RENEWABLE ENERGY ROADMAP FOR CENTRAL AFRICA

FINAL VERSION

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List of Abbreviations

CAPP	Central African Power Pool
CEMAC	Economic and Monetary Community of Central Africa
COMIFAC	Central African Forest Commission (Commission des Forêts d'Afrique Centrale)
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
GDP	gross domestic product
IRENA	International Renewable Energy Agency
PV	photovoltaic
RE	renewable energy
SAPP	Southern Africa Power Pool
SPLAT-C	System Planning Test model for Central Africa
VRE	variable renewable energy
SAPP	Southern African Power Pool

Measurements

GW	gigawatt
ha	hectare
MW	megawatt
MWh	megawatt hours
TWh	terawatt hours

Executive Summary

The 2015–17 oil price drop that severely impacted the economies of Chad, the Republic of Congo, Gabon and, to a lesser extent, Angola and Equatorial Guinea serves as a wakeup call to reduce dependency on a small number of export commodities (e.g. crude oil, timber, mining ores). Since then, several countries within the Economic Community of Central African States (ECCAS) have developed action plans to diversify their economies and create industries in an attempt to add local value to their products.

Economic, social and political stability in the region will remain fragile as long as its 100 million inhabitants are excluded from access to electricity. Opening the gateway to clean energy will not only enhance agriculture, industry and mining development; it also will promote inclusiveness and resilience. Access to clean energy will strengthen gender equality, reduce wealth inequity and enhance security.

The new paradigm is to transform Central Africa from a consumer of imported goods and services into one that exports goods of high added value. This can be achieved by strengthening the area's abundant renewable energy (RE) resources at its disposal and enabling these countries to transform rich natural wealth into goods and services for worldwide export. Renewables, therefore, will require a strong and concerted approach in the region, not only to spur growth the technologies but, more importantly, to improve socio-economic patterns.

Policy development and implementation in ECCAS countries, however, are challenges. Not only does the region face serious barriers that prevent integration, but it also lacks standard regulations across borders, there is little exchange of goods due to poor energy and transport networks, and there are few initiatives to enhance border crossings. Compared to other African Regional Economic Communities, the absence of strong institutional, regulatory and policy frameworks hinders ECCAS trade and the free movement of people and goods.

The purpose of this paper is to propose a Regional Renewable Energy Roadmap that will address energy transformation in ECCAS by enabling the region and its member states to effectively reap the benefits of their renewable energy resource potential. In order to achieve this, there are various key activities that are essential:

- Assess the cost-effectiveness of renewable energy with the support of international technical partners;
- Enhance the collection and processing of reliable renewable energy data to enable relevant stakeholders to effectively play an active role throughout the policy development process, and to perform market and socio-economic analyses relating to the deployment of RE;
- Strengthen the technical capacities of relevant national and regional stakeholders so as to establish realistic renewable energy targets, policies and an enabling environment to de-risk the sector as well as attract private investment.
- Boost private participation and financing for renewable energy projects.
- Introduce non-hydro renewables into national and regional planning.
- Build capacities for the development of bankable renewable energy project proposals and their implementation.
- Develop a critical mass of professionals capable of installing, operating and maintaining renewable energy systems.

- Establish a dedicated regional entity to promote widespread use of renewables in a co-ordinated and homogeneous manner throughout the region.

This Regional Renewable Energy Roadmap will require the strong political will of and support from all ECCAS countries for it to achieve its objectives effectively.

Implementation Strategy

Policies and actions outlined in the Roadmap can only be implemented following the principle of subsidiarity. While establishing a regional entity to promote renewables, ECCAS and the Central African Power Pool (CAPP) should develop activities of added value at the regional level. In tandem, each member state is encouraged to develop their National Renewable Energy Policy and Action Plan. The Renewable Energy Roadmap will ensure the following:

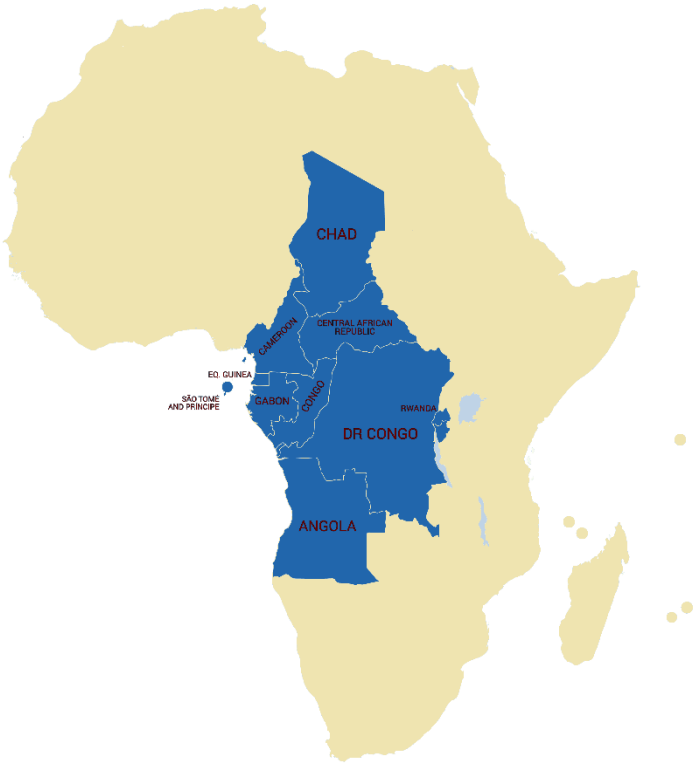
- Consistency between regional and national renewable energy policies.
- Ability of each member state to create and implement a National Renewable Energy Policy.
- Ability to attract local private sector investment in renewable power generation activities, including the production of equipment.
- Capacity development and training to create a critical mass of technicians, policy makers and other facilitators.
- Create an enabling environment for the private sector, including the areas of industry and banking, through financial intermediaries.
- Advocacy, awareness and knowledge sharing.

1. Introduction

1.1. Regional Background

The Economic Community of Central African States (ECCAS) is comprised of 11 member states. These are Angola, Burundi, Cameroon, Central African Republic, Chad, the Democratic Republic of Congo, the Republic Congo, Equatorial Guinea, Gabon, Rwanda and São Tomé and Principe. It has an area of nearly 6.7 million square kilometres and a population of approximately 160 million. The region is served by the Congo Basin, the second largest tropical rainforest in the world, with an abundant source of water (Table 1).

Figure 1: Map of the Economic Community of Central African States



Disclaimer: Boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

Central Africa is a paradoxical region in terms of energy. While most of its population lacks modern energy services, it has the most energy resources on the African Continent, with a 58% hydroelectrical potential and other primary energy resources that include oil, natural gas, uranium, biomass and geothermal, as well as solar and wind energy. Petroleum and biomass products, however, represent the main sources of energy.

Table 1. Geographic Overview of Central Africa

Area	6 600 600 square kilometres
Population	160 million

Forest	- 204 million hectares (ha) of moist forest with 12 million cubic metres of wood/year - 18.5 million ha of protected area comprises 10% of the sub-region - Abundant land resources: 27 061 million ha
Arable Lands	- Grazing land: 155 952,000 ha - Coastline: 1 200 kilometres
Hydrology	- Congo River Basin (second largest in the world) - Lake Chad Basin - 16 rivers shared with 7 trans-boundary basin organisations; - 5 lakes, with Tanganyika and Lake Chad being managed; - 15 wetlands listed under the Ramsar Convention[1]

Source: Author.

Of the 11 ECCAS member countries, seven (i.e. Angola, Cameroon, Chad, the Democratic Republic of Congo, the Republic of Congo, Equatorial Guinea and Gabon) are net exporters of energy (crude oil products) or have a high level of energy independence. Hydropower potential is approximately 150 000 megawatts (MW), with the Democratic Republic of Congo hosting two-thirds of the potential, followed by Cameroon with about one-sixth. The remaining 25 000 MW is shared among other member states. Hydropower resources of the region alone would be sufficient to meet the power needs of the entire African continent (Table 2). Across the region, solar, wind and geothermal potentials remain untapped due to an absence of appropriate policies, strategies and programs at the national and regional levels. Jointly with the Economic and Monetary Community of Central Africa (CEMAC), ECCAS is committed to develop a regional policy on which legislation, strategic planning and operational management of interventions in the energy sector will be based. ECCAS also intends to follow up on the interest of donors present at the Donors' Roundtable meeting on the energy sector in Central Africa, which was held in Brussels on 17 June 2016.

[1] The Ramsar Convention on Wetlands of International Importance is an international treaty for the conservation and sustainable use of wetlands

Table 2. Overview of the Energy Potentials of Central Africa

Energy potential	- The second largest tropical rain forest in the world - Hydropower: over 150 000 megawatts, with a potential for approximately 58% across Africa - 15% of African oil reserves (20 billion barrels) - Of the 11 ECCAS member states, 7 are net exporters of energy (crude oil products): Angola, Cameroon, Chad, the Democratic Republic of Congo, the Republic of Congo, Equatorial Guinea and Gabon. - Important oil and natural gas reserves - Solar irradiation between 5 kilowatt hours and 7.5 kilowatt hours per square metre/day - Small and micro hydro potential on tens of thousands of sites - Geothermal potential along the border between Burundi, the Democratic Republic of Congo and Rwanda - Methane gas in Lake Kivu - Large availability of residual biomass (forestry and agriculture) and urban waste from large cities: Brazzaville, Douala, Kigali, Kinshasa, Libreville, Luanda, Yaoundé, among others - Wind potential in Angola, Cameroon and Chad

Source: Author.

While non-hydro renewables, such as solar photovoltaic (PV), wind and bioenergy, offer significant potential for capacity addition, they nevertheless represent a relatively small share compared to hydropower. Despite the current low level of installed non-hydro renewable power, however, analyses carried out by the International Renewable Energy Agency (IRENA) suggest that the region's cumulative technical potential for solar, wind and biomass[2] stands at 3 868 terawatt hours (TWh) when compared to the region's approximate projection of 85 TWh electricity consumption for 2030 (Table 3).

[2] Biomass data represent conservative technical potential for co-generation, based on analysis in IRENA (2014a) and IRENA (2014b). Concentrated solar power, solar PV, and wind data are based on unpublished updates of IRENA (2014a), which apply exclusion criteria (e.g. geographic, technical, ecological, legislative) to theoretical RE potentials derived from high-resolution solar irradiation and wind speed datasets. The potential displayed may underestimate actual potential in some areas due to conservative assumptions regarding land use. Nevertheless, they are sufficiently vast that no country in the region would be expected to reach its resource constraint by 2030.

Table 3. Potential Technical Estimates for Renewable Energy in Central Africa (terawatt hours)

	Biomass	CSP	Solar PV	Wind
Angola	13	193	418	92
Burundi	4	3	12	1
Cameroon	23	38	125	13
Central African Republic	19	116	264	28
Chad	3	403	752	588
Congo, Democratic Republic of	144	118	350	43
Congo, Republic of	16	0	39	4
Equatorial Guinea	1	0	2	0
Gabon	10	0	17	0
Rwanda	2	2	10	0
Total	**234**	**874**	**1 989**	**771**

Source: IRENA analysis.

São Tomé and Principe is not included due to lack of data.

The figures in Table 3 refer to technical potentials and, as such, may not be suitable for deployment. They remain, however, highly substantial, given that total electricity consumption in Central Africa is projected to increase to approximately 85 TWh by 2030.[3]

1.2. Drivers for the Development of Renewable Energy in the Region

On a global level, many drivers exist to stimulate actors to support the deployment of renewable energy (RE) technologies. Aspects such as climate change mitigation; reduction of local air pollution and its underlying benefits for public health; energy security; access to modern energy sources for electricity; clean cooking and heating sub-sectors; financial advantages; and the creation of local economic value and jobs are few examples.

1.2.1. Electricity access rate improvements

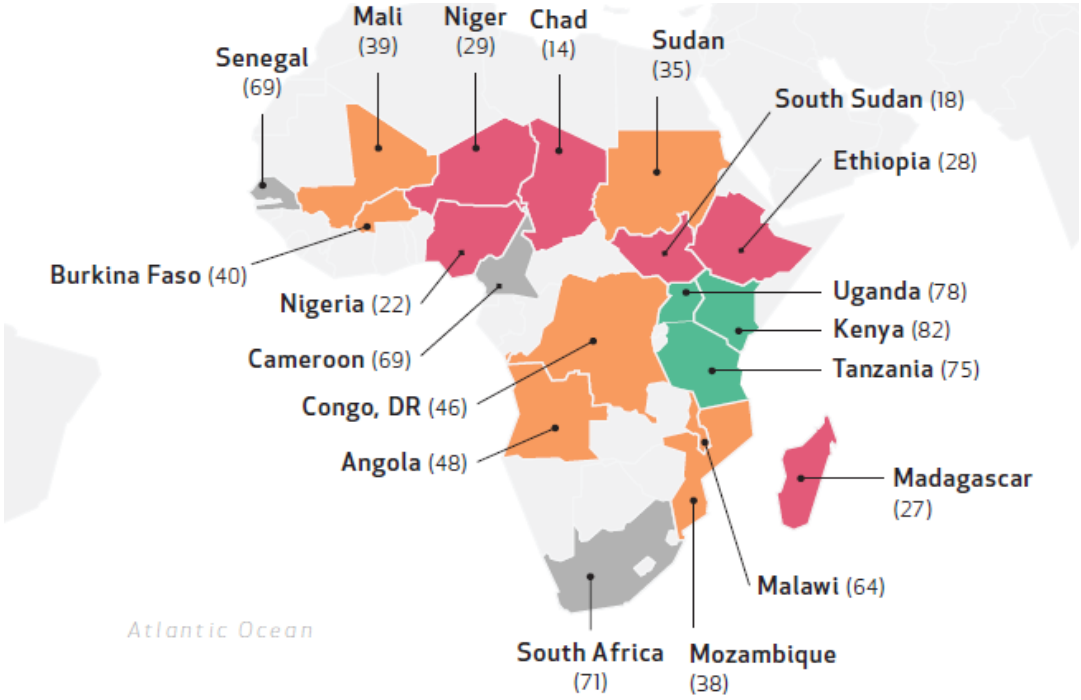
Compared to other parts of the world, Central Africa has a large energy resource endowment, well above the needs of the population. Despite this, however, its population is the most underserved in terms of access to modern energy services, such that

- average per capita consumption is around 167 kilowatt hours a year;
- the electrification rate (at approximately 25%) is the lowest in Africa, with more than 125 million people having no access to electricity;
- the power supply is unreliable, with the region experiencing frequent blackouts and national grids loosely interconnected to help improve power supply reliability; and
- the population continues to rely on traditional biomass (80%) to meet energy needs, despite the heavy environmental, social and economic burdens associated with the consumption of wood.

[3] Ibid.

Energy access is widely recognised as essential to improve economic welfare. Access to reliable, cost-effective and environmentally sustainable energy through renewable energy technologies can have a multiplier effect on development, such as reduced health effects, improved livelihoods, poverty alleviation, job creation, gender equality and enhanced access to water and food. These crosscutting impacts of renewable energy are at the heart of efforts to achieve the Sustainable Development Goals of the United Nations. In terms of a regulatory framework, the region is credited with an overall low score based on the World Bank's Regulatory Indicators for Sustainable Energy scorecard (RISE).[4]

Figure 2. Overall Energy Access Score of Central Africa, Based on the Regulatory Indicators for Sustainable Energy Scorecard



Source: Sustainable Energy for All

Disclaimer: Boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

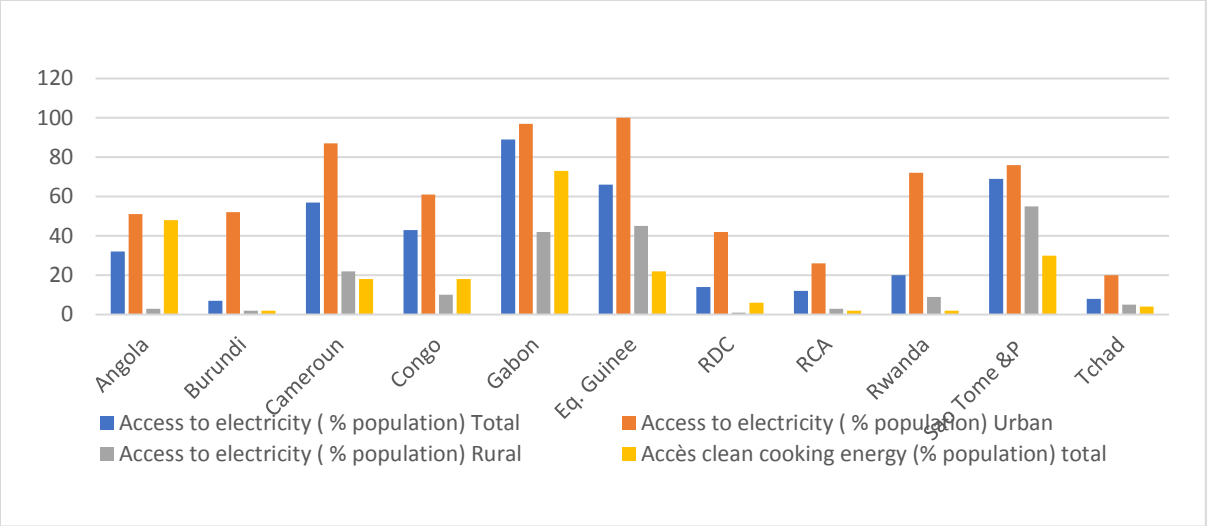
Key

Green: Countries with scores between 67 and 100 points
Grey: Country received a high score on RISE but is not a high-impact country for electrification
Orange: Countries with scores between 34 and 66 points
Red: Countries with scores lower than 34

Figure 3 provides an overview of the percentage of population with access to electricity and clean cooking energy, according to SE4All tracking data and the RISE scorecard.

Figure 3. Access to Modern Energy Services in Central Africa, 2014

[4] RISE scores reflect a snapshot of a country's policies and regulations in the energy sector, organised by the three pillars of Sustainable Energy for All (SE4All), an international organisation to help mobilise achievement of universal energy access, improve energy efficiency, and increase the use of renewables. Indicators are assigned to each pillar to determine the scores.



Source: Compiled from the World Bank's 2017 Regulatory Indicators for Sustainable Energy (RISE) scorecard.

Cameroon, Gabon, Equatorial Guinea and São Tomé and Principe present a level of urban electrification rates above 50%. The level of rural electrification is also higher in these countries, reflecting the political will of public authorities. Rwanda currently is promoting the development of solar and modern biomass (peat) to meet its goal of universal access to electricity. Sustained efforts are expected from Angola, Chad and the Republic of Congo to intensify their rural and urban electrification by allocating a portion their significant revenues from oil and gas to this endeavour. As seen by the electrification rates, the level of consumption in the region has the potential to grow significantly in most countries, even without considering economic growth, as access improves. This, together with a reduction in the level of losses in the system (over 20% of regional net production as of 2015) remain pressing challenges. Increased political stability in Burundi, the Central African Republic and the Democratic Republic of Congo would improve energy governance and mobilise the necessary funding to ramp up currently low electrification rates. The region has the potential to transition its power sector towards 100% renewables by tapping into its vast hydro and solar resources and by processing waste biomass.

1.2.2. Energy supply diversification

At present, thermal and large-scale hydropower plants are the main sources of electricity supply, while wood and charcoal provide more than 80% of cooking fuel. There are not yet utility-scale solar and wind plants in operation in the region.

RE could provide the most competitive form of power in Central Africa due to today's advanced technological reliability, declining technology costs and high resource potential. In terms of planning, hydroelectricity remains the main source, with large-scale projects such as the 40-gigawatt (GW) Inga hydroelectric project on the Congo River of the Democratic Republic of Congo and projects in Angola, Cameroon, the Republic of Congo and Gabon. Small-scale hydro is promoted as a viable option for rural electrification and agricultural and industrial use. Nevertheless, variable renewable energy options − thanks notably to their modular nature among others − present a series of comparative advantages as they tend to be (i) faster to implement; are closer to the effects of demand (reducing system losses and transmission costs); and require lower investment packages, thus making them more suitable to the financial capability of regional/local entrepreneurs and financial institutions.

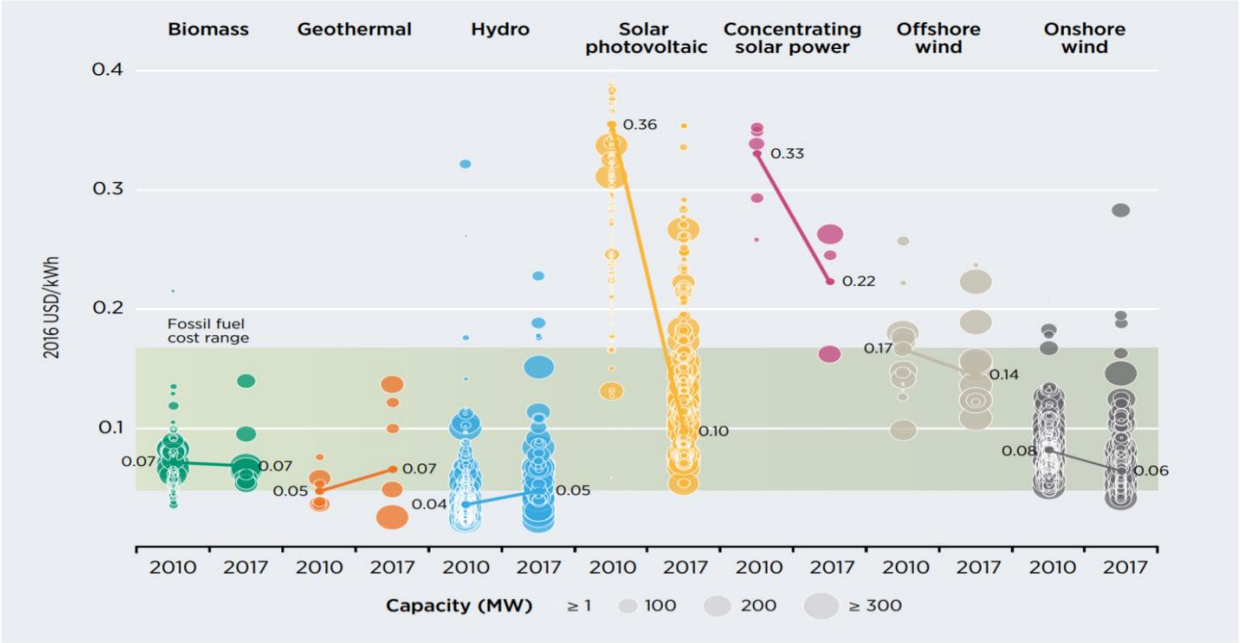
1.2.3. Low-carbon development pathways

The combustion of fossil fuels and traditional use of bioenergy is a major source of local air pollution, with sulphur dioxide, nitric oxide and microparticles some of the main pollutants. These pollutants can cause adverse human health effects, although they also can reduce agricultural yields, devastate forests and fisheries (acid rain) and damage buildings and infrastructure. The majority of adverse impacts, however, are evident on human health. Worldwide, some 8 million people a year die prematurely from indoor and outdoor air pollution caused by energy consumption for heating, cooking, power generation and transport. Unlike fossils fuels, renewable energy technologies offer the opportunity to move away from carbon-intensive systems and lead countries towards meeting climate objectives.

1.2.4. Economic reliability

RE technologies tend to be less expensive over the project lifetime than fossil fuel-powered generation. These costs also have been decreasing over the years, as can be seen from the graph below.

Figure 4. Global Levelised Cost of Electricity from Utility-Scale Renewable Power Generation Technologies, 2010–17



Source: IRENA (2018a)

In addition to falling costs, renewable energy technologies present an opportunity to reduce operational costs to a minimum by doing away with reliance on imported fossil fuels and exposure to volatile international markets. Globally, public and private actors are increasingly viewing renewable energy as a profitable investment that will provide higher revenues than other fuels. In several countries, renewables are or are becoming cost-competitive with other sources, even when not considering the negative externalities of fossil fuels and nuclear energy or the fact that fossil fuels receive four times the subsidies to renewables. Record-low prices for renewables are emerging at auctions, and these prices are often lower than those for fossil fuels. The short gestation period for

renewables and long-term fixed-price contracts provide strong incentives to invest in renewable energy over other sources.

1.2.5. Socio-economic value creation

Accelerating the deployment of renewable energy will fuel economic growth, create new employment opportunities, enhance human welfare, and contribute to a climate-safe future. Advances in renewable energy technologies and growing cost-competitiveness have strengthened the business case for renewables and opened new opportunities for countries to transform their energy systems. The benefits of scaling up renewable energy surpass cost competitiveness. Increased deployment can meet the energy needs of a growing population, drive development and improve well-being, while reducing greenhouse gas emissions and increasing natural resource productivity. An analysis of the job creation potential of renewable energy in the Central African context is outlined later in this document.

2. Power Supply and Demand

2.1. Status of the Power Sector

Total net electricity consumption in the region in 2015 amounts to roughly 26 TWh, nearly a 40% increase from 19 TWh in 2010, after an average annual growth rate of 6.6% over the five-year period (UN, 2015). Over that same period, Angola has seen the fastest rate of growth in consumption, at an annual average of 13%. Four countries, namely Angola, Cameroon, the Democratic Republic of Congo and Gabon, account for more than 90% of total regional demand and a similar level of total production. Table 4 shows electricity statistics in the region as of 2015.

Table 4. Electricity Supply and Demand in Central African Power Pool Countries, 2015[5]
(gigawatt hours)

	Total Production	Own Use	Net Production	Imports	Exports	Losses	Consumption
Angola	9 764	241	9 523	0	0	1 100	8 423
Burundi	166	8	158	96	0	0	258
Cameroon	6 758	66	6 692	1 414	0	2 322	5 784
Central African Republic	171	0	171	0	0	10	161
Chad	228	13	215	0	0	0	215
Congo, Dem. Rep. of	8 942	647	8 295	20	422	1 260	7 266
Congo, Republic of	1 734	194	1 540	18	22	772	796
Equatorial Guinea	939	40	899	0	0	116	783
Gabon	2 126	95	2 031	337	0	475	1 893
Rwanda	524	23	500	42	3	121	419
São Tomé and Principe	70	0	70	0	0	17	53
Total	**31 352**	**1 327**	**30 024**	**1 927**	**447**	**6 176**	**25 998**

Source: United Nations (2015), *2015 Energy*

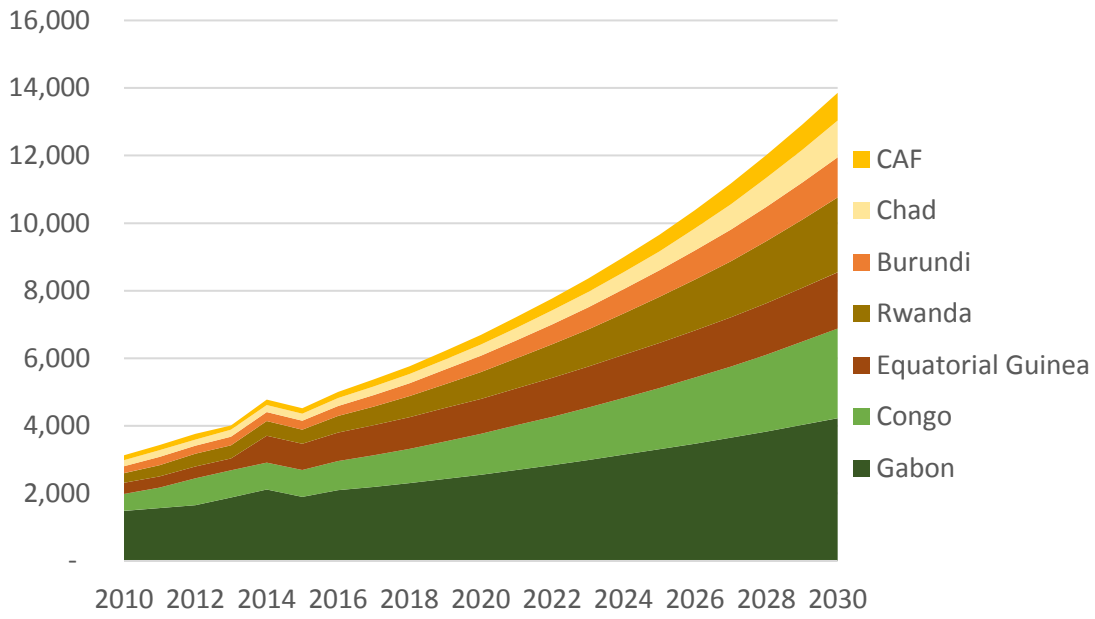
[5] During the validation meeting, some countries requested an update of the figures listed in the table but were unable to provide data that was more reliable than the 2015 figures. For this reasons, 2015 was kept as base year for all countries

Consumption growth here represents, in many cases, the expansion of electricity supply to existing demand from national populations, which was previously unmet.

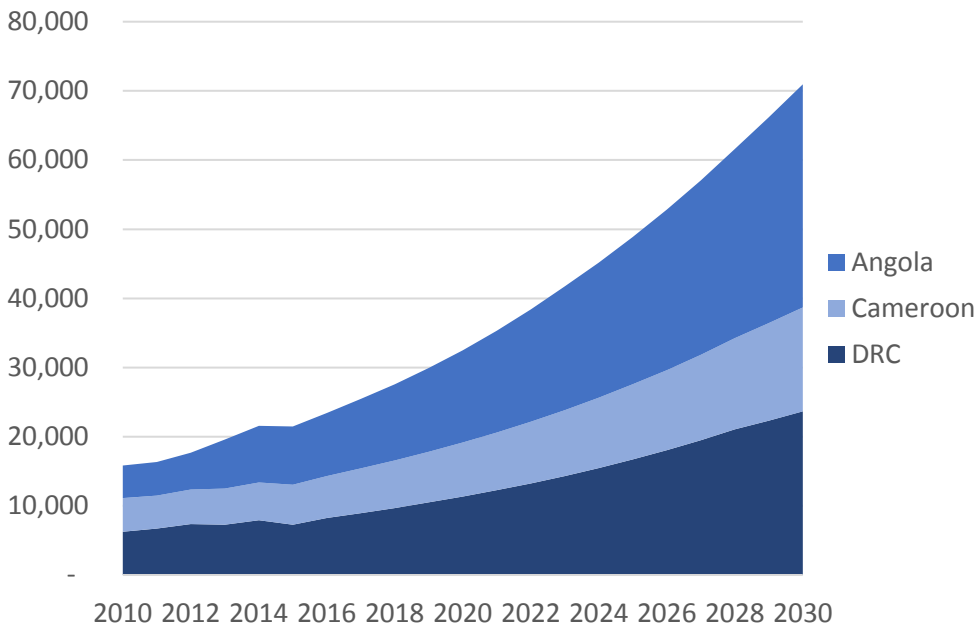
The figure below displays historic electricity demand in the region since 2010, along with future projections used in the analysis presented in Chapter 4 of this report.[6] Total consumption in the Central African region is projected to roughly triple from current levels, to more or less 85 TWh by 2030.

Figure 5. Final Electricity Demand in Central Africa: Historical as of 2015, Projections and Thereafter
(gigawatt hours)

(A)



[6] Electricity demand growth rates used for this study were drawn from NEPAD/AU/AfDB (2011). This work contains country-level electricity demand projections between 2007 and 2040 based on underlying assumptions of gross domestic product (GDP) growth, industrialisation prospects, population growth, energy access rates, and expansion of grid-connected electricity. NEPAD/AU/AfDB (2011) states, "GDP growth scenarios are based on a projected average annual growth rate of 6.2% for Africa. The annual growth rate is differentiated by country based on the PIDA Country macroeconomic projections." Electricity access rates for CAPP countries are assumed to increase from an average 20% in 2010 to 54% by 2030. See reference for further details. As the base year for the reference projections is 2007, there are discrepancies in some countries between the projected demand and actual historical demand for the period 2007–10. In such cases, the projections were calibrated to actual 2010-base year data (according to final consumption statistics from the United Nations Energy Statistics Database).



Source: IRENA Analysis

As of 2015, imports made up 6% of production in the region. Import dependency, however, has historically been high in selected smaller countries (e.g. Burundi and Rwanda). Notably, Burundi, the Democratic Republic of Congo and Rwanda are part of the Eastern Africa Power Pool interconnected system, and the three countries share interconnection capacity as well as the use of several hydropower generation sites. In the Central African Power Pool (CAPP), the Democratic Republic of Congo shares an interconnection with the Republic of Congo, and the country also has links to the Southern Africa Power Pool (SAPP) though Zambia.

Table 5 and Figure 6 capture the existing power generation capacity in the region by country and type. The generation capacity data behind this analysis is largely based on the UDI World Electric Power Plants database, complemented by in-house IRENA research.

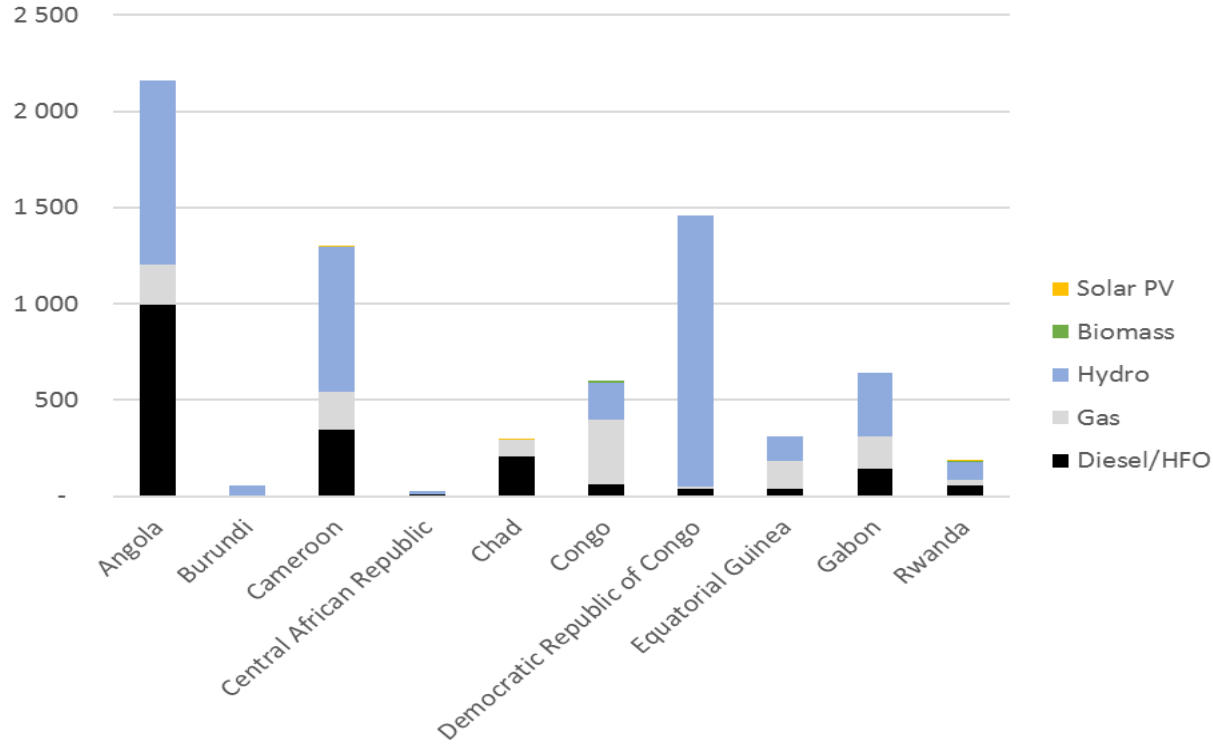
Table 5. Existing Power Generation Capacity in Central African Power Pool Countries as of 2015 (megawatts)

	Oil	Gas	Hydro	Biomass	Solar	Wind	Total
Angola	997	205	957	0	0	0	2 159
Burundi	6.1	0	50	0	0	0	56
Cameroon	344	201	755	0	0	0	1 300
Central African Republic	7.4	0	19	0	0	0	26
Chad	205	90	0	0	0	0	295
Congo, Dem. Rep. of	38	15	1 404	0	0	0	1 457
Congo, Republic of	60	350	194	8.5	0	0	600

Equatorial Guinea	38	147	127	0	0	0	313
Gabon	144	170	331	0	0	0	645
Rwanda	58	29	95	0.8	9	0	191
Total	**1 898**	**1 205**	**3 931**	**9**	**9**	**0**	**7 053**

Source: IRENA analysis, incorporating data from S&P Global (2018)

Figure 6. Existing Power Generation Capacity as of 2015: Central Africa (megawatts)

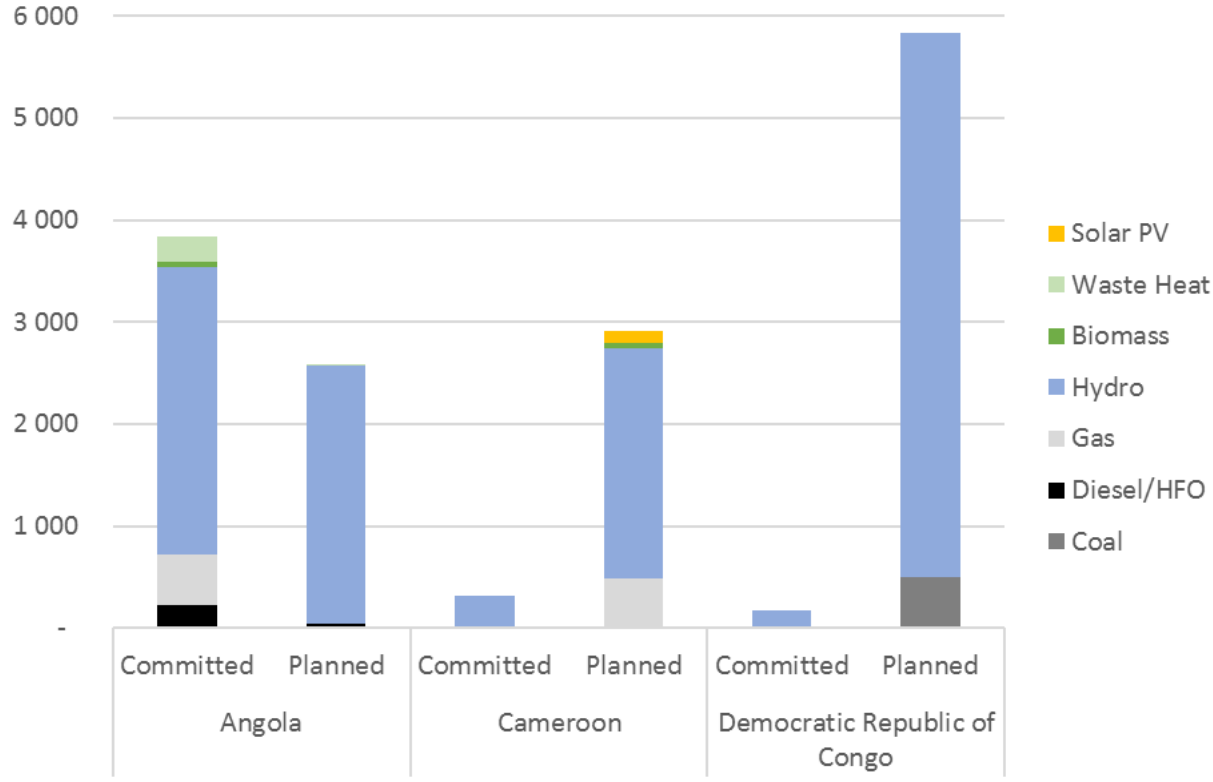


Source: IRENA analysis, incorporating data from S&P Global (2018)

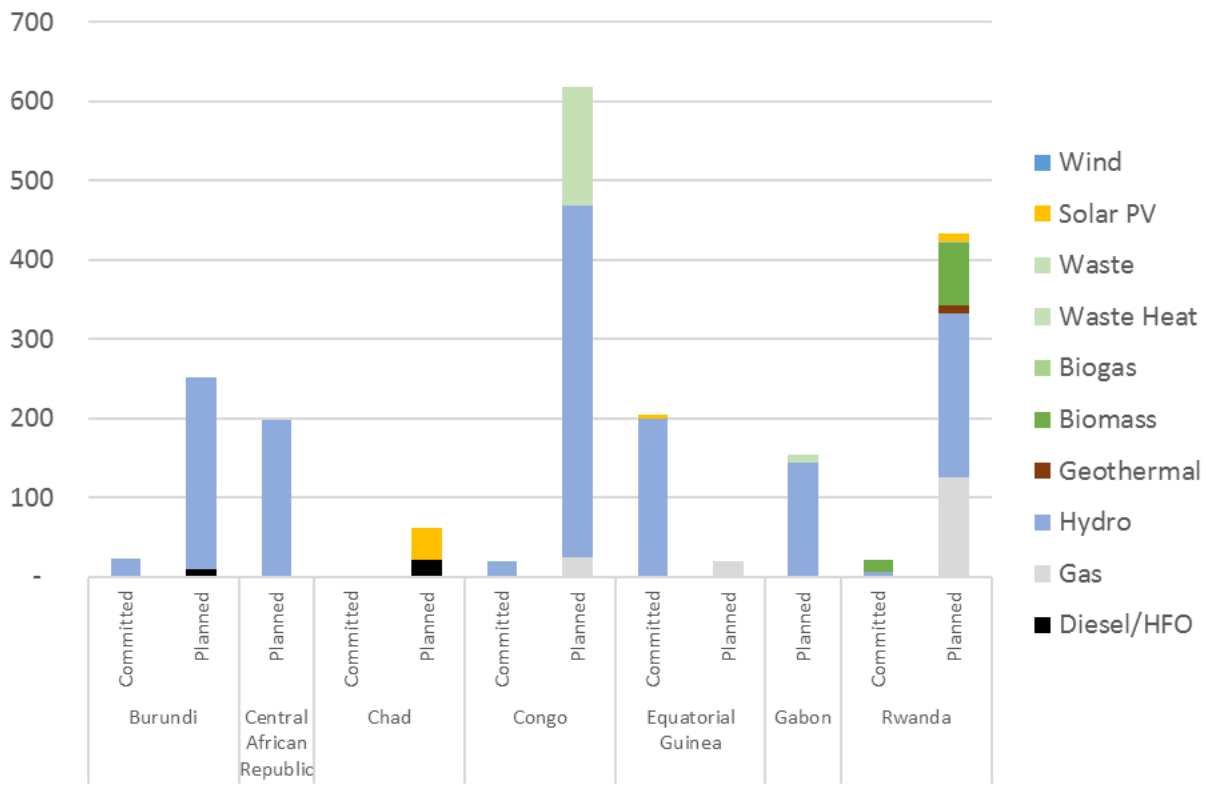
The region's total installed capacity, according to available data, is approximately 7 GW as of 2015, generating around 31 TWh of the electricity discussed earlier. A substantial amount of installed capacity in the region is not currently operating at full strength due to lack of maintenance or contractual and other issues; the figures shown here attempt to reflect this to the extent possible, reflecting capacity on line as of 2015. Hydropower makes up over 50% of the region's overall capacity and represents most of capacity in all countries except for Angola, Chad, the Republic of Congo and Equatorial where thermal capacity, such as oil/diesel/gas-fuelled turbines, holds a greater share. Most hydropower in the region belongs to the Democratic Republic of the Congo at 1.4 GW, half of which originates from the site at Inga Falls on the Congo River. Angola and Cameroon follow, with 957 MW and 755 MW, respectively. These three countries – Angola, Cameroon, and the Democratic Republic of Congo – account for 70% of installed capacity in the region. While there are small amounts of non-hydro renewables installed as of 2015, their presence is minor. To provide a view of the power generation infrastructure in the region's pipeline, Figure 7 displays

committed and planned capacity by type and country.[7]

Figure 7. Committed and Planned Power Generation Capacity as of 2015: Central Africa (megawatts)



[7] Statistics as of 2016, with 2015 as base year; for example, committed capacity could have been installed in 2016/17. As with existing capacity data, the committed and planned capacity data behind this analysis is largely based on the S&P World Electric Power Plants database, complemented by in-house IRENA research.



Source: IRENA analysis, incorporating data from S&P Global (2018), "World Electric Power Plants" (database), https://www.platts.com.es/products/world-electric-power-plants-database.

In terms of geographic distribution, as is the case with existing capacity, the three largest development pipelines are in Angola, Cameroon and the Democratic Republic of Congo. Together, they cover 89% of total committed and planned capacity in the region.

Based on these figures, hydropower clearly remains an important element in the region's planned power infrastructure development, representing 77% of 4.6 GW committed capacity as of 2015 and 87% of 13 GW planned capacity (i.e. potential projects without concrete commissioning dates). Of the planned hydropower capacity shown, 42% comes from one site alone, the widely discussed 4.8-GW Grand Inga Dam in the Democratic Republic of Congo. While this project – which represents only the first stage of a larger, more speculative development plan with approximately 40 GW of potential and several export opportunities – was initially meant to be commissioned by the early 2020s, it has now been delayed until around 2025 at the earliest. The second largest amount of capacity in the pipeline would come from thermal plants, although there notably would be – at least in terms of large-scale plans – much less oil/diesel-fuelled capacity in the overall mix than presently exists.

While non-hydro renewables, such as solar PV, wind, and bioenergy have greater absolute capacity amounts in the development pipeline, they nevertheless represent a relatively small share compared to hydropower. Despite the current level of installed non-hydro renewable power, however, there is clearly a substantial opportunity to further develop renewable resource potential in the region.

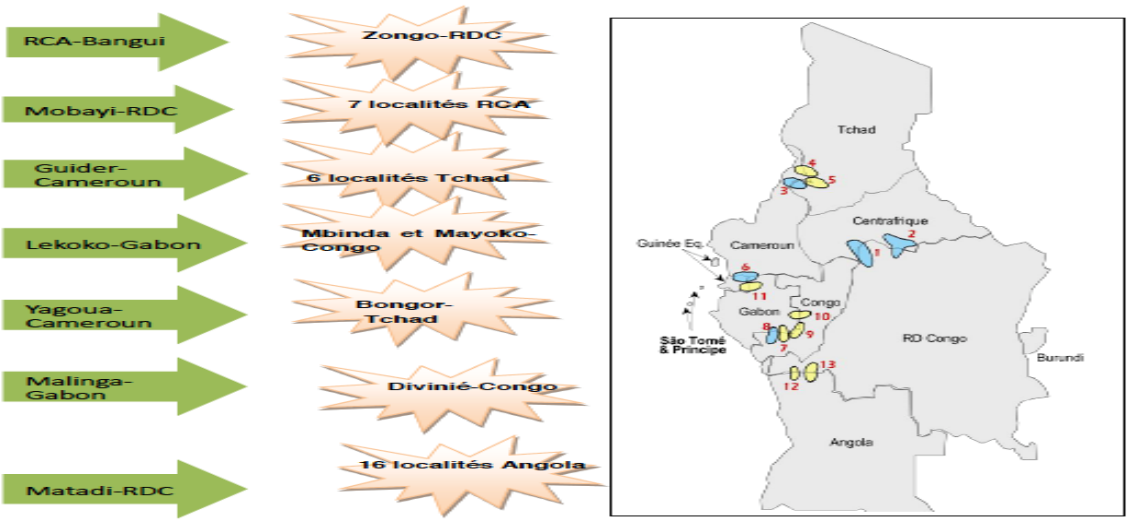
2.2. The Challenges of Power Infrastructure

Development of electricity systems in the region faces several challenges, which are as follows:

- Low performance of thermal power plants and frequent recourse to expensive fuel.
- Significantly few combined cycles.
- Insufficient availability of inputs, water or heat, as well as low load factor compared to installed capacity.
- Insufficient power transport networks and obsolescence of distribution networks. The technical and commercial losses exceed around 25%, sometimes reaching 60% (e.g. Republic of Congo).
- Frequent power cuts and a high rate of undistributed energy.
- Significant non-technical losses due to, for example, lack of electricity metres, unpaid bills by public administrations, among other causes, creating heavy financial losses for electricity companies.
- Lack of master plans of the generation, transmission and distribution or specific plans for the continuation of network expansion or rural electrification.
- Lack of energy information and reliable tariff systems.
- Most of the electricity sector regulatory authorities are neither functional nor independent, since they rely on the royalties of electricity companies.
- Institutions in rural electrification lack the resources and expertise to design, finance, implement and monitor rural electrification master plans.

The region urgently needs to address these limitations. It should also invest massively in modern transmission and distribution infrastructures, as well as mini grids for isolated areas.

Figure 8. Cross-Border Projects Promoted by The Central African Power Pool



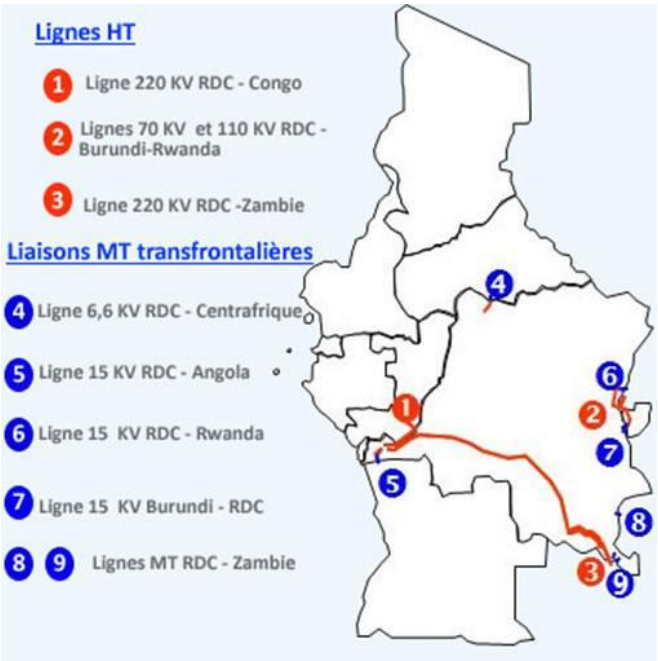
Source: CAPP (2016)

Disclaimer: Boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

CAPP has the mandate to promote electricity interconnection and the development of cross-border projects for rural electrification. With regard to the development of renewables, CAPP recommends that the efforts must concentrate first on small hydro, solar or other forms of renewables, taking the relay only where the hydro resource does not exist.

In the field of cross-border electrification with the use of renewables, CAPP has already identified several sites for small hydro power to allow the interconnection of rural areas across several countries. While CAPP is highly motivated to promote renewables, it lacks the financial means and human capacity to execute its cross-border projects. The long-awaited contribution from the region's power utilities to enable CAPP to conduct its mission is slow to materialise. The only high voltage interconnected networks are those of the Angola/Democratic Republic of Congo, Democratic Republic of Congo/the Republic of Congo; and the the Democratic Republic of Congo/Burundi. Moreover, there are medium-voltage connection of the Democratic Republic of Congo and Angola, Burundi and the Central African Republic.

Figure 9. Cross-Border Projects Promoted by the Central African Power Pool



Source: CAPP (2016)

Disclaimer: Boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

The weak infrastructure of national networks and regional interconnected systems make the cost of electricity significantly high. In the Republic of Congo, half of the produced electricity is lost as a result of, amongst others, the poor state of the distribution network as well as the lack of metering on the transmission and distribution networks. In some countries, the impact of power cuts is more than 4% of GDP. Security of energy supply is also a major concern for large and small businesses that face additional costs due to an unreliable electricity supply.

3. Existing Institutional and Policy Frameworks

3.1. Regional Institutional Framework

Economic Community of Central African States

ECCAS brings together the 11 countries of Central Africa. Under its auspices, as well as under those of CEMAC, regional energy co-operation aims to harmonise and co-ordinate policies and activities, in particular the following:

- Hydro-electricity: Co-operate in terms of inventory, planning and production, as well as in the development, operation and logical distribution of hydroelectricity from main river basins and their tributaries.
- Other sources of renewable energy: Co-operate in terms of research and development relating to cross-border electrification from solar, wind, geothermal and biomass energy.

Achievements to date at the institutional level are the

- creation of CAPP in April 2003;
- adoption of the Electricity Market Code in October 2009;
- adoption by Heads of state and governments of the ECCAS and CEMAC energy sector White Paper in May 2015;
- adoption of the CAPP strategic regional energy policy document in December 2014;
- Declaration of ECCAS Ministers on the development of a Central Africa Green Economy;
- creation by ECCAS Heads of State and governments of the Fund for Green Economy in Central Africa (Fonds pour l'économie verte en Afrique centrale, or FEVAC);
- Realization of the studies of the priority projects: - Study of interconnection of the electrical networks of the States of Central Africa - Priority Integrator Projects - cross-border electrification - Priority integrators Project of Great Lakes 2

Central African Power Pool

The regional approach of the ECCAS/CEMAC vision and energy strategy is articulated around CAPP, a specialised agency of the Economic Community of Central African States, created in 2003. It is responsible for the implementation of energy policy; co-ordination of regional infrastructure expansion (power network and generation plants); and establishment of legal, technical and commercial conditions to increase electricity investment and trade. CAPP is mandated to put in place a regulatory body for the electricity market in the region. Its main objectives are to

- secure the supply of electrical power to member countries;
- facilitate and co-ordinate the implementation of power infrastructure projects;
- improve the integration of ECCAS member country markets so as to create a regional electricity market; and
- increase the rate of electrification in the region to be able to meet electricity demands.

Energy of the Great Lakes

The creation of Energy of the Great Lakes in 1974 as an association resulted from the Study of the Electrification of the Great Lakes Region (EGL, 2015). Its mission is to ensure co-operation between the member states of the Economic Community of Great Lakes Countries (Burundi, the Democratic Republic of Congo and Rwanda), created in 1976, in the energy sector according to the following activities:

- Co-ordination of regional planning of the energy sector and the analysis of each member country's energy policy so as to synergise energy resource policy for the region.
- Design and monitoring of regional energy projects.
- Provision of training, capacity building and sharing of information so as to strengthen national capabilities in the planning and management of projects.
- Construction of the Ruzizi III and Ruzizi IV hydro power stations on the Ruzizi River;
- Promotion of private sector investment for the construction and operation of the Ruzizi III and Ruzizi IV power stations;
- Extension, rehabilitation and stabilisation of the interconnected power systems of the Economic Community of Great Lakes Countries, which form the backbone of the electricity exchange and market network in East Africa.

Central African Forest Commission

The Central African Forest Commission (Commission des Forêts d'Afrique Centrale, or COMIFAC) is the main agency responsible for the conservation and sustainable management of forest ecosystems and savannas of the Congo Basin. COMIFAC, which depends on support from multiple sources, implemented a program in 2009 to support the conservation of ecosystems in the Congo Basin, namely the Congo Basin Ecosystems Conservation Support Programme. The programme is co-financed by the African Development Bank and ECCAS (COMIFAC, 2018). With regard to biomass, COMIFAC has the ability to modernise the biomass energy sector.

At the national level, there is a limited number of relevant institutions responsible for the promotion of renewables. These are listed in Annex 1.

3.2. Policy Frameworks

3.2.1. Regional Policies

ECCAS Green Economy and Renewable Energy Vision

The ECCAS Green Economy and its renewable energy vision were adopted in May 2015 by ECCAS ministers of Environment and Sustainable Development. They constitute several programs aimed to fulfil and contribute to SE4ALL, including renewable energy targets. In addition, the Central African Green Economy Fund was adopted. There is evidence, however, that should the vision constitute a strategic framework and a strong political signal to develop renewables, effective measures are essential to promote renewable energy penetration for which initial capital will prove to be a significant challenge from potential investors.

ECCAS' Vision 2025

Adopted in 2007, the ECCAS Vision 2025 has as its main objective "making the region an area of peace, solidarity and balanced development."

ECCAS and CEMAC have identified energy as one of the pillars for growth in ensuring that Central Africa becomes an energy power that is capable of meeting the demands of the entire sub-region. According to the 2010–15 Regional Economic Programme, the CEMAC economy should be based on three pillars which include energy; agriculture and forestry; and mining and metallurgy. The ambitions of CEMAC are to increase installed power generation capacity of 25 000 MW by 2025 from 6 000 MW in 2012, including the establishment of hydroelectricity and gas-fired power stations.

ECCAS recognises the need to develop and implement policies and projects that will promote renewable energy (small hydro, biomass, solar) and energy efficiency. This can be done by reducing electricity transmission losses, upgrading or replacing generation equipment and recovering associated gases in oil fields.

For ECCAS and CEMAC alike, energy is considered one of the pillars for economic growth to ensure the sub-region's self-sufficiency, based on affordable and abundant energy services. The White Paper became the result of each entity's Vision 2025.

White Paper of the Economic Community of Central African States and Economic and Monetary Community of Central Africa

Emphasis should be placed on harmonising the objectives of ECCAS and CEMAC in terms of regional policy and strategy. As such, ECCAS and CEMAC released a White Paper in May 2015, providing a common vision to ensure that by 2030, there is universal access to modern energy services, particularly in Central Africa in terms of its sustainable and human development (ECCAS and CEMAC, 2014).

The vision: The White Paper has three guiding principles that support the common vision: (i) good governance at the regional, national, and local levels; (ii) energy security and the development of renewables, in particular hydro-electricity; and (iii) inclusive development and the reduction of poverty. The White Paper reflects the ambitions of member states to achieve by 2030 the objectives set out by SE4All.

The potential: The ecosystem of the ECCAS/CEMAC region, located in the Congo Basin, is essential for the rest of the planet. This area represents the second largest tropical rainforest area in the world and is home to not only a large water resource but also an abundance of energy resources such as oil, natural gas, uranium, hydropower, biomass, and other renewable potential.

The shortcomings: Approximately 125 million people in Central African have no access to electricity services. Only three countries in this region had a rate of electricity access above 50%. More than 112 million people had no access to modern fuels for cooking, 61 million of whom are in the Democratic Republic of Congo.

The objective: The White Paper presents a goal of 54% access to electricity by 2030; this implies servicing an additional 63 million inhabitants between 2014 and 2030. To achieve this, the production

capacity for renewable energy must be expedited to include hydro-electricity and biomass, as well as other renewable energy resources such as solar PV for rural populations. Installed capacity by 2030 should exceed 15 700 MW, with 30 000 MW by 2040.

The financing: New-generational capacities are only possible with the input of approximately USD 68 billion dollars between 2014 and 2030, of which more than 91% is earmarked for hydro-electricity. Between 2030 and 2040, an additional USD $54 billion will be required. The cumulative investment between 2014 and 2040, therefore, is USD $122 billion.

Total investment costs for increased access to electricity services for peri-urban and rural households will be USD 2.5 billion, of which USD 1.36 billion is targeted to rural areas between 2014 and 2030. Implementation of the White Paper has yet to be documented. In its present status, the level of achievement and the constraints since 2014 remain unknown.

CEMAC's Energy Policy towards 2035

CEMAC also produced its Vision 2025, adopted in 2010. It states, "make the CEMAC by 2025 an integrated and emerging (economic) region, where security, solidarity and good governance reign."

CEMAC's "Energy Policy towards a Horizon of 2035" confirms that Central Africa has a wealth of fossil and renewable energy resources, despite the fact that its rural and peri-urban populations alike have very limited access to modern energy. The lack of reliable and sufficient power seriously and negatively impacts the region's potential for economic development. Development of the region's industrial, mining, and agricultural sectors is stymied simply as a result of no power or where there may be some, at a high cost.

The vision: To ensure universal access to electricity by 2035 and to contribute to the region's economic emergence, member states must create the necessary conditions that are conducive to sustainability by deploying modern energy services at affordable prices. CEMAC's energy policy should provide the incentives to boost private investment in Central Africa. Not only should it mobilise increased foreign direct investment, it should also influence a shift away from the sole exploitation of oil resources. There is evidence that CEMAC countries attract less than 8% of foreign direct investment in Africa.

The objectives: Encapsulated in CEMAC's energy policy are the following objectives: (i) increase access to energy for member state populations as well as the private sector; (ii) engage countries in Central Africa to develop renewable energy from various available sources; and (iii) consider energy efficiency as a source of renewable energy. The actions identified to reach these objectives are listed in the table below:

Table 6. Strategic Themes Selected by the Economic and Monetary Community of Central Africa

Market	Action
Electricity market	At the regional level, develop network infrastructure for the production and transmission of electricity across borders
Agricultural biomass and forestry waste	Ensure cogeneration; produce electricity in rural areas or connect to the network

Biomass	Support at the regional, national, and local levels initiatives for the sustainable development and use of biomass energy. Increase awareness and build the capacity of stakeholders. Support the design, manufacture, and dissemination of successful technologies.
Mini hydro-electricity	Co-ordinate at the regional level the concept, design, construction, and operation of mini hydro-electricity systems, based on a public-private partnership approach.
Photovoltaic	Support and develop solar home systems; provide solar lighting for street lights.
Solar heaters	Support the development of domestic and collective solar water heaters.
Wind energy	Support member states to identify appropriates sites and undertake feasibility studies for wind power production.
Liquid petroleum gas (LPG)	Increase the rate of penetration of LPG in the energy mix of households and the tertiary sector (e.g. hospitality sector, hospitals) and small industry (e.g. metallurgy workshops and repairs).

3.2.2. National Policies

Implementation status of ECCAS renewable energy support policies

The data in Table 7 has been extracted from REN21 (2018). It highlights the status of instruments that have been recommended to promote sustainable energy in Central African countries.

Table 7. Renewable Energy Support Policies in Central Africa

Countries	Renewable Energy Targets	Regulatory Policies						Fiscal Incentives and Public Financing			
		Feed-In Tariff/Premium Payment	Electric Utility Quota Obligation/RPS	Net Metering/Billing	Transport Obligation/Mandate	Tendering	Other	Investment or Production Tax Credits	Reductions in Sales, Energy, CO_2, VAT or Other Taxes	Energy Production Payment	Public Investment, Loans, Grants, Capital Subsidies or Rebates
Angola	●				●						●
Burundi											
Cameroon	●								●		
Chad											
Congo, Rep. of											
Gabon											
Equatorial Guinea											

Congo, Dem. Rep. of											
Central African Republic											
Rwanda	●	●				●		●	●		●
São Tomé											

Source: REN21 (2018)

According to REN21 (2018), the region lags well behind in terms of implementing the necessary instruments to promote renewables. Most of those recommended have yet to be applied in the region. Only three countries have one or more instruments in place (i.e. Angola, Cameroon and Rwanda) and have established a renewable energy target. Rwanda has a feed-in tariff for renewables, various tendering mechanisms, a tax credit for renewable energy investment, and some tax rebates. Angola and Rwanda also appear be publicly investing as well as providing loans, grants and subsidies to promote renewables. Only Angola has established a policy for the transport sub-sector.

The REN21 (2018) report does not capture the entire scene and depicts only those instruments necessary to implement renewable energy policy. These include renewable energy and rural electrification policies and regulation frameworks that are present in some countries, obtained from desk reviews, questionnaires and field visits that fed into the drafting of this current Regional Renewable Energy Roadmap. Cameroon and Rwanda − and to a lesser extent, Gabon − have developed a comprehensive set of renewable energy policies. Nevertheless, the level at which each country has implemented these policies differs; for instance, Rwanda and Cameroon are at the stage of monitoring progress, while Gabon was seeking national assembly approval as of January 2018,. Moreover, Cameroon has established a special fund for renewable energy and rural electrification, one that is hosted by the Rural Electrification Agency that operates as a separate entity and promotes private investment. Cameroon also is in the process of identifying small and medium hydro resources.

Rwanda has mapped out its solar and wind resources and is in the process of establishing a renewable energy master plan. The level of implementation in terms of objectives and outcomes, however, has yet to be fully evaluated. Rwanda, furthermore, has put in place a biomass regulation to limit deforestation and is working on a long-term funding mechanism to promote renewables.

With regard to Gabon, identification of small and medium hydro resources is in progress. In addition, a massive rural electrification program based on solar power has begun, supported by the World Bank; and efforts continue to promote private sector investment with enabling policies.

Chad − as one of the most climate-vulnerable countries in the region − has established a biomass regulation to limit deforestation. At the same time, it is aggressively campaigning to promote liquid petroleum cooking gas in an effort to shift from the use of traditional biomass while appropriating certain parameters of forestry and rendering illicit the cutting of trees.

4. Future Regional Power Sector Prospects

IRENA has assessed the region's future power sector prospects and potential for renewable energy

deployment in the context of anticipated economic growth and regional integration. The analysis performed explores three possible pathways for future national power systems over the period 2016−30, with varying limitations on the penetration of variable renewable energy (VRE) sources such as solar PV and wind in power generation. Limitations on combined VRE penetration in national-level generation of 25%, 15%, and 5% were considered, in order to explore the implications for the broader power sector's evolution.[8] All three scenarios allow for cross-border electricity trade through existing and planned interconnection within CAPP, as well as with the Southern African Power Pool and the West African Power Pool (through the Democratic Republic of Congo and Cameroon, respectively), if such trade proves economically feasible.

The pathways presented here have been developed using IRENA's own power sector planning model for Central African countries. This is referred to as the System Planning Test model for Central Africa (SPLAT-C), in which are considered, *inter alia*, the retirement of current power infrastructure, geographical distribution of renewable resources, transmission and distribution infrastructure requirements, and the generation adequacy of national power systems.

The SPLAT-C model used for this study draws on a database of national power systems, consisting of existing generation units and international transmission lines, along with a range of future technology options. It is calibrated to replicate the national energy systems in the ECCAS region as of 2015. The SPLAT-C model currently covers the following ten African countries: Angola, Burundi, Cameroon, Central African Republic (CAF), Chad, the Democratic Republic of Congo, the Republic of Congo, Equatorial Guinea, Gabon and Rwanda. All CAPP members are included in the analysis. Angola and the Democratic Republic of Congo also are members of SAPP, and Burundi, the Democratic Republic of Congo and Rwanda also are members of the Eastern African Power Pool.

The SPLAT database provides publicly available data and is able to update data as it becomes available. The model calculates the future configuration of power systems to meet specified system requirements and future power demand, based on the minimisation of total system costs within the planning timeline. Results are based on a wide range of assumptions regarding, *inter alia*, future demand and existing, committed or planned power capacity, as well the cost and performance of generic power generation

[8] While 25% VRE penetration is the highest level analysed, with adequate infrastructure and institutions in place, there generally should not be any such limitation in reality, particularly by 2030. T – there are a number of national power systems which currently operate at VRE penetration levels well above 25% and lessons regarding best practice in this area are readily available.

technologies that are included as options for deployment in the SPLAT-C model.[9] [10] Figure 10, Figure 11 and Figure 12 present the capacity and production results across scenarios.

Figure 10. Pathways towards Future Power Sector Prospects for Renewable Energy Deployment in Central Africa: Capacity Mix in 2030 across All Scenarios (megawatts)

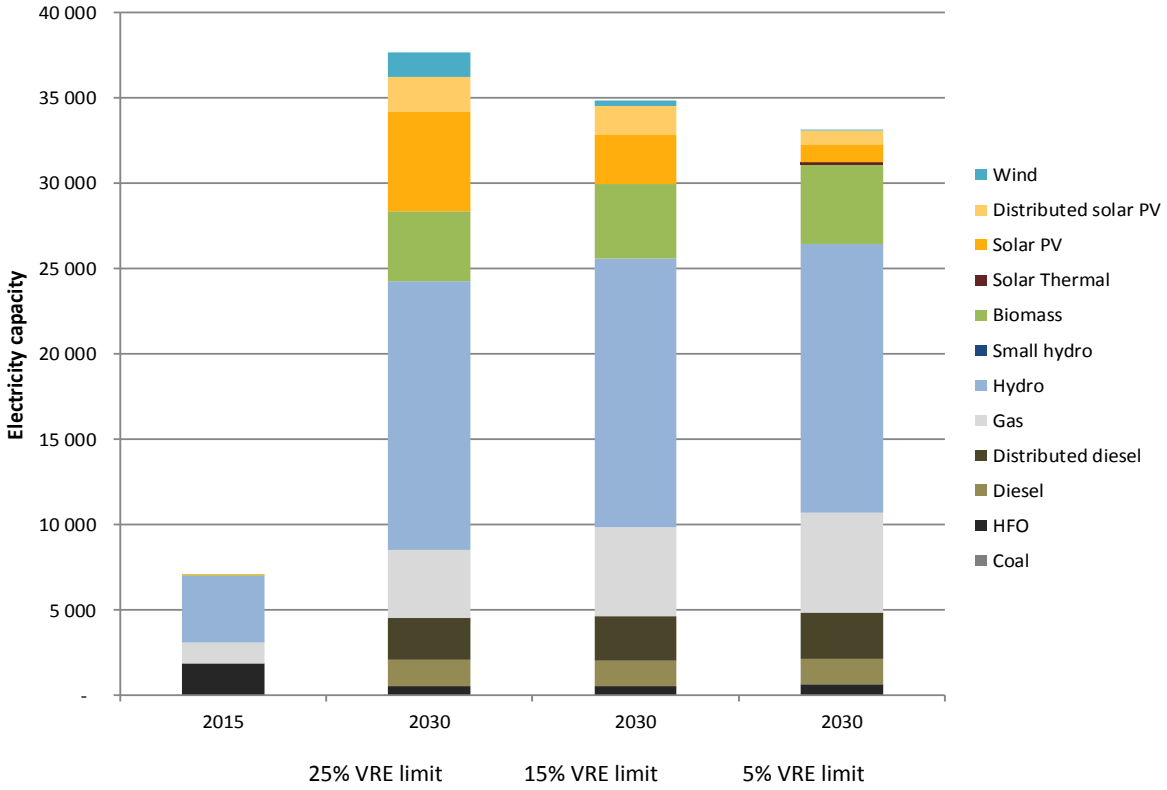


Figure 11. Pathways towards Future Power Sector Prospects for Renewable Energy Deployment in Central Africa: Total New Capacity Additions between 2016 and 2030 across All Scenarios (megawatts)

[9] Detail on any of the assumptions behind the analysis presented here, or country-level results, can be provided upon request.

[10] Basic disclaimers: (1) In the absence of an in-depth energy master plan for Central Africa, the analysis behind this summary document aims to compile information that could be helpful to support the development of power sector pathways in the region. Note that the analysis mainly uses publicly available data and, hence, a wide range of assumptions are adopted. As such, the present document should be regarded only as a starting point, which can be further improved in co-operation with the countries and CAPP. (2) Results of the analysis are not meant to be taken as predictions; rather, they provide insights that could potentially guide policy making. The model employed in this analysis provides optimal solutions for a particular set of conditions and, as such, alternate solutions might arise under another set of conditions. Rather than focusing on the numbers, the emphasis should be on possibilities to strengthen and expand the region's power generation infrastructure in a cost-effective manner. (3) The analysis behind this summary document assesses power sector development from a purely financial perspective, focusing on the supply of electricity. **There may be other considerations that affect the decision of governments to pursue certain technology pathways**. For instance, job creation, the establishment of a local industrial base, and/or interlinkages with agriculture or other sectors of the economy are only some aspects that may influence the attractiveness of certain technologies. Similarly, there are additional aspects that relate to electricity demand that are not considered in this study, although they could influence its growth over time, such as a more aggressive industrialisation policy.

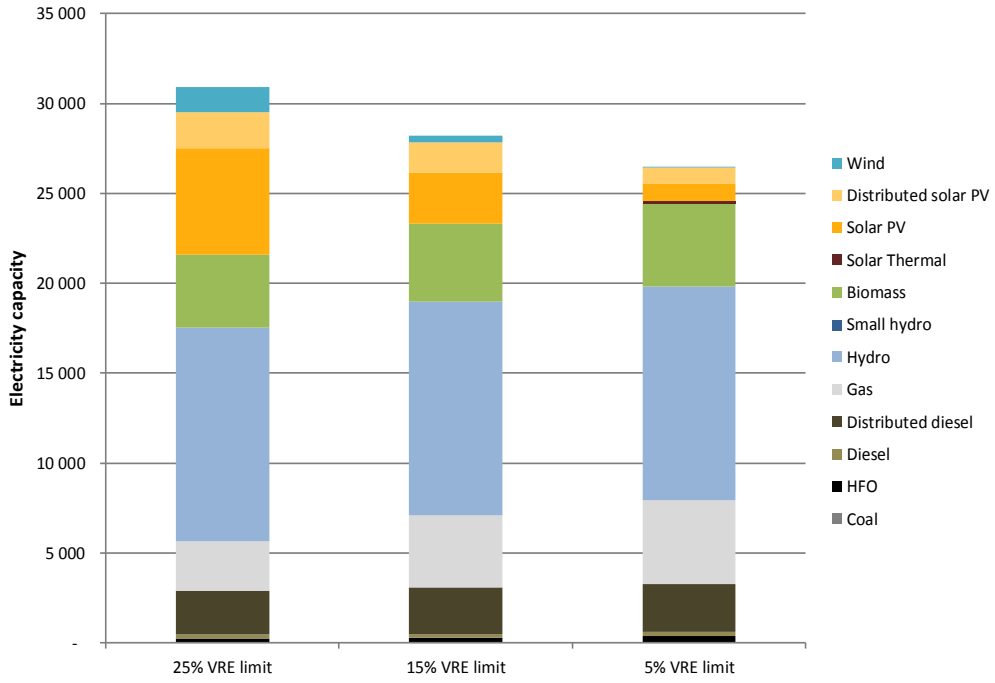
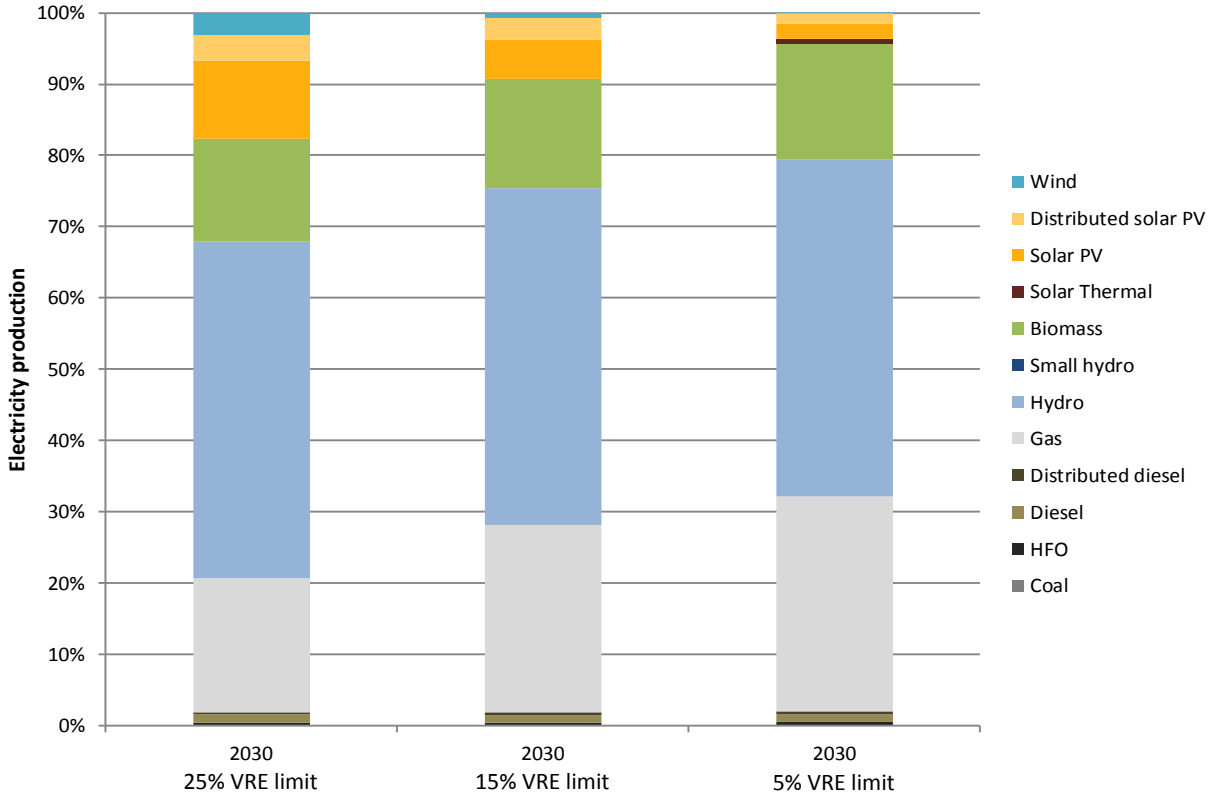


Figure 12. Pathways towards Future Power Sector Prospects for Renewable Energy Deployment in Central Africa: Production Mix in 2030 across All Scenarios
(gigawatt hours)



Across all scenarios, regional capacity expands significantly in order to supply the projected increases in electricity consumption presented in Section 2.[11] For example, by 2030 in the 25% VRE limit scenario, regional capacity is projected to be more than five times its 2015 level, driven largely by the economically competitive deployment of renewables. Between 2015 and 2030, the renewable share of capacity increases from 56% to 77% in that scenario, with 11 860 MW of hydropower, 7 908 MW of solar PV (including 2 017 MW of distributed solar PV), 4 083 MW of biomass, and 1 420 MW of wind constructed over the same period. To provide a sense of the pipeline required for this scale of deployment, such results would imply an annual average of circa 650 MW of solar PV to be installed at the regional level between 2020 and 2030.

The production mix naturally follows similar trends, with renewable power generation increasing nearly threefold between 2020 and 2030 alone in the 25% VRE limit scenario, to reach 79% of overall generation. Although fossil-fuelled capacity also increases over the horizon of this analysis – nearly tripling in all scenarios from current levels by 2030 – its share of production decreases by 2030 as diesel- and HFO-fuelled capacity becomes less utilised.

In general, even though the presence of hydropower and gas-fired thermal generation remains prominent in the region's capacity and production mix across scenarios, this analysis clearly projects a more diversified power sector in the future, in which increasingly competitive non-hydro renewables such as solar PV, biomass and wind are key drivers of infrastructure development.

While hydropower remains the largest source in the region in all three scenarios, the extent of hydropower construction does not change, with the same amount of capacity considered to be the most cost effective in each. Rather, if the penetration of solar PV and wind were to be limited in the analysis, those sources would be largely replaced by fossil-fuelled capacity and production.

Looking at an extreme case in which the combination of solar PV and wind is limited to only 5% of generation at the national level, overall deployment of VRE in the region would fall to only 1 863 MW of solar PV by 2030, with no additional wind capacity installed. This represents a reduction of 6 045 MW of solar PV and 1 419 MW of wind in comparison to the 25% VRE limitation scenario. To make up for that capacity, the region installs 2 283 MW more diesel-, HFO- and gas-fired capacity, relative to the 25% VRE limit scenario.

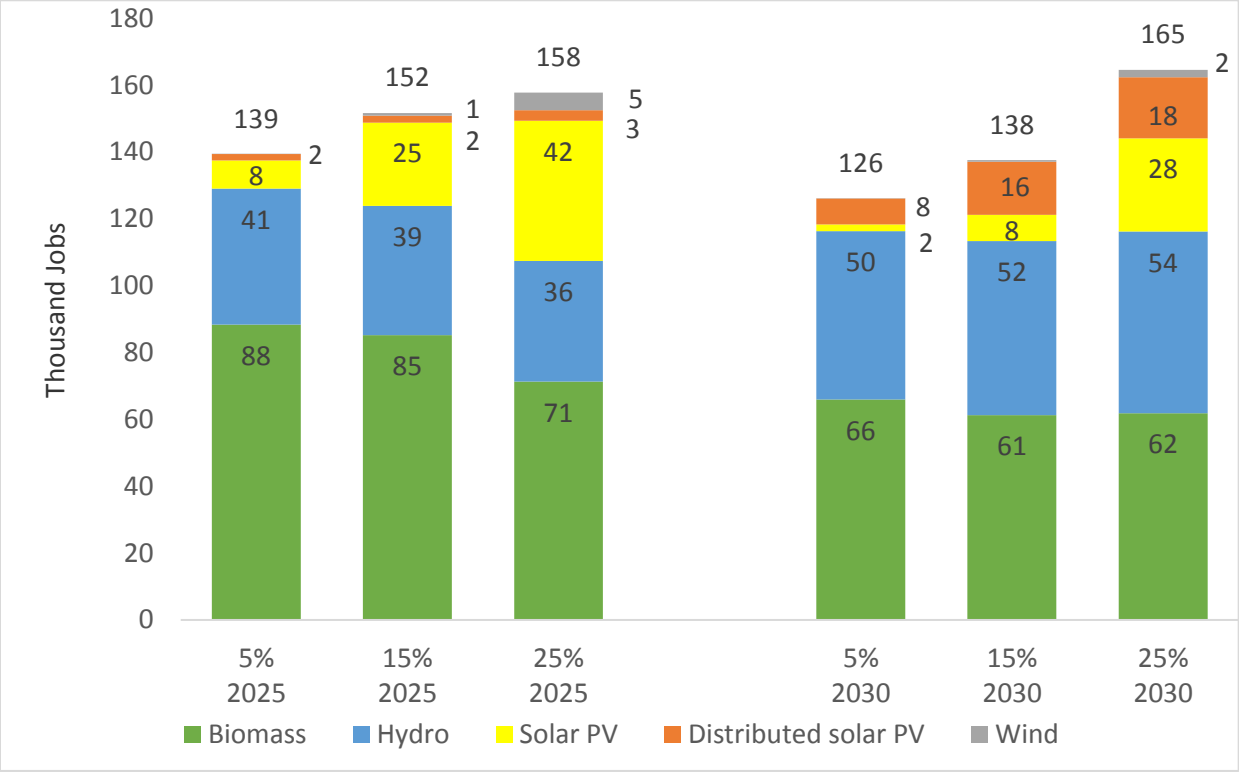
While the overall share of renewable capacity still expands across all scenarios, the share of fossil-fuelled production − mainly gas − increases rather than decreases by 2030 if VRE deployment is limited to 15% or below in national power systems. Broadly, scenarios in which VRE deployment is more limited represent a less diversified power sector by 2030, with the region remaining heavily reliant on fossil fuels and hydropower to meet demand.

[11] Note that capacity displayed as "HFO" in 2015 figures presented in this section represents an aggregated amount of existing diesel- and HFO-fueled plants.

5. Socio-Economic Benefits: Renewable Energy Jobs

The introduction of VRE in the Central African power sectors can lead to significant job creation. The following analysis is based on the scenarios presented in Chapter 4 for the region. Greater shares of VRE in the power system can create more job opportunities. While Figure 13 illustrates key projections for 2025 and 2030, the text focuses on 2030 results. Total renewable energy employment in 2030 ranges from 126 000 to 165 000 direct[12] jobs, rising as the share of VRE technologies (solar PV, distributed solar PV and wind) is increased from 5% to 25%. VRE technologies account for a greater share of total renewable energy employment as their penetration increases, reaching a high of 29% in 2030 under the 25% VRE scenario.

Figure 13. Renewable Energy Jobs by Technology for Different VRE Penetration Scenarios: Central Africa



Source: IRENA Analysis

Even so, biomass is by far the leading renewable energy job creator in all scenarios. Most of the biomass jobs in the scenario with 25% VRE penetration are found in labour-intensive fuel production (feedstock production, harvesting, gathering and processing) and operation and maintenance segments of the value

[12] Direct employment refers to employment that is generated directly by core activities without taking into account the intermediate inputs necessary to manufacture RE equipment or construct and operate facilities. Indirect employment includes the employment in upstream industries that supply and support the core activities of RE deployment.

chain (Table 8). Conventional hydropower, which is by far the leading renewable energy technology by capacity in all scenarios, remains the second largest renewable energy employer in all scenarios. In 2030 in the 25% VRE scenario, it accounts for 54 287 jobs, a dominant percentage of which is involved in construction and installation of new projects. Distributed and centralised solar PV, together, account for 28% of total renewable energy jobs in the 25% VRE scenario. Most of these jobs (56%) are in the labour-intensive construction and installation segment of the value chain. Wind energy accounts for a small number of jobs in 2030 in the 25% VRE scenario. Most of these jobs are in the operation and maintenance segment of the value chain, since most of the construction and installation of these projects has been carried out by 2025. Wind energy grows quickly from 2020 to 2030, although new capacity additions slow down in the 2025−30 phase, leading to a lower number of construction and installation jobs.

Data from real-world projects also can shed some light on the composition of the workforce of renewable energy projects. IRENA's series of reports on Leveraging Local Capacities uses real-world data to provide a quantitative overview of the labour requirements in the deployment of solar PV and onshore and offshore wind energy technologies (IRENA 2017a; IRENA 2017b; IRENA 2018b). These studies show that the labour requirements of the solar PV installation segment – the largest segment of the solar PV value chain in the 25% VRE scenario in 2030 – are dominated by construction workers and technicians. In fact, around 90% of the person-days required in this segment are construction workers and technicians. The second-most prevalent occupation group for this phase includes civil engineers and foremen (6%), followed by health and safety experts (2%), electrical and mechanical engineers (1%) and experts of environmental impacts and quality control (1%).

Table 8. Renewable Energy Jobs by Technology and by Segment of the Value Chain in Central Africa

Type of Renewable Energy	Penetration Scenario (%)	Manufacturing	Construction and Installation	Operation and Maintenance	Fuel Production	Total
Wind	5	0	0	1	0	**1**
	15	0	0	433	0	**433**
	25	158	270	1 801	0	**2 229**
Distributed solar photovoltaic	5	1 057	5 128	1 659	0	**7 844**
	15	2 174	10 546	3 181	0	**15 902**
	25	2 486	12 057	3 749	0	**18 293**
Solar photovoltaic	5	21	103	1 819	0	**1 943**
	15	436	2 114	5 308	0	**7 859**
	25	2 892	14 028	10 963	0	**27 882**
Biomass	5	663	8 002	29 683	27 582	**65 930**
	15	581	7 017	27 799	25 848	**61 246**
	25	871	10 516	26 182	24 301	**61 870**
Hydro	5	5 741	30 343	14 311	0	**50 395**
	15	6 011	31 774	14 311	0	**52 097**
	25	6 360	33 616	14 311	0	**54 287**
Total renewable energy	**5**	**7 482**	**43 576**	**47 473**	**27 582**	**126113**
	15	**9 203**	**51 452**	**51 033**	**25 848**	**137 536**

	25	12 767	70 486	57 007	24 301	164 561

Source: IRENA Analysis

6. Key Actions Identified

The proposed Regional Renewable Energy Roadmap for developing renewable energy aims to serve as a springboard for transformation of the energy systems of the ECCAS region to enable effective exploitation of the abundant renewable energy potential, currently largely untapped except for hydropower. In this context, the Regional Renewable Energy Roadmap involves priority action in several areas to strengthen the existing enabling technical, policy, regulatory, institutional and financial frameworks that will contribute to ongoing regional and national efforts to promote more accelerated deployment of renewable energy across the region.

6.1. Resource Assessment

Assessing the cost-effective renewable energy potential

While the traditional use of biomass constitutes an important part of the energy mix, the region has not moved towards deployment of modern and sustainable bioenergy technologies across power and end-use sectors. In the power sector, vast solar, wind and bioenergy resources of the region have not so far been used in complementing the predominant role of hydropower, and they still represent a relatively small share. This is partly due to the low understanding of the cost-effective potential of non-hydro renewables. Several publicly available data sources emanating from the work of international partners provide relevant information of the technical potential of non-hydro renewables. There is still a need to gain more detailed understanding, however, of the resource-technical potentials as well as an assessment to identify the renewable power potential that can be deployed in a cost-competitive manner.

The region can benefit from the expertise of specific institutions in the mapping of cost-effective potential of renewables, including IRENA's Global Atlas for Renewable Energy[13] and the World Bank for solar and wind energy, as well as the Food and Agriculture Organization of the United Nations for bioenergy. The support can take the form of tailor-made studies as well as ground measurement campaigns.

Recommended actions:

- Map the most suitable locations across the region for the development of small hydropower, wind, solar PV and biomass energy.
- Build technical capacity at the regional level to introduce maps and train experts on how to use the outcomes of the resource mapping for generation and transmission system expansion planning.
- Undertake an assessment of cost-effective renewable energy potentials across the region.
- Establish frameworks to undertake project-specific resource assessments.

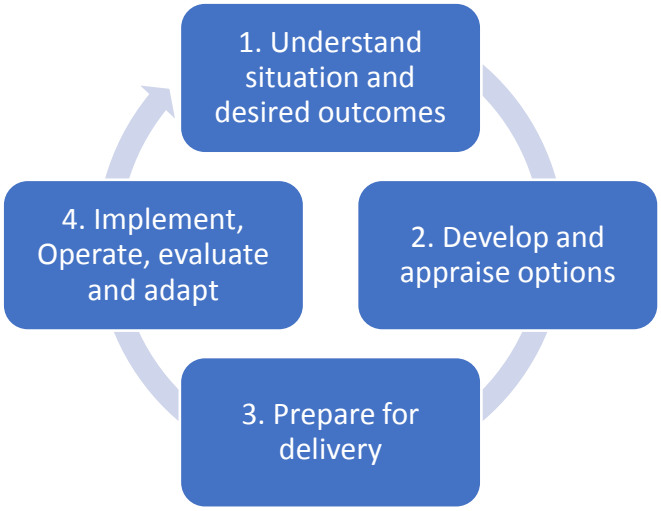
[13] IRENA's Global Atlas for Renewable Energy is a web platform that offers maps to locate RE resources across the world. The initiative, co-ordinated by IRENA, aims to provide countries access to essential data and expertise to evaluate their potential for RE deployment. In the past six years, the initiative has brought together more than 50 highly skilled international research institutions to share over 2 000 RE maps on a single platform, covering solar, wind, bioenergy, geothermal and marine energies. See http://www.irena.org/globalatlas

6.2. Energy Data

Enhancing the collection, processing and dissemination of renewable energy data

In terms of policymaking, reliable data is paramount in all stages of policy development. This includes an understanding of the current situation to policy implementation and evaluation.

Figure 14. Role of Reliable Data in the Policy Development Cycle



Source: OECD/IEA 2015

First, reliable data is essential to establish reference scenarios that relate to an overall situation. In addition, areas for action should be identified in an effort to achieve specific national targets. At this stage, targets may yet need to be agreed on.

On that basis, options can be developed and evaluated as a second step. Ex-ante scenarios can be developed and their feasibilities can be assessed against the realities of the country/region and the larger macroeconomic options that are available. At this stage, the data should be sufficiently reliable to understand, quantify and analyse the impacts, costs, risks and benefits of policy options, including in relation to the broader socio-economic and environmental benefits. A decision should be made on whether more in-depth research and analysis is necessary in order to effectively implement the policy.

The relevance of reliable data is evident when implementing pilot programmes and projects so as to enable the gathering of good practices, agree on and execute delivery mechanisms with partners and regulatory authorities, and establish adequate monitoring and evaluation processes as well as reporting frameworks. At the implementation stage, the gathering of reliable data and processing mechanisms will assist in the monitoring of performance indicators against expected outputs, thus operationalising established frameworks. This also will complement the evaluation process.

To ensure success in renewable energy development, the decision-making process requires reliable data on supply (i.e. generation, transmission and distribution) and demand, as well as energy sector planning, benchmarking statistics and tracking (e.g. Sustainable Development Goals of the United Nations, SE4All

and regional and national targets). Data is critical for governments, utilities and international organisations alike, as well as think-tanks and academia, among others.

As is the case in most regions of sub-Saharan Africa, the quest for reliable, consistent and up-to-date information on the potentials of renewable energy energy in Central Africa is a challenge. The necessary mechanisms to gather, process and disseminate information are simply not in place. Moreover, countries in Central Africa differ in terms of their basic indicators, such as rate of access to electricity, rate of coverage, among other issues. Gaps in the data as a result of a lack of human capacity need to be addressed.

Recommended actions:

- Harmonise energy terminologies, definitions and related assumptions across the region.
- Build capacity to collect, process and disseminate energy statistics.
- Enhance the management and knowledge of energy resources
- Establish a regional energy information system that is reliable and up to date.

6.3. Long-Term Energy Planning

Introducing Solar, Wind, Geothermal, Small hydropower and biomass into national and regional planning depending on the economic viability

Resource assessment is essential to comprehend not only the location and quantity of renewable energy sources, but also how different factors impact theoretical, technical, economic, and market potential. Once an assessment has been performed, results should be integrated into long-term energy planning processes so as to pave the way for development. Applying appropriate tools and models will provide a shared vision of the energy sector over coming decades, and will promote dialogue on various long-term scenarios. Given the long lifespan of energy infrastructure, investment decisions made today can shape an energy system for decades. Long-term planning is therefore crucial to better understand how renewable energy resource potential can realistically be integrated into energy systems over time in a cost-effective and co-ordinated manner. From a wide range of global contexts, there is evidence that long-term planning is vital and has clear benefits for national and regional stakeholders when setting realistic and parallel renewable energy targets as well as in policymaking, communicating with civil society and establishing an enabling environment to de-risk the sector for investment.

Initiating effective long-term planning at the national and regional levels will require co-ordinated efforts to collect, process and disseminate energy data, including reliable statistics, demand assessments and supply analyses. Only after this can effective dialogue with a wide range of energy sector stakeholders take place on the use of energy planning tools and the development of long-term scenarios. Institutional and human capacities in carrying out these processes can be strengthened by adding relevant trainings and sharing best practices. The literature on planning and promoting renewable energy in Central Africa suggests that a range of fundamental barriers (e.g. availability of funding, institutional structures and

human resource development) must first be addressed prior to co-ordinating among stakeholders. The Central Africa region is able to benefit from the expertise of international technical partners such as IRENA. IRENA has a track record of assisting countries and regions in formulating long-term planning for the energy sector (Box 1).

Recommended actions:

- Build capacity for long-term energy planning processes and the tools to link the assessment of renewable potential to actual development.
- Prepare national and regional power sector or energy master plans that account for an increased share of variable renewables.

Box 1. Planning for Central Africa's Renewable Future

The need for comprehensive energy planning has been recognized by regional stakeholders – at the 2015 IRENA event Planning Renewable Energy Strategies: Africa Power Sector, African leaders and international experts gathered to discuss this topic, and underscored the lack of adaptable, realistic energy plans for the continent, the need for more substantive data in the power sector and the lack of co-ordination between government and industry. Participants noted that lack of planning often results in expensive short-term solutions that can have significant adverse economic impact. Accordingly, proposals were put forth to make use of updated data and tools in long-term planning, collaborate with academia and governments, commit to capacity building, and build consensual master plans across energy sector stakeholders to increase investor confidence and attract finance.

To support such efforts, IRENA has developed energy system analysis tools (Systems Planning Test (SPLAT) models) that apply to all African countries. These are able to design and explore medium- to long-term power system pathways, prioritise investment options and assess the economic implications of a given investment path. SPLAT models are built on IRENA's renewable energy database and are linked with other IRENA tools to ensure that the best data is available. The modelling framework provides a robust starting point for capacity building and use by Africa's national and regional planning experts, and is designed around the principles of local expert ownership, data transparency and accessibility.

Using the SPLAT models, as well as methodological research from the IRENA project, Addressing Variable Renewables in Long-term Energy Planning, IRENA has held extensive workshops and training sessions to enhance energy planning practices in African contexts. Regionally, a six-month capacity development programme, using the SPLAT-West Africa model, was organised for West African experts in 2015/16 by IRENA and the Centre for Renewable Energy and Energy Efficiency of Economic Community of West African States. In-depth support to develop national energy master plans, using the SPLAT modelling framework, has been recently provided to the Government of Sierra Leone and the Government of Swaziland.

Source: Kenfack et al. (2017), "How Can We Promote Renewable Energy and Energy Efficiency in Central Africa? A Cameroon Case Study." www.sciencedirect.com/science/article/pii/S1364032116307742.

6.4. Enabling National and Regional Policy and Regulatory Framework for Investments

6.4.1. Setting ambitious but realistic regional and national targets for renewable energy deployment

RE targeting has emerged as a popular mechanism to set national and regional economies on a path towards a more secure and sustainable energy future. They play a crucial role in the global energy landscape by providing an overview of renewable energy trends and indicating the envisioned trajectory of deployment, thereby helping to anchor medium- and long-term expectations. Therefore, they can serve different functions throughout the policymaking process.

Robust target design depends on the primary policy objectives pursued. Country examples show that rather than being motivated by one single overarching objective, governments are increasingly adopting renewable energy targets to meet multiple interconnected objectives such as energy security, environmental sustainability and socio-economic benefits.

As highlighted in Chapter 4, setting three levels of targets (5%, 15% and 25%) for variable renewable energy penetration shows a precise substantive transformation of the regional power mix by 2030; and the reduction of dependency on large hydro (from 55% in 2015 to 48%, 44% and 40% by 2030 under the three scenarios) and on fossil fuels (from 45% in 2015 to 32%, 29% and 23% by 2030 under the three scenarios). Out of the 11 countries of the ECCAS region, only Angola, Cameroon and Rwanda have set national renewable energy targets. This highlights the need to enhance the understanding of policymakers on the crucial role of target setting in developing renewable energy markets and building the capacity of the relevant stakeholders at the national and regional levels.

In their design phase, renewable energy targets need to be based on a sound knowledge base, where metrics and design features are one dimension, and where decisive contextual factors, such as political, institutional and economic aspects also are considered (Box 2). Clearly articulating the objectives underlying renewable energy targets can help balance the costs and benefits of different target levels and types, while also improving the monitoring of their impacts over time.

Recommended actions:

- Undertake studies to define appropriate national and regional renewable energy targets.
- Provide training on how to set realistic renewable energy targets.
- Build capacity to target key energy stakeholders, including policymakers, regulators, utilities and

others on viable technology deployment options and their benefits.

Box 2: Central Role of Renewable Energy Targets

By the end of 2016, at least 176 countries had renewable energy targets. While the majority of countries continues to focus on the electricity sector, with 150 countries having set renewable electricity targets to date, the number of countries setting targets for the heating/cooling sector is evidence of a remarkable progression in the last ten years, from 2 countries in 2005 to 47 by mid-2015. While they remain at the intersection of multiple policy drivers and priorities, the design of robust targets depends on the primary policy objectives pursued.

Targets can have a number of positive functions at different stages of the policymaking process (i.e. formulation, implementation, and monitoring and evaluation). At the policy implementation stage, for example, targets signal political commitment, indicate long-term investment and innovation trends, improve co-ordination and motivate stakeholders to take action. When backed by supportive policy and investment frameworks, they can provide long-term visibility to industry, a critical ingredient in stimulating deployment at scale. Targets can also help drive valuable knowledge and local skills development, given the long timeframes involved in building human capacity.

Source: IRENA (2015)

6.4.2. Creating stronger frameworks for renewable energy policy and regulation

RE policies remain the most important driver of deployment, and an enabling policy framework should provide for long-term certainty in revenue streams; overall stability and predictability by reducing uncertainties and transactional costs; and standardising procedures to increase private sector participation. Box 3 provides details of the essentiality of having a broad set of policies with underlying benefits.

Unlike the Economic Community of West African States (ECOWAS) and Southern African Development Community regions, there is no regional policy to promote all sources of renewable energy in Central Africa, hydropower being the only renewable energy source considered in the regional energy policy (White Paper). At the national level, only Cameroon, Gabon and Rwanda have developed comprehensive policies and instruments to promote renewables.

In order for Central Africa to efficiently, coherently and sustainably harness its entire renewable energy potential, the region should consider the successful examples of other African sub-regions such as ECOWAS, where a regional energy policy – the ECOWAS Renewable Energy Policy adopted by the Summit of Heads of States – was translated into national policies, thus forming the basis of the region's country SE4All targets and the energy components of the nationally determined contributions of each country. The ECOWAS Renewable Energy Policy is complemented by the ECOWAS Energy Efficiency Policy that aims to implement measures that would make available 2 000 MW of power generation capacity through efficiency gains and, in the long run, more than double the annual improvement in energy efficiency compared to 2010 levels.

Renewable energy policies need to be supported with regulatory instruments and incentives – financial (fiscal and public financing) and non-financial alike – in order to trigger regulated deployment. As

highlighted in Table 7, only Angola, Cameroon and Rwanda have some regulatory policies and financial incentives in place. These countries need to be further strengthened while other countries should consider introducing specific policies.

Policies to support the transition to renewables should adopt a holistic approach that covers not only the deployment of renewables, but also their integration into the broader energy system and economy-wide policies that affect the sustainability and pace of the transition. Box 3 highlights the scope of such broader set of policies to achieve full benefit from deployment at various levels.

With respect to administrative processes relating to renewable project development, countries of the region can consider further streamlining planning and permit procedures, as well as remove administrative barriers to improve the ease of doing business for the private sector. Complex and lengthy procedures can lead to significant administrative and transactional costs that may discourage potential investors and project developers from entering the market.

In addition, given the current absence of renewable energy technology standards in the ECCAS region, specific standards and codes will be worth creating for such technologies to ensure adequate quality, safety and operation of equipment. International co-operation can be facilitated by IRENA and other partners to build the capacities of relevant technical institutions in the region for the development of renewable energy standards.

Recommended actions:

- Carry out studies to develop approaches and strategies for renewable energy development, able to be well integrated into the broader regional energy strategy.
- Carry out studies to develop renewable energy policies at the national level, as well as related policy support schemes (including, financial and non-financial measures) that will enable effective implementation of policies.
- Develop specific equipment quality and operational standards for the deployment and operation of renewable energy technologies.
- Enhance the necessary skill base within institutions responsible for policy development and implementation.

Box 3. Holistic Approach to Renewable Energy Policies

Rapid change in the energy field calls for a new way to classify policies. The energy transition involves the transformation of the energy system and the socio-economic structure upon which it is built. Policies to support the transition need to adopt a holistic approach that accounts for both these dimensions. As renewables have transitioned from niche to mainstream, the policies that drive the transition must cover not only the deployment of renewables, but also their integration into the broader energy system and economy-wide policies that affect the sustainability and pace of the transition.

Direct policies and instruments are used to support the development and deployment of renewable energy (RE) technologies, not only in the general sense but also in the context of expanding access to electricity and other forms of clean energy. These are typically classified as "push", "pull", and "fiscal and financial". Push policies mandate certain actions such as electricity quotas; use of solar water heaters or biofuels mandates; rural electrification; and the popularisation of clean cook stoves or biogas. Pull policies incentivise certain actions, for example, through pricing or regulation. Fiscal and financial policies and instruments include tax incentives, grants and subsidies.

Integrating policies incorporate the use of renewables and energy efficiency in the heating and cooling, transport, and power sub-sectors into the larger energy and economic system and into the daily lives of consumers. This category includes policies to ensure the development of the infrastructure needed (e.g. transmission and distribution networks, charging stations for electric vehicles, district heating infrastructure); enhance system flexibility (e.g. support for energy storage deployment) to promote sector coupling; and support for research, development and demonstration. Measures to encourage the economy to take full advantage of successive steps in the energy transition also are needed to ensure a smooth and sustainable energy transition for all.

Enabling policies contribute to a wider environment for RE development. These include policies that issue clear signals to stakeholders, level the playing field for renewables (e.g. fossil fuel subsidy reforms, carbon pricing policies), manage land use, ensure the reliability of technology (e.g. quality and technical standards, certificates), facilitate access to affordable financing at multiple levels and support labour-market needs (through direct measures and through education and training). The development of a local industry can be supported through industrial policy (e.g. leveraging local capacity) and trade policies (e.g. trade agreements, export promotion). Finally, renewables can be supported through environmental and climate policies and regulations.

Some measures can aid in enabling as well as integrating renewables. These include the establishment of a supportive governance and institutional architecture (e.g. streamlined permit procedures, dedicated institutions for renewables), awareness programmes to induce behavioural change, and the coupling of RE policies with livelihood development. Social protection policies to address disruptions are also needed for a sustainable energy transition.

Source: IRENA, OECD/IEA 2018

6.5. Renewable Energy Project Development and Finance

6.5.1. Building capacities on developing bankable renewable energy projects

As in most of sub-Saharan Africa, the low involvement of the local private sector in the renewable energy sector in the ECCAS region is partly due to limited technical expertise in the development of bankable

projects as well as viable business plans, loan requests and managing and maintaining businesses successfully. Support for all stakeholders involved in project financing, including project developers and local financial institutions, could come in the form of reinforced local capacities in project preparation, development, financing and implementation. This support also is relevant for operators of off-grid markets. Further support could originate from a regional programme for the promotion of renewable energy entrepreneurship, whose ultimate objective would be to increase the confidence of financial institutions in sustainable energy systems and create linkages between entrepreneurs and financial institutions.

Recommended actions:

- Reinforce local capacities to improve the quality of project proposals and increase overall project bankability.
- Support enhanced interaction among market players, particularly linking project developers and financiers, to accelerate deal flow and renewable energy investment.
- Facilitate access to affordable financing to support replicable, scalable and potentially transformative renewable energy projects.

To support countries in this area, IRENA has developed a project facilitation framework comprising a suite of tools, described in Box 4.

Box 4. Renewable Energy Project Facilitation Framework of the International Renewable Energy Agency

The International Renewable Energy Agency (IRENA) offers a number of tools to facilitate development of bankable projects and access to financing at affordable terms. These are described below.

Global Atlas: This site offers an appraisal service to assess the financial prefeasibility of wind and solar sites that have been earmarked by countries by calculating the adequate tariff required for an investor to build the project on that site.

Project Navigator: This online platform provides comprehensive, easily accessible and practical information, tools and guidance to assist in the development of bankable renewable energy (RE) projects. The tool introduces a project lifecycle process that is structured in several distinct phases and is designed to support the progressive development of RE projects. At this stage, technical concept guidelines are available for on-shore wind, solar photovoltaic, woody biomass, small hydro, mini-grids and solar home systems.

Sustainable Energy Marketplace: This is a virtual platform to facilitate access of promising low-carbon energy projects to financing. At the African hub of the Sustainable Energy Marketplace, IRENA conducts project assessments while providing a better understanding on the needs of projects in the region. This is then used for matchmaking and linking projects to financing institutions, as well as other relevant stakeholders, depending on the specific needs of a project.

IRENA/Abu Dhabi Fund for Development Project Facility: This partnership commits concessional loans worth USD 350 million in co-funding over annual funding cycles to RE projects in developing countries. Six selection cycles have been successfully facilitated by IRENA, resulting in the allocation of USD 214 million in fund loans to 21 RE projects. The selected projects aim to improve energy access, energy security and livelihoods, at the same time being replicable, transformative and sustainable.

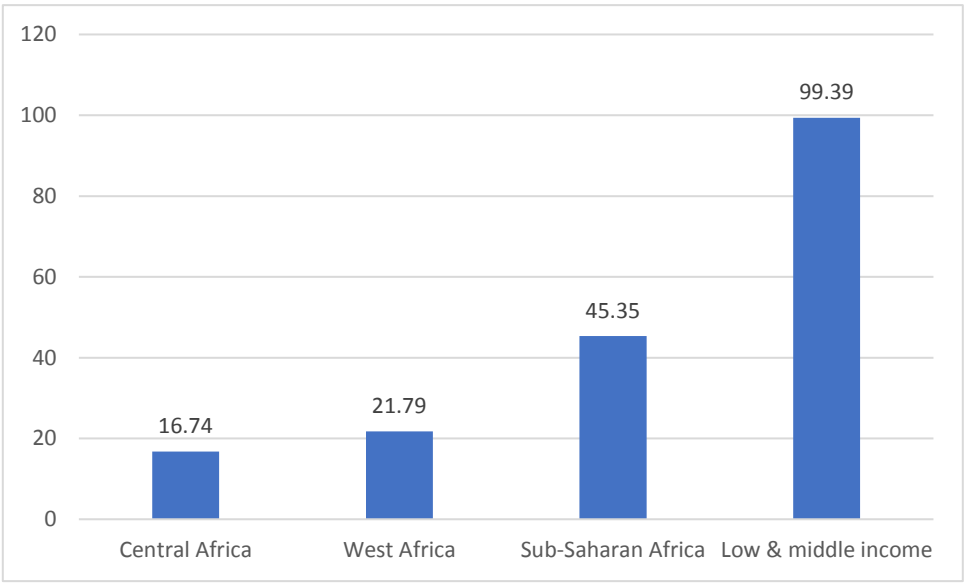
6.5.2. Enhancing private participation and financing for renewable energy projects

For effective private sector participation in national economic activity, a set of measures at the institutional level and at the level of the overall economic landscape should be put in place. The ECCAS region's low access to private investment is clearly the result of an absence of or weak private sector development institutions, limited private-public dialogue and economic factors that include inadequate labour productivity, low capital and lack of appropriate fiscal frameworks. Despite the presence of private sector support institutions and investment promotion agencies in the region, the former on the one hand often lack the necessary human, technical and financial resources to carry out their mission. On the other hand, investment promotion agencies neither sufficiently incentivise the public sector with regard to reforms nor do they advise authorities on how to improve the investment climate for public and private sector investment opportunities and partnerships at the international level (AfDB, 2013).

Furthermore, capital to support the local private sector is rather stringent. As illustrated in Figure 15, the median ratio of private sector credit to GDP in ECCAS is rather low compared to the low-to-middle income country medians in sub-Saharan Africa. This implies low access of businesses to financing, a factor that could be a result of the low liquidity of local financial institutions, exacerbated by the limited range of financial products offered. The relative absence of non-banking financial institutions to offer alternative ways to untap finance and fund private investment is evident. Banking services are costly, at 11% in 2010 and rising to 15% with a maturity of two years.

Financing challenges also arise due to a multitude of factors that ultimately increase the risk aversion of lenders (Box 5). Moreover, existing regulatory and institutional frameworks do not provide sufficient protection to creditors.

Figure 15. Credit to the Private Sector in Central Africa (percent of gross domestic product)



Source: World Bank Database.

As mentioned in earlier chapters of this paper, Central Africa is one of the continent's richest regions in terms of resources. Its economies, however, are poorly diversified and largely concentrate on the oil and mining sectors. Combined, these two sectors represent from 30% of national revenue in Cameroon to up to 76% in Gabon and in excess of 90% in Equatorial Guinea (EITI, 2013). Most often, these sectors are in

the hands of larger companies, with a marginal role left for small- and medium-size enterprises. Economic diversification, with an increased role for renewables, should be sought in order to allow for strong and shared growth. The role of renewable energy through the fostering of private investment is an important piece of this puzzle.

Table 9. Financial Risk Mitigation Tools to Address Investment Risks

Financial Risk Mitigation Tools to Address Investment Risks								
	Political risk	**Policy and regulatory risk**	**Counterparty risk (power off-taker risk)**	**Grid interconnection and transmission line risk**	**Technology risk**	**Currency risk**	**Liquidity and refinancing risk**	**Resource risk**
Government guarantee	X	X	X					
Political risk insurance	X	X	X	X		X		
Partial risk/credit guarantee	X	X	X	X	X			
Export credit guarantee	X	X	X	X	X			
Currency risk hedging instrument						X		
Currency risk guarantee fund						X		
Local currency lending						X		
Internal/external liquidity facility			X				X	
Liquidity guarantee							X	
Put option							X	X
Grant and convertible grant								X
Resource guarantee fund								X
Portfolio guarantee								X

Source: IRENA (2016)

By providing access to effective risk mitigation instruments, governments will be able to make a critical contribution to help mobilise private capital for renewable energy investment. With the help of international partners of various types, such as the Overseas Private Investment Corporation and the African Trade Insurance Agency, countries of the region could implement many such instruments to mitigate the risks and attract more investment.

Furthermore, ECCAS countries should work towards an enabling business environment to attract foreign investment so as to improve access to financing. Indeed, the World Bank's Ease of Doing Business Index provides a bleak definition of the region. Out of the 191 countries ranked, only Rwanda ranks outside the bottom 30 countries at No. 41.

Box 5. Perceived Risks Associated with Renewable Energy Investments

There are real and perceived risks associated with renewable energy investments on several levels:

- Risk associated with political events that adversely impact the value of investments (e.g. war, civil disturbance, currency inconvertibility, breach of contract, expropriation, non-honouring of obligations).
- Policy and regulatory risk due to potential changes in legal or regulatory policies that have significant, adverse impacts on project development and implementation (e.g. incentive programs, interconnection regulations, permit processing).
- Power off-taker risk in relation to the risk of default by power off-taker, typically the power utility.
- Grid risk arising from limitations in interconnection, grid management, and transmission infrastructure.
- Technology risk associated with use of nascent technology or relevant inexperienced and unskilled labour.
- Currency risk linked to changing or volatile foreign exchange rates where there is a currency mismatch between revenues and liabilities (debt financing).
- Liquidity risk arising from revenue shortfalls or mismatches between the timing of cash receipts and payments.
- Refinancing risk where a borrower is unable to refinance the outstanding loan midway through the life of a project due to inadequate loan terms (the maturity of the loan is mismatched with the lifetime of the asset).
- Resource risk associated with uncertainties around the availability, future price and/or supply of the renewable energy resource (e.g. risk related to bioenergy and geothermal energy projects).

Source: IRENA (2016)

Recommended actions:

- Explore the potential of establishing risk mitigation frameworks at the national and/or regional level(s) to address the various types of risk that prevail along the development cycle of renewable energy projects (Table 9).
- Develop mechanisms to increase the level of liquidity of local financial institutions and untap the opportunity of non-banking financial institutions in order to increase access to capital and reduce the cost of debt for private actors.
- Put in place effective institutional and regulatory frameworks to streamline the institutional climate for the development of small- and medium-size renewable energy entrepreneurs and create specific mechanisms to support their development.

6.6. Institutional Set-Up and Skill Development across the Renewables Value Chain

6.6.1. Strengthen capabilities in the installation, operation and maintenance of renewable energy systems

Central Africa suffers from a shortage of highly qualified technicians for the sizing, design, installation and maintenance of variable renewable energy systems. The creation of 126 500 to 164 500 jobs[14] along the value chain (including 43 500 to 70 500 in construction and installation; 7 000 to 12 500 in manufacturing; and 47 500 to 57 000 in operations and maintenance) would bear substantial socio-economic benefit. With that in mind, the curricula of training institutions for the ECCAS region has to include all aspects of renewable energy project development (i.e. technical, management and financial). This will strengthen the level of local skills from the conceptualisation stage of renewable energy projects to those of financial engineering, construction and operations and maintenance, together with the prospect of innovation. Not only, however, should the dearth of qualified labour be addressed by increasing the capacity of skills, but national and regional markets also should be strengthened in terms of project planning, manufacturing, installation, grid connection and operation and maintenance.

Recommended actions:

- Develop awareness-raising through public campaigns, education and training programmes that target a diversity of groups such as government entities, businesses and civil society. This should be supplemented by communication initiatives from public and local decision makers on the strong business case for renewable energy in countries across the region.
- Implement regular, intensive education and capacity-building programmes to further strengthen expertise in renewable energy across the project development value chain (e.g. resource assessment, planning, design and operations and maintenance of variable renewable energy power installations, monitoring and evaluation).
- Include renewable energy components in the curricula of secondary and higher education as well as vocational institutions across the region.
- Co-ordinate action among national stakeholders at the country and cross-border levels to promote local job opportunities, supported by fiscal and financial incentives.
- Provide on-the-job training for young and entry-level engineers in the local job market, particularly within the power sector.

Development of a skilled labour market in the ECCAS region is − and should continue to be − heterogenous across the region. Least-advanced countries should be able to leverage on the skills available in those countries with the most success in the region. Restrictions on the freedom of movement and the right to resettle in some countries, which are barriers to achieve this need lifting in order to fully benefit from the advantages of regional integration.

6.6.2. Creating a dedicated regional entity to promote renewable energy

To ensure that this Regional Action Plan is implemented in a co-ordinated and effective manner, a specific regional entity has to be created to ensure the mobilisation of technical and financial resources. The entity should be based on the principles of efficiency and continuity.

[14] The range of figures is according to the 5-25% scenario of VRE penetration in the region's power mix by 2030.

In practical terms, the following stages will be conducive to the adequate operationalisation of such a regional body:

- Establishment phase (political buy-in, feasibility study, hosting arrangements).
- Definition of institutional framework for implementation of the Action Plan.
- Mobilisation of financial resources to ensure implementation of the Action Plan.
- Drafting of key work programme activities and their execution.

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Annex 1: Overview of the key actions identified as amended during the Technical Validation Meeting

Pillars	Objectives	Actions
Renewable Energy Resource Assessment	Assessing the cost-effective renewable energy potential	• Map the most suitable locations across the region for the development of small hydropower, wind, solar PV and biomass energy. • Build technical capacity at the regional level to introduce maps and train experts on how to use the outcomes of the resource mapping for generation and transmission system expansion planning. • Undertake an assessment of cost-effective renewable energy potentials across the region. • Establish frameworks to undertake project-specific resource assessments.
Energy data	Enhancing the collection, processing and dissemination of renewable energy data	• Harmonise energy terminologies, definitions and related assumptions across the region. • Build capacity to collect, process and disseminate energy statistics. • Enhance the management and knowledge of energy resources • Establish a regional energy information system that is reliable and up to date.
Long-term planning	Introducing Solar, Wind, Geothermal, Small hydropower and biomass into national and regional planning depending on the economic viability	• Build capacity for long-term energy planning processes and the tools to link the assessment of renewable potential to actual development. • Prepare national and regional power sector or energy master plans that account for an increased share of variable renewables.
Enabling National and Regional Policy and Regulatory Framework for Investments	Setting ambitious but realistic regional and national targets for renewable energy deployment	• Undertake studies to define appropriate national and regional renewable energy targets. • Provide training on how to set realistic renewable energy targets. • Build capacity to target key energy stakeholders, including policymakers, regulators, utilities and • others on viable technology deployment options and their benefits
	Creating stronger frameworks for renewable energy policy and regulation	• Carry out studies to develop approaches and strategies for renewable energy development, able to be well integrated into the broader regional energy strategy. • Carry out studies to develop renewable energy policies at the national level, as well as related policy support schemes (including, financial and non-financial measures) that will enable effective implementation of policies. • Develop specific equipment quality and operational standards for the deployment and operation of renewable energy technologies. • Enhance the necessary skill base within institutions responsible for policy development and implementation.

Renewable Energy Project Development and Finance	Building capacities on developing bankable renewable energy projects	• Reinforce local capacities to improve the quality of project proposals and increase overall project bankability. • Support enhanced interaction among market players, particularly linking project developers and financiers, to accelerate deal flow and renewable energy investment. • Facilitate access to affordable financing to support replicable, scalable and potentially transformative renewable energy projects.
	Enhancing private participation and financing for renewable energy projects	• Explore the potential of establishing risk mitigation frameworks at the national and/or regional level(s) to address the various types of risk that prevail along the development cycle of renewable energy projects • Develop mechanisms to increase the level of liquidity of local financial institutions and untap the opportunity of non-banking financial institutions in order to increase access to capital and reduce the cost of debt for private actors. • Put in place effective institutional and regulatory frameworks to streamline the institutional climate for the development of small- and medium-size renewable energy entrepreneurs and create specific mechanisms to support their development.
Institutional Set-Up and Skill Development across the Renewables Value Chain	Strengthen capabilities in the installation, operation and maintenance of renewable energy systems	• Develop awareness-raising through public campaigns, education and training programmes that target a diversity of groups such as government entities, businesses and civil society. This should be supplemented by communication initiatives from public and local decision makers on the strong business case for renewable energy in countries across the region. • Implement regular, intensive education and capacity-building programmes to further strengthen expertise in renewable energy across the project development value chain (e.g. resource assessment, planning, design and operations and maintenance of variable renewable energy power installations, monitoring and evaluation). • Include renewable energy components in the curricula of secondary and higher education as well as vocational institutions across the region. • Co-ordinate action among national stakeholders at the country and cross-border levels to promote local job opportunities, supported by fiscal and financial incentives. • Provide on-the-job training for young and entry-level engineers in the local job market, particularly within the power sector.
	Creating a dedicated regional entity to promote renewable energy	• Engagement of technical and financial partners • Conduct of the feasibility study • Definition of the institutional framework for the implementation of the Regional Renewable Energy Roadmap • Mobilisation of financial resources to ensure the implementation of the Regional Renewable Energy Roadmap. • Drafting of key activities of the work program and their implementation.

Annex 2: Overview of Main National Energy Institutions

The following is a list of key institutions in each country within the Economic Community of Central African States that relate to the energy sector.

Central Africa Republic	
MEH	Ministère de l'Energie et de l'Hydraulique (Ministry of Energy and Water)
DGE	Direction Générale de l'Energie (General Directorate of Energy)
ARSEC	Agence de Régulation de Secteur Electrique en Centrafrique (Regulatory Agency for the Electricity Sector of the Central African Republic)
ACER	Agence Centrafricaine d'Electrification Rurale (Rural Electrification Agency of the Central African Republic)
Democratic Republic of Congo	
MEH	Ministère de l'Energie (Ministry of Energy)
SNEL	Société Nationale d'Electricité (National Power Utility)
ENERCA	Energie Centrafricaine (Power Utility of the Central Africa Republic)
Democratic Republic of São Tomé and Principe	
MIRNE	Ministère des Infrastructures et Ressources Naturelles et Environnement (Ministry of Infrastructure, Natural Resources and Environment)
Gabonese Republic	
MEE	Ministère de l'énergie et de l'Eau (Ministry of Energy and Water)
DGE	Direction Générale de l'Energie (General Directorate of Energy)
CNEE	Conseil National de l'Eau potable et de l'Electricité (National Council for Potable Water and Electricity
ARSEE	Agence de Régulation du Secteur de l'Eau Potable et de l'Electricité (Regulatory Agency for Potable Water and Electricity)
SEEG	Société d'Energie et d'Eau du Gabon (Energy and Power Company of Gabon).
Republic of Angola	
MEE	Ministère de L'Energie et de l'Eau (Ministry of Energy and Water)
PRODEL	Entreprise Nationale de Production d'Electricité (National Power Generation Company)
ENDE	Entreprise Nationale de Distribution d'Electricité (National Power Distribution Company)
GAMEK	Entreprise de Gestion hydroélectrique du Moyen Kwanza (Managing Company of the Hydroelectricity Plant of Middle Kwanza)
IRSEA	Institut de Régulation du Secteur Électrique et de l'Eau (Electricity and Water Regulatory Institute)
Republic of Burundi	
MHEM	Ministère de l'Hydraulique, de l'Energie et des Mines (Ministry of Water, Energy and Mines)
ABER	Agence Burundaise de l'Électrification Rurale (Burundese Rural Electrification Agency)

Republic of Cameroon	
MINEE	Ministère de l'Energie et de l'Eau (Ministry of Energy and Water)
ME	Ministère de l'Environnement (Environment Ministry)
AES/SONEL	Société mixte de production et de distribution d'électricité (Mixte Society of Electricity Generation and Distribution)
ARSEL	Agence de régulation du secteur électrique (Electricity Sector Regulatory Agency)
AER	Agence d'électrification rurale (Rural Electrification Agency)
EDC	Electricity Development Company
Republic of Chad	
MEP	Ministère de l'Energie et du Pétrole (Ministry of Energy and Petroleum)
DE	Direction de l'Energie (Directorate of Energy)
SNE	Société Nationale d'Electricité (National Power Utility)
Republic of Congo	
MEH	Ministère de l'Energie et de l'Hydraulique (Ministry of Energy and Water)
E^2C (ex-SNE) - Energie Electrique du Congo	E^2C (ex-SNE) - Energie Electrique du Congo (National Power Utility)
ARSEL	Agence de Régulation du Secteur de l'Electricité (Energy Regulatory Agency)
ANER	Agence Nationale d'Electrification rurale (National Rural Electrification Agency)
Republic of Equatorial Guinea	
MMIE	Ministère des Mines, de l'Industrie et de l'Energie (Ministry of Mining, Industry and Energy)
DGE	Direction Générale de l'Energie (General Directorate of Energy)
SEGESA	Société de l'Energie de la Guinée Equatoriale (Power Utility of Equatorial Guinea)
DGNRE	Direction Générale des Ressources Naturelles et de l'Énergie (General Directorate for Natural Resources and Energy)
EMAE	Société Mixte d'Electricité de São Tomé et Principe (Power Utility of São Tomé and Principe)
Republic of Rwanda	
MININFRA	Ministry of Infrastructure
MINIRENA	Ministry of Natural Resources
RDB	Rwanda Development Board
RURA	Rwanda Utilities Regulatory Authority
RSB	Rwanda Standards Board
REMA	Rwanda Environment Management Authority
NCST	National Commission of Science and Technology