEREBOU-BONDOUKOU_225	142	ALM570	2018-2022	
Côte d'Ivoire	LI	BOUAKE2-SEREBOU_225	132	ALM570	2018-2022	
Côte d'Ivoire	LI	AZITO-BAKRE_225	10	ALM570	2018-2022	
Côte d'Ivoire	LI	VRIDI-BAKRE_225	5	ALM570	2018-2022	
Côte d'Ivoire	LI	ADZOPE-AKOUPE-ZEUDJI_225	100	ALM570	2018-2022	
Côte d'Ivoire	LI	SONGON-AKOUPE ZEUDJI_225	25	ALM570	2018-2022	
Côte d'Ivoire	LI	ANYAMA-AKOUPE ZEUDJI_225	10	ALM570	2018-2022	
Côte d'Ivoire	LI	BUYO-DUEKOUE_225	110	ALM570	2018-2022	
Côte d'Ivoire	LI	DUEKOUE-MAN_225	86	ALM570	2018-2022	
Côte d'Ivoire	LI	ZAGNE-TOULEPLEU_225	165	ALM570	2018-2022	
Côte d'Ivoire	LI	SAN PEDRO-SOUBRE_225	128	ALM570	2018-2022	
Côte d'Ivoire	LI	SOUBRE-BUYO_225	79	ALM570	2018-2022	
Côte d'Ivoire	LI	DUEKOUE-ZAGNE_225	77	ALM570	2018-2022	
Côte d'Ivoire	LI	SAN PEDRO 1-SAN PEDRO 2_225	10	ALM570	2018-2022	
Côte d'Ivoire	LI	TAABO-YAMOUSSOUKRO_225	80	ALM570	2018-2022	
Côte d'Ivoire	LI	YAMOUSSOUKRO-KOSSOU_225	50	ALM570	2018-2022	
Côte d'Ivoire	LI	KOSSOU-BOUAKE3_225	110	ALM570	2018-2022	
Côte d'Ivoire	LI	BOUAKE3-BOUAKE2_225	10	ALM570	2018-2022	
Côte d'Ivoire	LI	BUYO-DALOA_225	87	ALM570	2018-2022	

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Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Côte d'Ivoire	LI	SEREBOU-DABAKALA_225	67	ALM570	2018-2022	
Côte d'Ivoire	LI	DABAKALA-KONG_225	98	ALM570	2018-2022	
Côte d'Ivoire	LI	VRIDI-RIVIERA_225	18.3	ALM570	2018-2022	
Côte d'Ivoire	LI	ANYAMA-ADZOPE_225	100	ALM570	2018-2022	
Côte d'Ivoire	LI	ATTAKRO-ADZOPE_225	75	ALM570	2018-2022	
Côte d'Ivoire	LI	SAN PEDRO-SOUBRE_225	128	ALM570	2018-2022	
Côte d'Ivoire	LI	KATIOLA-FERKE_225	12	ALM570	2018-2022	
Côte d'Ivoire	LI	KONG-FERKE_225	85	ALM570	2018-2022	
Côte d'Ivoire	LI	ZAGNE-TOULEPLEU_225	165	ALM570	2018-2022	
Côte d'Ivoire	LI	SAN PEDRO 1-SAN PEDRO 2_225	10	ALM570	2018-2022	
Côte d'Ivoire	LI	GRIBO-POPOLI-SAN PEDRO_225	3	ALM570	2018-2022	
Côte d'Ivoire	LI	BOUNA-BONDOUKOU_90	180	ALM228	2018-2022	
Côte d'Ivoire	LI	TANDA-AGNIBILEKRO_90	84	ALM228	2018-2022	
Côte d'Ivoire	LI	TANDA-BONDOUKOU_90	52	ALM228	2018-2022	
Côte d'Ivoire	LI	LABOA-TOUBA_90	65	ALM228	2018-2022	
Côte d'Ivoire	LI	TOUBA-MAN_90	100	ALM228	2018-2022	
Côte d'Ivoire	LI	DALOA-VAVOUA_90	57	ALM228	2018-2022	
Côte d'Ivoire	LI	VAVOUA-ZUENOULA_90	56	ALM228	2018-2022	
Côte d'Ivoire	LI	MANKONO-SEGUELA_90	71	ALM228	2018-2022	
Côte d'Ivoire	LI	ZUENOULA-MANKONO_90	82	ALM228	2018-2022	
Côte d'Ivoire	LI	BOUAKE1-BOUAKE3_90	20	ALM228	2018-2022	
Côte d'Ivoire	LI	DAOUKRO-ATTAKRO_90	53	ALM228	2018-2022	
Côte d'Ivoire	LI	SEREBOU-DAOUKRO_90	103	ALM228	2018-2022	
Côte d'Ivoire	LI	AYAME 1-ABENGOUROU_90	156	ALM228	2018-2022	
Côte d'Ivoire	LI	AYAME 1-AYAME 2_90	4	ALM228	2018-2022	
Côte d'Ivoire	LI	LABOA-TOUBA_90	78	ALM228	2018-2022	
Côte d'Ivoire	LI	MARABADIASSA-KATIOLA_90	39	ALM228	2018-2022	
Côte d'Ivoire	LI	BOUAKE1-BOUAKE3_90	20	ALM228	2018-2022	
Côte d'Ivoire	LI	YAMOUSSOUKRO1-YAMOUSSOUKRO2_90	7	ALM228	2018-2022	
Côte d'Ivoire	LI	CENTRALE-PYLONE_90	N/A	ALM228	2018-2022	
Côte d'Ivoire	LI	PYLONE-VERS KORHOGO_90	N/A	ALM228	2018-2022	
Côte d'Ivoire	LI	TAABO-AGBOVILLE_90	118	ALM225	2018-2022	
Côte d'Ivoire	LI	MANKONO-MARABADIASSA_90	57	ALM228	2018-2022	
Côte d'Ivoire	LI	TOULEPLEU-MINE ITY_90	57	ALM228	2018-2022	
Côte d'Ivoire	LI	SINGROBO-TAABO_90	3	ALM 228	2018-2022	
Côte d'Ivoire	TF	400/225 AKOUPE ZEUDJI N°1	-	200 MVA	2018-2022	
Côte d'Ivoire	TF	400/225 AKOUPE ZEUDJI N°2	-	200 MVA	2018-2022	
Côte d'Ivoire	TF	400/225 SAN PEDRO2 N°1	-	200 MVA	2018-2022	
Côte d'Ivoire	TF	400/225 SAN PEDRO2 N°2	-	200 MVA	2018-2022	
Côte d'Ivoire	TF	400/225 BINGERVILLE N4	-	350 MVA	2018-2022	
Côte d'Ivoire	TF	400/225 BINGERVILLE N5	-	350 MVA	2018-2022	

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Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Côte d'Ivoire	TF	400/225 BINGERVILLE N6	-	350 MVA	2018-2022	
Côte d'Ivoire	TF	400/225 AKOUPE-ZEUDJI N1	-	350 MVA	2018-2022	
Côte d'Ivoire	TF	400/225 AKOUPE-ZEUDJI N2	-	350 MVA	2018-2022	
Côte d'Ivoire	TF	400/225 BAKRE N1	-	350 MVA	2018-2022	
Côte d'Ivoire	TF	400/225 BAKRE N2	-	350 MVA	2018-2022	
Côte d'Ivoire	TF	400/225 SAN PEDRO N1	-	200 MVA	2018-2022	
Côte d'Ivoire	TF	400/225 SAN PEDRO N2	-	200 MVA	2018-2022	
Côte d'Ivoire	TF	330/225 BINGERVILLE N1	-	350 MVA	2018-2022	
Côte d'Ivoire	TF	330/225 BINGERVILLE N2	-	350 MVA	2018-2022	
Côte d'Ivoire	TF	330/225 BINGERVILLE N3	-	350 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 AKOUPE ZEUDJI N°1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 AKOUPE ZEUDJI N°2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/93 (4) LABOA N°2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BOUNDIALI	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BOUNDIALI	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BONDOUKOU N1	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BONDOUKOU N2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 YOPOUGON1 N°1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 YOPOUGON1 N°2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 TREICHVILLE N°1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 TREICHVILLE N°2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 (1) ABOBO N°1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 (1) ABOBO N°2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 (1) ABOBO N°3	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 (1) ABOBO N°4	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BONDOUKOU N°1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BONDOUKOU N°2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 SEREBOU N°1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 SEREBOU N°2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 TOULEPLEU	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 (2) SAN PEDRO 1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 DIVO	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/93 SEREBOU N°1	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/93 SEREBOU N°2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/93 BONDOUKOU N°1	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/93 BONDOUKOU N°2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/93 (2) MAN N°2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/93 (2) SOUBRE N°2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 (3)TAABO N°1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 (3)TAABO N°2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 SAN PEDRO N°1	-	100 MVA	2018-2022	

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Côte d'Ivoire	TF	225/90 SAN PEDRO N°2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/93 (5) BUYO N°2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 YAMOUSSOUKRO2 N°1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 YAMOUSSOUKRO2 N°2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BOUAKE3 N°1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BOUAKE3 N°2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/93 (6)KOSSOU N°2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 DALOA	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 GAGNOA N°1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 GAGNOA N°2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/93 FERKE	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/93 BOUAKE 2 N°2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 FERKE N1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 FERKE N2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 MAN	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BOUAKE 2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 LABOA	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BUYO	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BOUNDIALI	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BIA-SUD N1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BIA-SUD N2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 ATTAKRO N1	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 ATTAKRO N2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 KATIOLA N1	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 KATIOLA N2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 KORHOGO N1	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 KORHOGO N2	-	70 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 YAMOUSSOUKRO N1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 YAMOUSSOUKRO N2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BOUAKE3 N1	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 BOUAKE3 N2	-	100 MVA	2018-2022	
Côte d'Ivoire	TF	225/90 DALOA N1	-	100 MVA	2018-2022	
Côte d'Ivoire	SVC	SVC FERKE - 225 kV	-	50 MVAr	2018	
Côte d'Ivoire	SVC	SVC MAN - 225 kV	-	50 MVAr	2019	
Côte d'Ivoire	SVC	SVC BONDOUKOU - 90 kV	-	50 MVAr	2020	
Côte d'Ivoire	REAC	Reactor BONDOUKOU - 90 kV	-	50 MVAr	2019	Number of taps?
Côte d'Ivoire	REAC	Capacitor DABOU – 90kV	-	7.2 MVAr	2018	3 taps?
Côte d'Ivoire	REAC	Capacitor DALOA - 90 kV	-	14.4 MVAr	2019	6 taps?
Côte d'Ivoire	REAC	Capacitor TOUBA - 90 kV	-	14.4 MVAr	2019	6 taps?
Côte d'Ivoire	REAC	Capacitor BOUNA - 90 kV	-	4.8 MVAr	2021	2 taps?
Côte d'Ivoire	REAC	Capacitor ADZOPE - 90 kV	-	7.2 MVAr	2021	3 taps?

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Côte d'Ivoire	REAC	Capacitor DIVO - 90 kV	-	12 MVAr	2020	5 taps?
Côte d'Ivoire	REAC	Capacitor SEGUELA - 90 kV	-	4.8 MVAr	2020	2 taps?
Côte d'Ivoire	REAC	Capacitor TONGON - 90 kV	-	4.8 MVAr	2020	2 taps?
Côte d'Ivoire	REAC	Capacitor YOPOUGON1-90kV	-	7.2 MVAr	2018	30 kV connection; 3 taps?
Côte d'Ivoire	REAC	Capacitor YOPOUGON1-90kV	-	7.2 MVAr	2018	15 kV connection; 3 taps?
Côte d'Ivoire	REAC	Capacitor ZAGNE - 90 kV	-	12 MVAr	2020	5 taps?
Ghana	LI	Prestea-Kumasi 330 kV	N/A		2018	
Ghana	LI	Aboadze-Dunkwa-Kumasi-Kintampo-Tamale-Bolgatanga 330 kV	N/A		2019	
Ghana	LI	Sunyani-Berekum 161 kV	N/A		2018	
Ghana	LI	Asawinso-Juabeso-Mim 161 kV	N/A		2018 or 2019?	
Ghana	LI	Break-in of 161kV Akosombo-Nkawkaw line at Tafo	N/A		Delayed	How far is the break-in?
Ghana	LI	Upgrade of Achimota-Acrra East-Volta lines (2)	-	213 to 488 MVA	2019	
Ghana	TF	Upgrade transformers in Tarkwa, Akwatia, KoNogo, Asawinso, Asiekpe, Tamales, New Tarkwa,	-		2019	Size of transformers?
Ghana Ghana	TF REAC	Sunyani, New Tema, Cape Coast, Kpandu et Winneba. Dunkwa, Kumasi, Bolgatanga reactors	- -		2019 2019	Size of transformers?
Ghana	SS	New Pokuase Substation 330 kV on Aboadze-Volta	-		2019	
Ghana	SS	New Accra Substation?	A5 330		2018	Connection?
Ghana	SS	New Substation GIS at Accra Central	A4 161		2019	Same project as Accra?
Mali	LI	Sikasso-Bougouni-Bamako 225 kV	N/A		2021	Double terne
Mali	LI	Duplicate of Manantali-Bamako	-		2021	
Mali	LI	Reinforcement Manantali-Kayes	-		N/A	
Burkina Faso	LI	Double circuit line Kossodo-Poste Ouaga Est-	N/A		2020	
Mali	LI	Poste Patte d'Oie - 90 kV	-		N/A	
Burkina Faso Burkina Faso	LI LI	Kossodo-Ziniaré 90 kV Upgrade to 90 kV of line Zagtouli-Koudougou	25 100		2020 2020	
Burkina Faso	LI	Kaya-Ziniaré 90 kV double circuit	70		2020	
Burkina Faso	LI	Pa- Dedougou 90 kV	N/A		N/A	
Burkina Faso	LI	Wona-Dedougou 90 kV	60		2020	
Burkina Faso	LI	Zano-Koupela 132 kV	55		2020	
Burkina Faso	TF	Ouga I 90/15 kV	-	40 MVA	2018	Zagtouli Solar Project
Burkina Faso	TF	Zano 132/33 kV	-	40 MVA	2018	
Togo-Benin	LI	Davié-Notsé_161	54.5	178.5 MVA	2025	
Togo-Benin	LI	Davié-Légbassito_161 n°1	14	178.5 MVA	2018	
Togo-Benin	LI	Davié-Légbassito_161 n°2	14	178.5 MVA	2018	
Togo-Benin	LI	Notsé-Atakpamé_161	70	178.5 MVA	2025	
Togo-Benin	LI	Atakpamé-Kara_161	250	178.5 MVA	2025	

Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Togo-Benin	LI	Kara-Bandjeli_161	75	178.5 MVA	2022	
Togo-Benin	LI	Kara-Mango_161	164	178.5 MVA	2020	
Togo-Benin	LI	Mango-Dapaong_161	78	178.5 MVA	2020	
Togo-Benin	LI	Porga-Tangieta-Natitingou_161	110	178.5 MVA	2022	
Togo-Benin	LI	Bembereke-Kandi_161	114	178.5 MVA	2018	
Togo-Benin	LI	Kandi-Guene-Malanville_161	90	178.5 MVA	2018	
Togo-Benin	LI	Onigbolo-Parakou_161 n°1	280	178.5 MVA	2018	
Togo-Benin	LI	Onigbolo-Parakou_161 n°2	280	178.5 MVA	2018	
Togo-Benin	LI	Dapaong-Mandouri 161	N/A	178.5 MVA	2020	
Togo-Benin	LI	Atakpamé-Lomé 161	N/A	178.5 MVA	2021	
Togo-Benin	LI	Notse-Adjarala	N/A	128 MVA	N/A	
Togo-Benin	LI	Adjarala-Ava n°2	N/A	128 MVA	N/A	
Togo-Benin	TF	ATAKPAME – T3_161 / ATAKPAME – T3_20	-	16 MVA	2019	
Togo-Benin	TF	BANDJELI – T1_161 / BANDJELI – T1_34	-	20 MVA	2022	
Togo-Benin	TF	BANDJELI – T2_161 / BANDJELI – T2_34	-	20 MVA	2022	
Togo-Benin	TF	BEMBEREKE – T1_161 / BEMBEREKE – T1_34	-	20 MVA	2018	
Togo-Benin	TF	BEMBEREKE – T2_161 / BEMBEREKE – T2_34	-	20 MVA	2018	
Togo-Benin	TF	BLITTA – T1_161 / BLITTA – T1_34	-	20 MVA	2022	
Togo-Benin	TF	BLITTA – T2_161 / BLITTA – T2_34	-	20 MVA	2022	
Togo-Benin	TF	CINKASSE - T1_161 / CINKASSE - T1_0.4	-	16 MVA	2022	
Togo-Benin	TF	DAPAONG -T1_161 / DAPAONG - T1_22	-	16 MVA	2022	
Togo-Benin	TF	DAPAONG -T2_161 / DAPAONG - T2_34,5	-	16 MVA	2022	
Togo-Benin	TF	KANDI – T1_161 / KANDI – T1_34	-	20 MVA	2018	
Togo-Benin	TF	KANDI – T2_161 / KANDI – T2_34	-	20 MVA	2018	
Togo-Benin	TF	LEGBASSITO – TR1_161 / LEGBASSITO – TR1_20	-	50 MVA	2018	
Togo-Benin	TF	LEGBASSITO – TR2_161 / LEGBASSITO – TR2_20	-	50 MVA	2018	
Togo-Benin	TF	MALANVILLE – T1_161 / MALANVILLE – T1	-	20 MVA	2018	
Togo-Benin	TF	MANGO – TR1_161 / MANGO – TR1_20	-	20 MVA	2020	
Togo-Benin	TF	MANGO – TR2_161 / MANGO – TR2_20	-	20 MVA	2020	
Togo-Benin	TF	NATITINGOU – T1_161 / NATITINGOU –T1_20	-	20 MVA	2022	
Togo-Benin	TF	NOTSE – T1_161 / NOTSE – T1_33	-	12.5 MVA	2025	
Togo-Benin	TF	PORGA – T1_161 / PORGA – T1_20	-	20 MVA	2022	
Togo-Benin	TF	TANGUIETA – T1_161 / TANGUIETA – T1_20	-	20 MVA	2022	
Gambia	TF	Brikama 225/30 kV	-	2 x 75 MVA	2021	OMVG
Gambia	TF	Soma 225/30 kV	-	2 x 15 MVA	2021	OMVG
Guinea Bissau	TF	Bissau 225/30 kV	-	3 x 20 MVA	2021	OMVG
Guinea	LI	Linsan-Fomi 225 kV	N/A	250 MVA	2020	Double circuit?

Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Guinea	LI	Linsan – Kisougoudou 225 kV (Guinea Loop)	N/A		N/A	Double circuit?
Guinea	LI	Kisigoudou – N'Zérékoré 225 kV (Guinea Loop)	N/A		N/A	Double circuit?
Guinea	LI	Maneah-Linsan 225 kV	N/A		N/A	Double circuit?
Guinea	TF	Linsan 225/110 kV	-	2 x 75 MVA	2021	OMVG
Guinea	TF	N'Zérékore 225/110 kV	-	40 MVA	2020	CLSG
Niger	LI	Salkadmana-Niamey 330 kV	400	760 MVA	2021	
Niger	LI	Kandadji- Gouroubanda 132 kV	190	107.7 MVA	2022	Double terne
Niger	LI	Salkadmana-Tahoua 132 kV	60	107.7 MVA	2021	
Niger	LI	Dosso-Balleyara 132 kV	85		2020	
Niger	LI	Reinforcement HV grid Niamey	N/A		2020	Which lines
Senegal	LI	Tanaf-Ziguichor 225 kV	N/A		N/A	
Senegal	LI	Mbour-Kayar_225	N/A		2018	
Senegal	LI	Mbour-Kayar_225	N/A		2018	
Senegal	LI	OLAM-Sendou_225	N/A		2018	
Senegal	LI	Mbour-OLAM_225	N/A		2018	
Senegal	LI	Sendou-Kounoune_225	12	348 MVA	2018	
Senegal	LI	Sendou-Kounoune_225	12	348 MVA	2018	
Senegal	LI	Tobene-Kounoune_225	53	348 MVA	2018	
Senegal	LI	Tobene-Kounoune_225	53	348 MVA	2019	
Senegal	LI	Fatick-SAPCO_225	N/A		2018	
Senegal	LI	SAPCO-MBOUR_225	N/A		2018	
Senegal	LI	Fatick-Kaolack_225	40	348 MVA	2020	
Senegal	LI	Africa Energy-Tobene_225	30		2020	
Senegal	LI	Africa Energy-Tobene_225	30		2020	
Senegal	LI	Mboro-Tobene_225	200	348 MVA	2020	
Senegal	LI	Mboro-Tobene_225	200	348 MVA	2020	
Senegal	LI	Bakel-Tambacounda_225	N/A		2021	
Senegal	LI	Cap Des Biches-Kounoune_90	6.5	86 MVA	2020	
Senegal	LI	Hann-Patte d'Oie_90	1.2	81.80 MVA	2020	
Senegal	LI	Hann-Patte d'Oie_90	1.2	81.80 MVA	2026	
Senegal	LI	Hann-Patte d'Oie_90	1.2		2030	
Senegal	REAC	Reactance KAOLACK 225 kV	-	20 MVAr	N/A	
Senegal	REAC	Reactance TOUBA 225 kV	-	25 MVAr	N/A	
Senegal	REAC	Reactance KOUNOUNE 225 kV	-	25 MVAr	N/A	
Sierra Leone	LI	Freetown-Bumbuna 225 kV		250 MVA		
Sierra Leone	LI	Waterloo-Freetown 131 kV				
Sierra Leone	TF	Kamakwie 225/33 kV	-	40 MVA	2020	CLSG
Sierra Leone	TF	Yiben 225/33 kV	-	40 MVA	2020	CLSG
Sierra Leone	TF	Bumbuna 225/161 kV	-	2 x 70 MVA	2020	CLSG
Sierra Leone	TF	Bikongore 225/33 kV	-	40 MVA	2020	CLSG
Sierra Leone	TF	Kenema 225/33 kV	-	40 MVA	2020	CLSG

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Liberia	TF	Mano 225/33 kV	-	40 MVA	2020	CLSG
Liberia	TF	Monrovia 225/33 kV	-	70 MVA	2020	CLSG
Liberia	TF	Buchanan 225/33 kV	-	40 MVA	2020	CLSG
Liberia	TF	Yekepa 225/33 kV	-	40 MVA	2020	CLSG
Mauritania	LI	Noukchott-Nouadhibou 225 kV	N/A		2020	Double circuit?
Mauritania	LI	Noukchott-St LYess- Tobene 225 kV	N/A		2020	Double circuit?
Nigeria	LI	Owerri-Ahoada-Yenegoa 1x132kv circuit	N/A	N/A	2020	
Nigeria	LI	Alaoji-Umuahia 2x132kV circuits	N/A	N/A	2020	
Nigeria	LI	Mbalano-Okigwe 1x132kv circuit	N/A	N/A	2020	
Nigeria	LI	2nd Benin-Onitsha 1x330kv circuit	N/A	N/A	2020	
Nigeria	LI	3rd Benin - Onitsha 2x330KV circuits	N/A	N/A	2020	
Nigeria	LI	Onitsha - Oba - Nnewi - Ideato-Okigwe 2x132kv circuits	N/A	N/A	2020	
Nigeria	LI	Nsukka - Ayangba 2x132KV circuits	N/A	N/A	2020	
Nigeria	LI	Owerri - Abo Mbaise 2x132KV circuits	N/A	N/A	2020	
Nigeria	LI	Onitsha-Ifitedunu 2x132kV circuits	N/A	N/A	2020	
Nigeria	LI	Umuahia-Ohafia 1x132kV circuit	N/A	N/A	2020	
Nigeria	LI	Umuahia - Mbalano 1x132kV circuit	N/A	N/A	2020	
Nigeria	LI	Ohafia - Arochukwu 1x132kV circuit	N/A	N/A	2020	
Nigeria	LI	Abakaliki - Amasiri 2x132kV circuits	N/A	N/A	2020	
Nigeria	LI	Ugwuaji-Nnenwe 2x132kV circuits	N/A	N/A	2020	
Nigeria	LI	Nnenwe-Mpu 2x132kV circuits	N/A	N/A	2020	
Nigeria	LI	Akure-Ado Ekiti 1x132kv circuit	N/A	N/A	2020	
Nigeria	LI	Tline Ikeja West - Ayobo 2x132kV circuits	N/A	N/A	2020	
Nigeria	LI	Benin North-Oshogbo 2x330KV circuits - 1 circuit LILO at New Akure substation	N/A	N/A	2020	
Nigeria	LI	New Abeokuta - Igboora - Lanlate 2x132kv circuits - Tee-off at Igboora- Igangan	N/A	N/A	2020	
Nigeria	LI	Ganmo -Ogbomosho 2x132kV circuits	N/A	N/A	2020	
Nigeria	LI	Ikorodu - Odogunyan - Shagamu 2x132kV circuits	N/A	N/A	2020	
Nigeria	LI	Omotosho-Epe-Aja 2x330KV circuits.	N/A	N/A	2020	
Nigeria	LI	Oshogbo- Ede 2x132KV circuits	N/A	N/A	2020	
Nigeria	LI	Erukan - Omotosho 2x330KV circuits	N/A	N/A	2020	
Nigeria	LI	Obajana-Okeagbe 2x132kV circuits	N/A	N/A	2020	
Nigeria	LI	Owerri-Ahoada-Yenegoa 2x132kv circuits	N/A	N/A	2020	
Nigeria	LI	Afam-Port Harcourt 2x132kV circuits - LILO at Port Harcourt main TS	N/A	N/A	2020	
Nigeria	LI	3rd Benin - Onitsha 2x330KV circuits	N/A	N/A	2020	
Nigeria	LI	2nd Benin-Onitsha 1x330kv circuit	N/A	N/A	2020	
Nigeria	LI	Afam IV - Afam II 1x132kV circuit	N/A	N/A	2020	

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Nigeria	LI	Alscon - Ibom Power 2x132kV circuits	N/A	N/A	2020	
Nigeria	LI	Obudu - Ogoja 2x132KV circuits	N/A	N/A	2020	
Nigeria	LI	Yenagoa - Oporoma 2x132kv circuits	50	N/A	2020	
Nigeria	LI	Delta-Port Harcourt 2x330kV circuits	N/A	N/A	2020	
Nigeria	TF	330/132/33kV at Onitsha and Benin.	-	150 MVA	2020	
Nigeria	TF	132/33kv at Aboh -Mbaise	-	2 x 60 MVA	2020	
Nigeria	TF	330/132KV at Olorunsogo	-	2 x 150 MVA	2020	provisional
Nigeria	TF	330/132/33kV at Onitsha	-	150 MVA	2020	second additional unit?
Nigeria	TF	132/33kV at Ukpilla, Edo State	-	60 MVA	2020	
Nigeria	TF	Amukpe	-	1x30/40MVA	2020	
Nigeria	TF	330/132/33kV at Afam TS for rehabilitation	-	1 x 150MVA	2020	
Nigeria	SS	Substations Imo - Rivers - Bayelsa States	-	N/A	2020	
Nigeria	SS	Umuahia	-	2x30/40MVA, 132/33kV	2020	
Nigeria	SS	Ideato	-	2x60 MVA, 132/33 kV	2020	
Nigeria	SS	Arochukwu	-	2x30/40MVA, 132/33kV	2020	
Nigeria	SS	Okigwe	-	2x30/40MVA 132/33kV	2020	
Nigeria	SS	Ohafia	-	2x30/40MVA 132/33kV	2020	
Nigeria	SS	Mbalano.	-	2x30/40MVA 132/33kV	2020	
Nigeria	SS	Nnewi	-	2x60 MVA 132kV	2020	
Nigeria	SS	Oba	-	2x60 MVA, 132/33 kV	2020	
Nigeria	SS	Ifitedunu	-	2 x 60MVA 132/33kV	2020	
Nigeria	SS	Amasiri, Afikpo	-	2x60MVA,132/33kV	2020	
Nigeria	SS	Mpu	-	2x60MVA,132/33kV	2020	
Nigeria	SS	Nnenwe	-	2x60MVA, 132/33kV	2020	
Nigeria	SS	Odogunyan	-	2 x 60MVA, 132/33kV	2020	
Nigeria	SS	Ayobo	-	2 x 60MVA, 132/33kV	2020	
Nigeria	SS	New Akure	-	2X150MVA,330/132KV + 2x60MVA, 132/33kV	2020	
Nigeria	SS	Ogbomosho	-	2 x60MVA 132/33kV	2020	
Nigeria	SS	Lanlate	-	2x30/40 MVA, 132/33 kV	2020	
Nigeria	SS	Igangan	-	2x60MVA 132/33KV	2020	
Nigeria	SS	Ede	-	2X60MVA	2020	voltage levels ?
Nigeria	SS	Omotosho	-	2x 150MVA, 330/132KV + 2x60MVA, 132/33kV	2020	
Nigeria	SS	Okeagbe, Ondo State	-	2x60MVA 132/33kV	2020	
Nigeria	SS	Ose LGA Headquarters, Ondo State	-	2x60MVA, 132/33kV	2020	
Nigeria	SS	Calabar	-	2x150MVA, 330/132/33kV	2020	
Nigeria	SS	Ughelli Power Plant	-	1x60MVA	2020	
Nigeria	SS	Ogoja	-	2x30/40MVA, 132/33kV	2020	

Final version

Country	Type	Element	Length [km]	Sizing	Commissioning Year	Comment
Nigeria	SS	Oporoma	-	2x 60MVA, 132/33KV	2020	

Final version

At the helm of the Energy Transition, Tractebel provides a full range of engineering and consulting services throughout the life cycle of its clients' projects, including design and project management. As one of the world's largest engineering consultancy companies and with more than 150 years of experience, it's our mission to actively shape the world of tomorrow. With about 4,400 experts and offices in 33 countries, we are able to offer our customers multidisciplinary solutions in energy, water and infrastructure.

TRACTEBEL ENGINEERING S.A.
Boulevard Simón Bolívar 34-36
1000 - Bruxelles - BELGIQUE
tractebel-engie.com

Laurence CHARLIER
tel. +32 2 476 31 07 92
laurence.charlier@tractebel.engie.com