ACCESS TO RENEWABLE ENERGY IN AFRICA

Abdourahmane Mbade Sene*

Abstract

The paper aims to understand trends in geographical distribution and temporal changes in access to renewable energy in Africa. A principal component analysis is then applied to data collected from the World Bank. Africa has the highest rates of renewable energy consumption in the world due to significant use of wood for cooking, low electricity consumption, and a large consumer market for renewable energies products. However, its renewable electricity production is below that of the world. For 25 years, renewable energy consumption and renewable electricity production have been steadily declining worldwide.

1. Introduction

Renewable energies play a strategic role in an international context marked by the scarcity of fossil fuel reserves, rising prices and global warming (Carbonnier et Grinevald, 2011). As clean energy, their importance is also related to the issues and roles of sustainable development in today's economies. Africa is today marked by many concrete initiatives on renewable energies at national or regional level.

For example, since the Bonn Conference on Sustainable Energy in 2001, a number of policies have been launched in West Africa, such as the White Paper of the Economic Community of West African States (ECOWAS) in 2006, the establishment of the Center for Renewable Energy and Energy Efficiency of ECOWAS (ECREEE), the Regional Initiative for Sustainable Energy (IRED) and the Renewable Energy Development and Energy Efficiency Program (PRODERE).

Several policies are also launched in most African countries: the creation of Renewable Energy and Energy Management Agencies in several African countries and the launch of several North-South partnerships to support renewable energies access policies in Africa. For example, the Africa-European Union Energy Partnership (AEEP), which has set itself the goal of constructing 10,000 megawatts (MW) of hydroelectric facilities, including 5,000 MW of wind capacity and 5,000 MW of solar capacity by 2020. This multiplication of policies and actions for the promotion of renewable energies in Africa reflects their importance in the energy development of the continent but also its considerable potential not yet exploited (ADEA, 2015).

* Department of geography, University of Assane Seck, BP 523, Ziguinchor, Senegal. E-mail: asene@univ-zig.sn.

Several studies have focused on the achievements and potentials existing in each African country or region (Ferrenbech, 2012; CEREEC, 2012; REN 21, 2016; ONU Environnement and BNEF, 2017). However, few studies have focused on making a comparative study of access to renewable energies between different countries or understanding their place in development policies. In this context, the general objective of this research is to characterize access to renewable energies in the different countries of the continent. The specific objectives are to first determine the place of renewable energies in development policies. Next, they seek to categorize countries according to their access to renewable energy. Finally, they examine the evolution trends of the West Africa region in terms of access to renewable energy in an African and global context.

2. Theoretical and methodological framework

2.1 Review of the literature

In terms of scientific and academic literature, renewable energy access policies are generally approached from the angle of the energy transition considered as the cornerstone for the fight against climate change and the achievement of sustainable development objectives (Bouchard, 2014; Alexeeva et Y. Roche, 2014). It should be noted, however, that even in developed countries, the concept of energy transition was launched only in the 1980s (Krause et al., 1980). And the concretization of the implementation of the energy transition policy really begins in Europe only from 2000 in Germany with its decision to leave the nuclear power and put in place a policy of financial support for renewable energies (Bruns et al., 2010; Mautz, 2008). This policy will then be taken up by several other European countries (Bailoni et Deshaies, 2014). Today, Europe, like most developed countries, despite its efforts, is still struggling with the application of its renewable energy policies (Deshaies, 2013; Smil, 2010).
In this context, what is the role of renewable energy access policies in African countries? In terms of the scientific literature, most of the documentation dealing with this issue seems to be confined to reports from public or private organizations working in the sector (ADEA, 2015; REN 21, 2016). Like other parts of the world, especially Europe, the situation in Africa is generally presented with ups and downs (Ferrenbech, 2012; Magrin, 2007).

2.2 Methodology

The analysis method has three components: data collection, principal component analysis (PCA), and map processing of results. The data collected is from 2013 and comes from the World Bank. Their database is a compilation of data from several reliable sources. The data collected consists of six variables also called indicators (Table 1) distributed among the 54 independent African States. The choice of variables is related, on the one hand, to their relevance for a study of territorial disparities in terms of access to renewable energies and socio-economic development, but also to their availability. Table 1 shows the World Bank's proposals for definitions of the indicators used in the analysis (Banque mondiale, 2016).

INDICATORS	INDICATORS DEFINITION
Indicators related to access to renewable energies	
Renewable energy consumption	% of total final energy consumption
Renewable electricity output	% of total electricity output
Indicators related to socio-economic development	
GDP per capita (current US$)	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars.
Mortality rate, under-5 (per 1,000 live births)	Under-five mortality rate is the probability per 1,000 that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year.
Access to electricity, urban	% of urban population
Access to electricity, rural	% of rural population

Table 1: Definition of indicators used in the ACP (Source: Study results)

The PCA, a multivariate analysis, is performed using SPSS software. The PCA determines the correlations between the variables and identifies the factorial axes. It offers a first assessment of the spatial distribution of indicators (Sène et Codjia, 2016). However, it requires certain conditions relating to the normality of the variables and their correlation before its realization. After studying the normality of the data, two of the following three conditions must be satisfied: the value of the Kaiser-Mayer-Olkin index (KMO), the Bartlett test and the correlation matrix (Le Moal, 2002). The Kolmogorov-Smirnov test indicates that, on average, the variables have a significance greater than 0.05. Then, they have a normal distribution. The ACP has a good KMO (0.721). The Bartlett sphericity test (value of 0.000) is also satisfactory. The conditions being satisfied, the ACP is generated.

Finally, a spatial analysis via the ArcMap application of the ArcGis 10 mapping software is carried out in order to better understand disparities in access to renewable energies on an African or even global scale. The Excel software is also used to develop graphs that allow to better understand trends in access to renewable energy.

The indicators selected are globally well representative of all available current data on renewable energies in Africa and in the world (percentage of renewable energy consumption, percentage of renewable electricity production). They also include some relevant socio-economic development indicators such as GDP per capita, infant mortality rate, percentage of access to electricity in urban areas, and percentage of access to electricity in rural areas.
These indicators of socio-economic development are commonly used to determine people's quality of life and their level of economic and social development. The study of their correlation with indicators of access to renewable energies, by factor analysis, makes it possible to deduce the nature of the links between policies of access to renewable energies of African countries with their socio-economic development policies. It also makes it possible to develop a categorization of countries according to their access to renewable energies and their level of socio-economic development.

3. Characterization of access to renewable energy

3.1 Independent access to the level of socio-economic development of the countries

The ACP reduced the mass of original data from 54 African countries and six variables into two major groups represented by components 1 and 2 (Figure 1). Component 1 reflects a strong positive correlation between indicators of GDP per capita and percentages of access of the rural and urban population to electricity. It also shows a strong but negative correlation between these indicators and the infant mortality rate. It is therefore identified as the level of socio-economic development of the countries. Component 2 reflects a strong correlation between the two other variables corresponding to the percentages of renewable energy consumption and renewable electricity production. It corresponds to access to renewable energies.

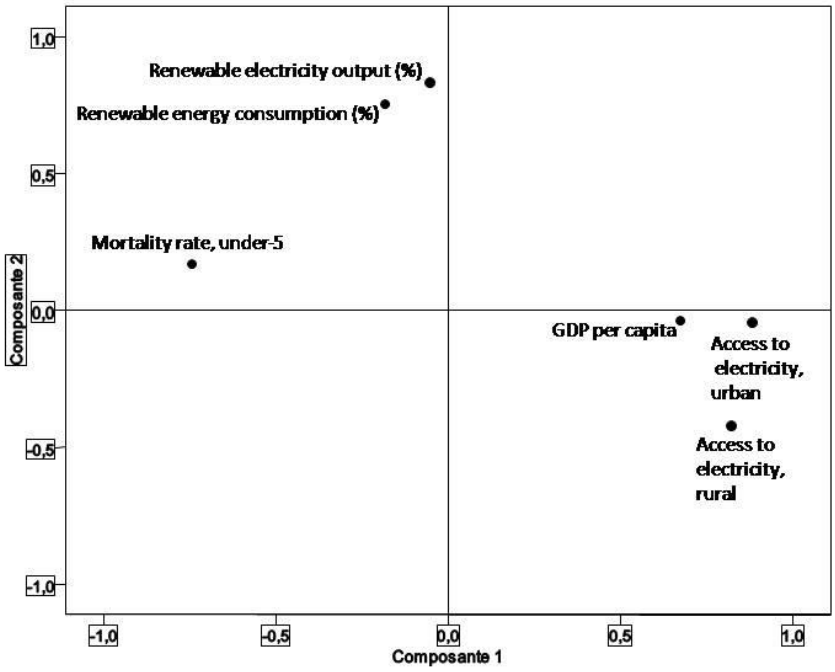

Figure 1: Saturations diagram (variable and components correlation) - Source: Study results

Two main trends emerge: (1) the existence of a close link between the consumption of renewable energies and the production of clean electricity; (2) the lack of a direct correlation between indicators of access to renewable energies and those of socio-economic development. In other words, access to renewable energy in Africa is not directly related to the quality of life or the level of socio-economic development of countries.

This result confirms some widely held beliefs that the share of "traditional" renewable energies is all the stronger in Africa as the level of development is low (Magrin, 2007). In fact, countries with a higher level of development have more means of access to "modern" renewable energies (wind, solar, etc.) that are more expensive. The equilibrium is thus quickly restored and some of the more developed countries such as Morocco, Algeria and Egypt and among the least developed, like Mauritania, South Sudan and Niger, show similarities in terms access to renewable energy (Figure 2).

The score diagram (Figure 2) shows four categories of African countries divided according to their indicators of access to renewable energy and their level of socio-economic development. The first group of countries (Ethiopia, Namibia, Lesotho, Zambia, Mozambique, Burundi, Malawi, Congo, Cameroon, Sudan, Kenya and so on) mainly English-speaking and East, Central and Southern Africa has the best indicators of access to energy renewable but with average socio-economic indicators.

The second group (Cape Verde, Mauritius, Seychelles, Algeria, Egypt, Morocco and Tunisia) is characterized by high socio-economic development indicators but with relatively low indicators of access to renewable energies. These countries are mainly from North Africa and a few island countries. The strong electrification of rural and urban areas of North African countries tends to increase their level of socio-economic development. They have significantly higher rural (99%) and urban (100%) electrification rates than those in sub-Saharan Africa, respectively 16% and 59% (Combes et Kéré, 2015).

The third group (Chad, Somalia, South Sudan, Guinea Bissau, Sierra Leone, Liberia and Niger) is characterized by the weakest socio-economic indicators in Africa and low to medium renewable energies access indicators. Most of the countries in this group are from West Africa. Most of these countries experienced political instability and civil war, which negatively affected their social and economic progress.

The fourth group of countries, which is more numerous, is characterized by an intermediate situation both in terms of indicators of access to renewable energies and the indicators of socio-economic development. Several West African countries are part of the latter group: Côte d'Ivoire, Ghana, Guinea, Togo, Nigeria and so on.

This categorization highlights an important fact: the countries in each major geographical area of the continent (southern, western, eastern, central and southern Africa) have almost similar characteristics in terms of socio-economic development and access to renewable energies. An effective way to improve access to renewable energy in the continent would be to create regional pools that fit more or less into the four categories highlighted. Through these regional pools, countries could gather their resources and

spread their networks across national borders by capitalizing on regional diversity of resources and demand.
The idea of regional energy pools is already defended on the continent. For example, Avila et al. (2017) argue that they would save more than $ 50 billion in capital investment in the electricity sector. "They would also facilitate the adoption of additional strategies to integrate large amounts of intermittent renewable energy, such as the existing hydroelectric reservoir for storage, the deployment of new chemical and mechanical storage technologies and the adoption of demand response programs across the region" (Avila et al., 2017).

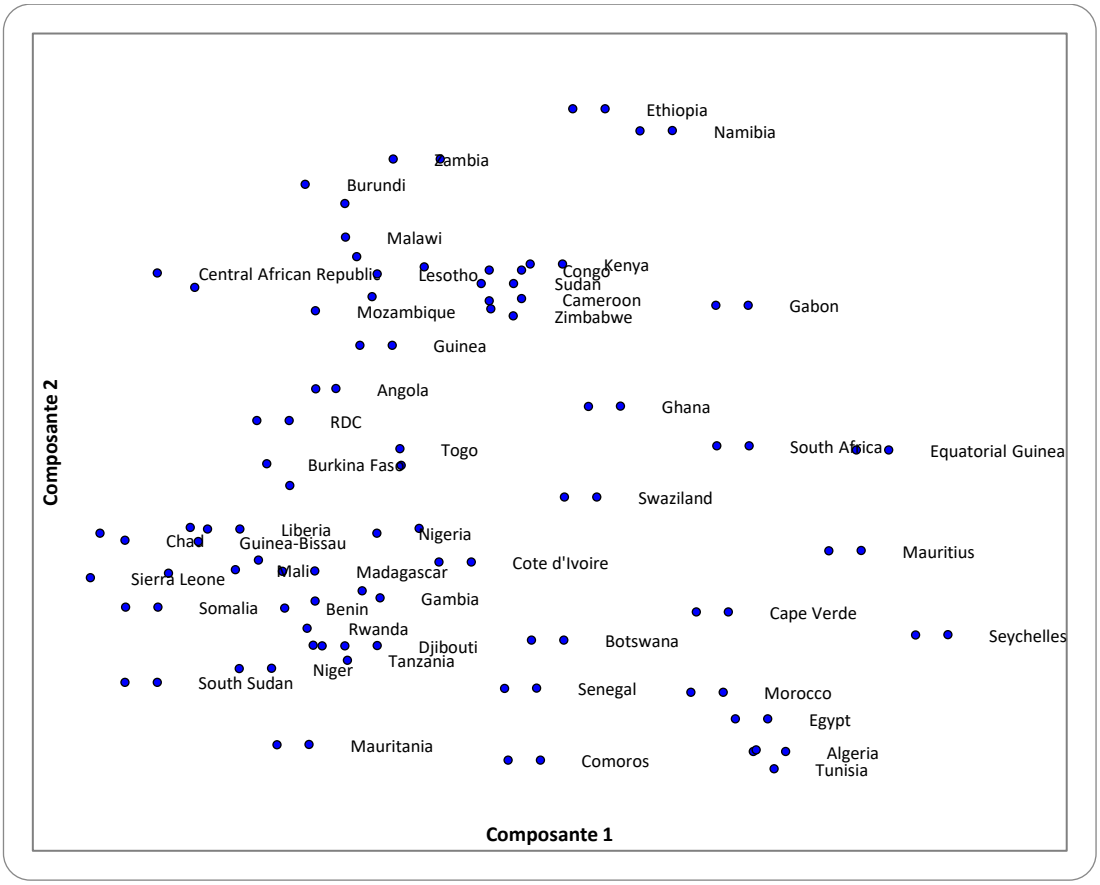

Figure 2: Scoring diagram (country and component correlation) - Source: Study results

3.2 Irregular geographical distribution

The mapping of component 2 on access to renewable energy indicates a very irregular situation across the continent and large geographical areas (Figure 3). With the exception of North Africa, which is globally characterized by low percentages, in all other major regions of the continent, the situation is very different from one country to another. However, in sub-Saharan Africa, West Africa has the lowest indicators. Access to renewable energies in this region does not depend on the geographical location of countries at the coast or inland, their level of socio-economic development, or their stable political history.

Ghana and Guinea top the list, followed by Guinea-Bissau, Liberia, Burkina Faso, Togo and Nigeria. Senegal, Mauritania and Niger, all Sahelian countries, have the lowest indicators. The other regions, especially Southern, Central and Eastern Africa, have the best average indicators, although the situation is very different from one country to another (Figure 3). Access to renewable energy in these countries does not depend on any specific geographical feature. Those with the highest access rates are coastal or continental.

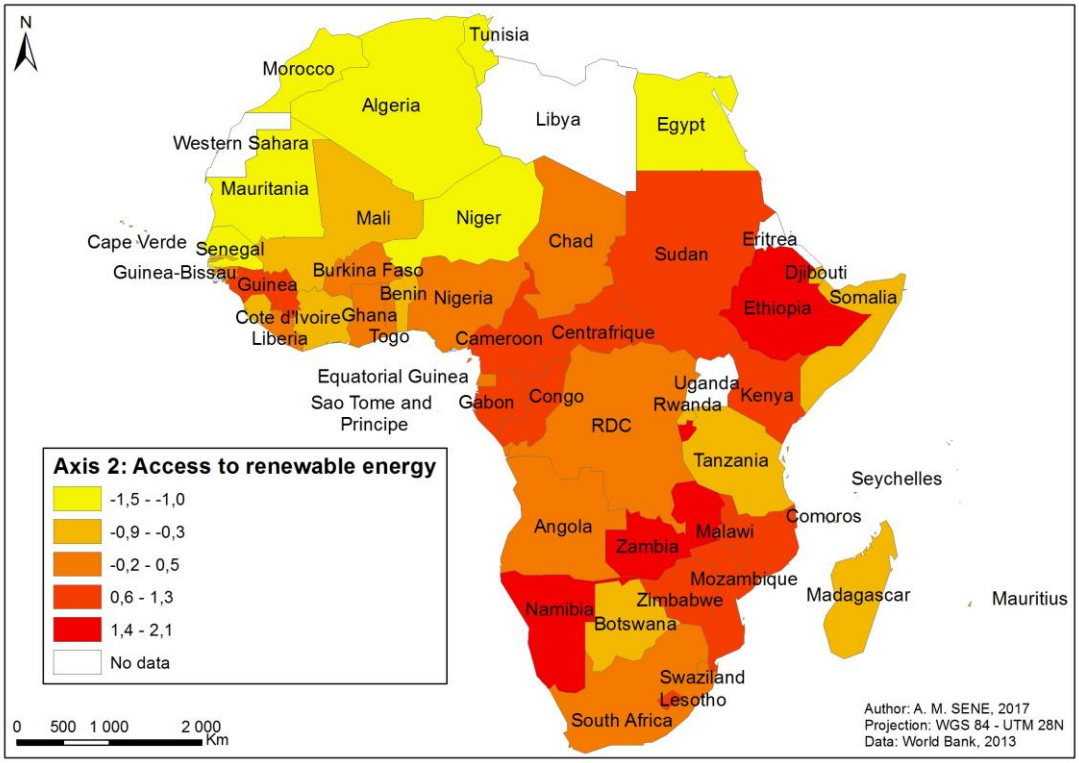

Figure 3: Geographic disparity of access to renewable energy in Africa - Source: Study results

4. Dynamics of access to renewable energy: the case of West Africa

4.1 Variable temporal evolutions

The main trend in the change in the renewable energy consumption percentage (% of total energy consumed) in West Africa shows that most countries have, at least once, a consumption percentage greater than 80 % between 1991 and 2011: for example, Guinea-Bissau, Mali, Niger, Nigeria, Sierra Leone, Côte d'Ivoire, Guinea, Togo and Burkina Faso (Figure 4). Only four countries, all Sahelians, have never reached a percentage of consumption equal to 80% between 1991 and 2001: Senegal, Gambia, Mauritania and Cape Verde. Their consumption varies between 20 and 60% in this period. The West Africa countries have, for the most part, a high percentage of renewable energy consumption (more than 80% of the total energy consumed).
This situation is general in sub-Saharan Africa and is due to a strong exploitation of renewable natural plant resources. "The so-called traditional energies, derived from

renewable raw materials (wood and charcoal) and agricultural by-products (crop residues, animal excrement), occupy a preponderant place in sub-Saharan Africa" (Magrin, 2007). The energy balance of the region in 2010 indicates that nearly 78% of energy demand, over the entire global energy mix of the majority of countries, comes from traditional biomass. And more than 90% of the population uses wood and charcoal for domestic cooking (Ferrenbech, 2012).
However, there is a general decline in the percentage of renewable energy consumption in all countries except Côte d'Ivoire, which is a relatively small jump from 72.4% in 1991 to 79.3% in 2011. The decline recorded varies from one country to another. By way of illustration, Benin's consumption of renewable energies dropped from 95% in 1991 to 51% in 2011, while Nigeria's consumption decreased from 86.5% in 1991 to 86.1% in 2011.

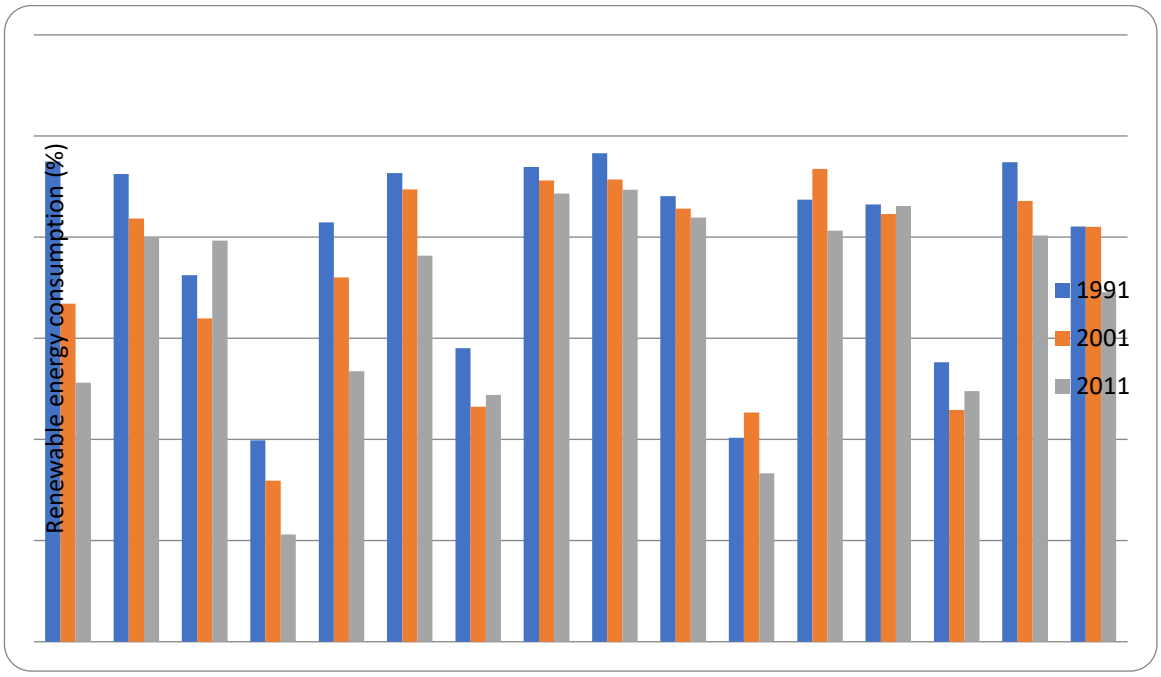

Figure 4: Evolution of renewable energy consumption in West Africa - Source: Study results

Compared to renewable energy consumption, the percentage of renewable electricity generation in West Africa shows greater disparities both between countries and within a country over time (Figure 5). In particular, it indicates that the percentage of renewable electricity production is much lower than the percentage of renewable energy consumption.
In a context where the rate of rural electrification as urban is low, the challenges for the West African region are then important especially since it has a significant potential for wind, solar and hydroelectric power generation (CEREEC, 2012). In 2011, only Togo has a production above 80%. All other countries produce less than 40%. Countries such as The Gambia and Guinea-Bissau even registered zero production between 1990 and 2012. In all countries, production is steadily declining or becoming jagged (Figure 5).

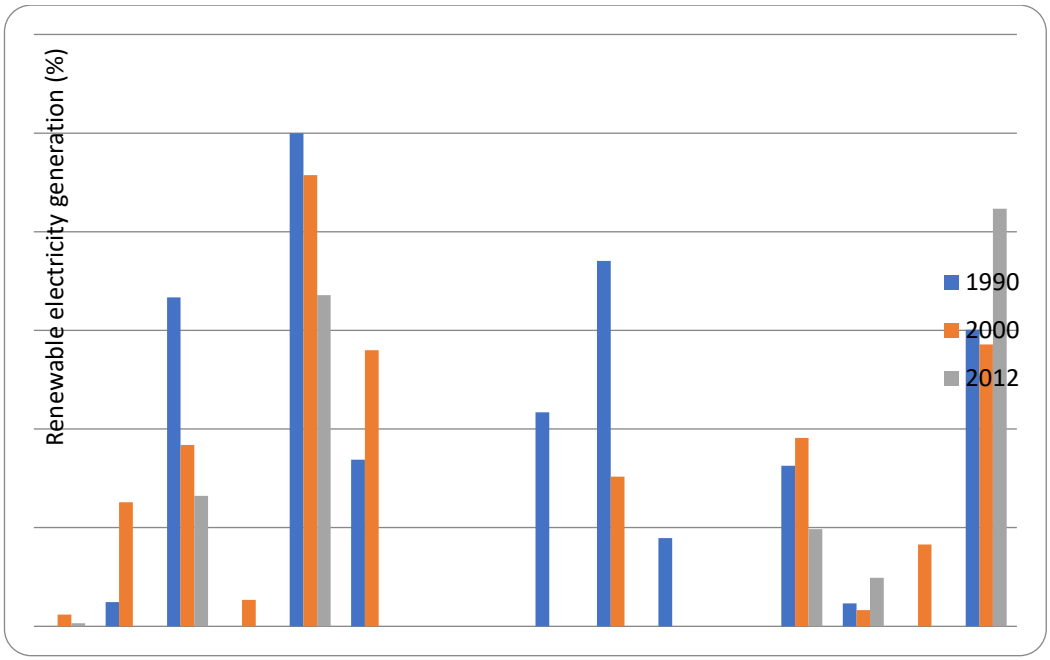

Figure 5: Renewable electricity generation in West Africa - Source: Study results

4.2 Downward trend in access rates

The average percentage of renewable energy consumption in West Africa is significantly higher than that of the world between 1990 and 2011 (Figure 6). In 2011, for example, the average consumption in West Africa is 77.6% against 32% for the world average. According to Claustre et al., The African continent has the highest rate of primary renewable energy consumption globally because of the high use of wood for cooking coupled with low electricity consumption (many tens of millions of Africans do not have access to electricity) (Claustre et al., 2014).

Electricity consumption in 2013 is only 488 Kilowatt hours per inhabitant (KWh / inhabitant) for sub-Saharan Africa compared with 672.6 KWh / inhabitant for South Asia, 2130 KWh / inhabitant for Latin America and the Caribbean and 2880 KWh / inhabitant for North Africa and the Middle East. It is much higher in industrialized regions like Europe and Central Asia (5429 KWh / inhabitant) and North America where it amounts to 13241 KWh / inhabitant (Banque mondiale, 2016). For example, less than 15 per cent of sub-Saharan Africans have access to electricity (Magrin, 2007), and even in the top ten hydrocarbon producing countries of sub-Saharan Africa, two-thirds of the population have no access to electricity (Carbonnier et Grinevald, 2011; IEA, 2008). Factors that limit the development of electricity in the region are the lack of effective technical, financial and political mechanisms for the development of energy resources.

In addition, there is a general decline in the consumption of renewable energies both in West Africa and globally. The average for West Africa rose from 84% in 1990 to 72.6% in 2011, a decrease of 11.4% in 20 years. Globally, the decrease is also noted but slower: 5.7% between 1990 and 2011.

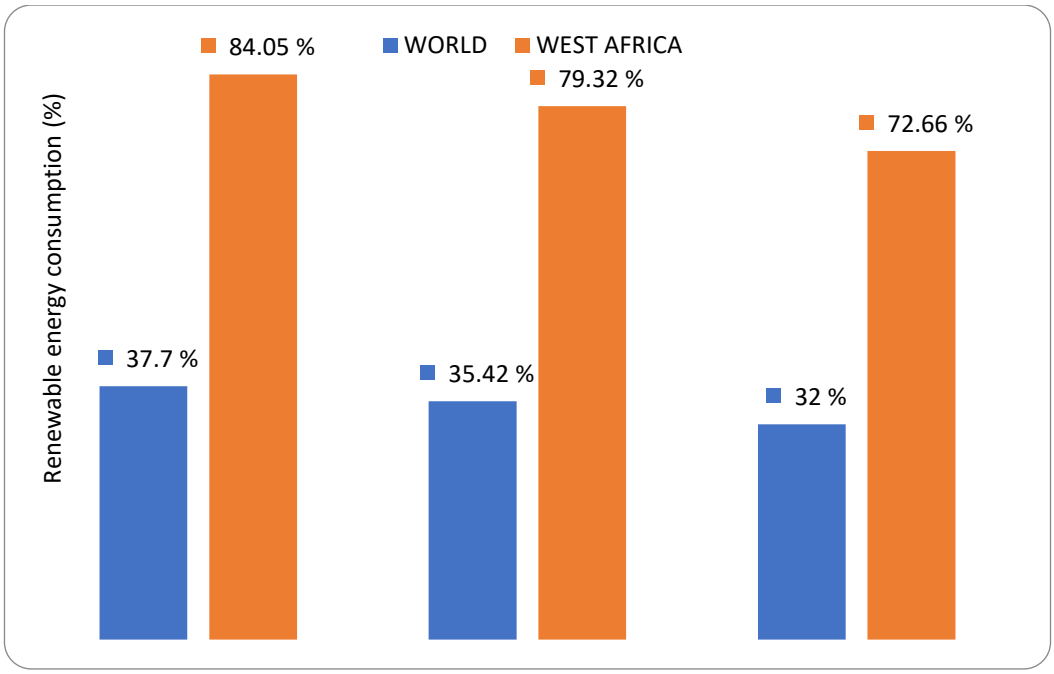

Figure 6: Average consumption of renewable energies in West Africa and the world - Source: Study results

The average percentage of renewable electricity produced in West Africa is lower than that of the world. The gaps are more and more important between the two averages over the years. As with renewable energy consumption, there is also an overall trend of decreasing renewable electricity production on both scales between 1990 and 2012 (Figure 7).

These results confirm the work of Michaelowa and Michaelowa (2011), who argue that funding for renewable energy projects has generally declined in recent years. They state that "the advent of international climate policy in the 1990s has not stimulated renewable energy and energy efficiency projects in the framework of bilateral development cooperation, which accounts for the bulk of aid (Michaelowa et Michaelowa, 2011). Their analysis shows that the Rio Summit of 1992 was accompanied by a marked increase in aid related to renewable energy projects. However, the Kyoto Conference in 1997, the Kyoto Protocol Agreement and its ratification in 2005, rather reversed this trend. They have shown a sharp decline in "traditional" renewable energy projects such as hydropower and geothermal energy from their peak in the early 1980s to the same time as "new" renewable energies such as solar, wind and biomass have been erratic since their peak in the late 1990s.

According to UN Environment and Bloomberg New Energy Finance (BNEF), investment in renewable energy has decreased by 30% in developing countries and by 14% in developed countries in 2016. African countries such as South Africa and Morocco have even experienced in 2016 a decline of 60% or more of their investments due to a lower demand than expected in electricity and delays in financing (ONU Environnement and BNEF, 2017).

Several authors agree today that the often higher costs of renewable energies compared to other fossil fuels justify their difficult breakthrough in the energy

sector, despite the fact that they contribute to reducing greenhouse gas emissions (Claustre et al., 2014; Cruciani, 2014; Ronneau, 2013). However, the market trend indicates a gradual decline in the price of renewable energy technologies (ONU Environnement and BNEF, 2017), while some fossil energy sources such as oil tend to increase (CEREEC, 2012). If this trend continues, the current decline in renewable energy consumption and renewable electricity production could therefore change or even reverse in the coming decades.

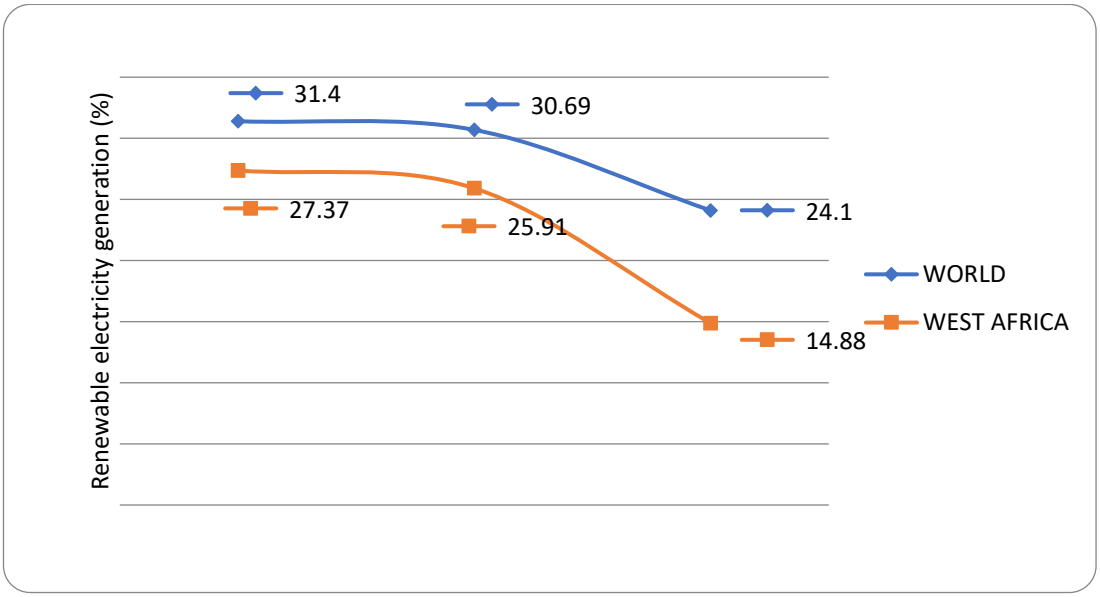

Figure 7: Renewable electricity generation in West Africa and in the world - Source: Study results

4.3 Strong geographical disparities

West Africa, like the African continent, is one of the regions in the world with the highest average percentages of renewable energy consumption (Figure 8). In addition to the strong exploitation of its renewable plant resources (wood, charcoal), other factors also play a role in this high consumption. In fact, sub-Saharan Africa is now a vast consumer market for renewable energy products. The latest report on the global status of renewable energies in 2016 indicates that sub-Saharan Africa is the world's largest market for off-grid solar products (1.37 million units) ahead of South Asia (1.28 million units sold) (REN 21, 2016).

The average percentage of renewable energy consumption in West Africa is higher than most developed countries such as the United States, European Union countries, India, China, Japan or Australia. Renewable electricity production follows the same trends as renewable energy consumption in Africa. "Developing economies have thus invested more in electricity and renewable fuels than developed economies." (REN 21, 2016).

At the scale of the African continent, consumption is very different from one country to another, but also from one region to another. However, we note that North Africa and several Sahelian countries south of the Sahara, such as Senegal, Mali and Mauritania, are among the lowest percentages of renewable energy

consumption (Figure 8). The justification could come, in part, from the weakness of plant biomass in this part of the continent, which then leads to lower pressure on these plant resources, which form the bulk of renewable energy consumption in Africa.

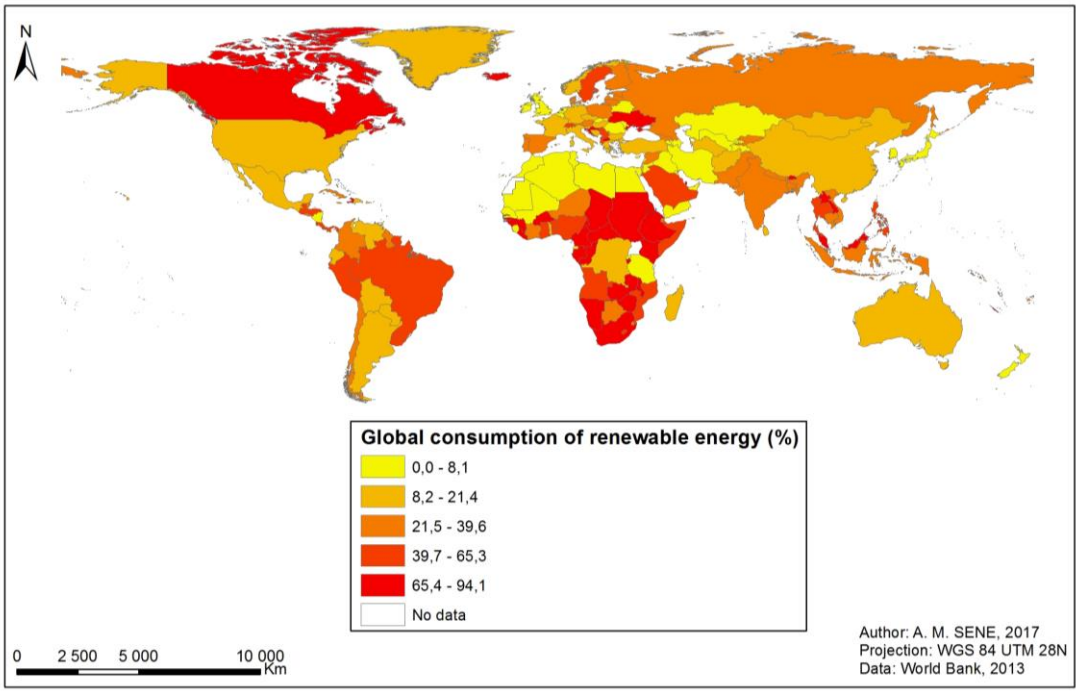

Figure 8: Renewable energy consumption in the world - Source: Study results

5. Conclusion

Africa stands out with countries that have some of the best indicators of access to renewable energy in the world. At the continental level, access to renewable energy is independent of the level of socio-economic development of countries and their quality of life. For example, rural and urban access to electricity is not correlated with renewable energy consumption or renewable electricity generation. For example, North African countries have the highest percentages of access to rural and urban electricity despite the fact that they have the lowest percentages of renewable electricity generation.

Four categories of African countries are identified according to their indicators of access to renewable energies and their level of socio-economic development. The first group, consisting mainly of English-speaking countries in Eastern, Central and Southern Africa, has the best indicators of access to renewable energy but with average socio-economic indicators. The second group, made up of North African and island countries, is characterized by high socio-economic development indicators but with relatively low indicators of access to renewable energies. The third group, mostly formed by West African countries, is characterized by the weakest socio-economic indicators in Africa and indicators of access to renewable energies that are low to medium. The fourth group of countries, more numerous and mostly made up of West African countries, is

characterized by an intermediate situation both in terms of access to renewable energies indicators and socio-economic development indicators. The development of energy policy strategies, following these categories corresponding to regional pools, would facilitate the achievement of national and regional energy sufficiency targets. It would boost access to energy across the continent.

The countries with the lowest indicators of access to renewable energies are those in North Africa and some Sahelian countries in West Africa such as Senegal, Mauritania and Niger. The regions of southern, eastern and central Africa, which are often richer in plant biomass, therefore have the highest rates of access to renewable energies. In addition to these broad trends, the overall picture is very different from one country to another in each geographical region of the continent.

The average percentage of renewable energy consumption in West Africa in 2011 (72.66%) is significantly better than that of the world (32%). On the other hand, for renewable electricity production, the average of West Africa (14.88% in 2012) is lower than the world average (24.1% in 2012). However, in both cases, there is a decrease in the averages of West Africa and the world between 1990 and 2012.

Contrary to popular belief and the expectations of the scientific literature, the average percentages of renewable energy consumption and renewable electricity production have steadily decreased over the last 25 years in West Africa and in the world. Even higher costs of clean energy technology partly justify this trend. However, not only has the dynamism of international renewable energy policy been noted since the 1992 Rio Summit and the Bonn Conference on Sustainable Energy in 2001, but there is also a gradual decrease in the costs of clean energy products.

The mapping shows that Sub-Saharan Africa is one of the regions with the best indicators in terms of percentage of renewable energy consumption. At first glance, the subcontinent appears to be a leader in renewable energies facing developed countries in the North and many Asian countries. However, the analyzes show that this leadership is linked to a very important use of wood for cooking and to a low consumption of electricity. The African continent is also a large consumer market for renewable energy products from abroad rather than a real producer despite its huge potential such as wind, solar, hydroelectricity and geothermal energy.

References

Alexeeva O.V. et Y. Roche (2014), La Chine en transition énergétique: Un virage vers les énergies renouvelables?, *VertigO - la revue électronique en sciences de l'environnement*, 14(3), http://vertigo.revues.org/15540.

ADEA (2015), *L'énergie en Afrique à l'horizon 2050*, Rapport d'étude, p. 160.

Avila N., Carvallo J. P., Shaw B., and Kammen D. M. (2017), The energy challenge in sub-Saharan Africa: A guide for advocates and policy makers: Part 1: Providing energy for sustainable and equitable development, Oxfam Research

Backgrounder series, https://www.oxfamamerica.org/static/media/files/oxfam-RAEL-energySSA-pt1- fr.pdf.

Bailoni M. et Deshaies M. (2014), Le Portugal et le défi de la transition énergétique : enjeux et conflits, *Cybergeo: European Journal of Geography*, http://cybergeo.revues.org/26567.

Banque mondiale (2016), Base de données de 2013, http://donnees.banquemondiale.org.

Bouchard C. (2014) Transition énergétique: contexte, enjeux et possibilités, *VertigO - la revue électronique en sciences de l'environnement*, 14(3), http://vertigo.revues.org/15975.

Bruns E., Ohlhorst D. and Wenzel B. (2010), 20 Jahre Förderung von Strom aus erneuerbaren Energien in Deutschland - eine Erfolgsgeschichte, *Renews Spezial*, Ausgabe,
http://www.unendlich-viel-energie.de/uploads/media/41_Renews_SpezialJahre_EE-Strom-Foerderung.pdf.

Carbonnier G. et J. Grinevald (2011), Énergie et développement, *Revue internationale de politique de développement*, 2, http://poldev.revues.org/687.

CEREEC (2012), Politique en matière d'énergies renouvelables de la CEDEAO, Version final, Praia.

Claustre R., Jedliczka M. et Fink M. (2014), Énergies renouvelables - en finir avec les idées reçues. Réseau Action Climat France (RAC-F), CLER - Réseau pour la transition et Hespul, http://www.hespul.org/wp-content/uploads/2014/05/ENR-idees_recues_CLER-Hespul-RAC_2014.pdf.

Cruciani M. (2014), Le coût des énergies renouvelables, *Notes de l'IFRI*, Paris, IFRI.

Deshaies M. (2013), Essor et limites des énergies renouvelables en Allemagne: la transition énergétique en question, *Revue de l'énergie*, 613, mai-juin, 169-184.

IEA (2008), *World energy outlook 2008*, Paris, IEA.

Krause F., Bossel H. and K. F. Müller-Reißmann (1980), Energiewende - Wachstum und Wohlstand ohne Erdöl und Uran, Francfort, S. Fischer Verlag.

Le Moal L. (2002), L'analyse en composante principale, Document de recherche, L'ACP sous SPSS, http://www.lemoal.org/download/spss/ACP.pdf.

Magrin, G. (2007), L'Afrique sub-saharienne face aux famines énergétiques, *EchoGéo*, 3, http://echogeo.revues.org/1976.

Mautz R., Byzio A. and W. Rosenbaum (2008), Auf dem Weg zur Energiewende: Die Entwicklung der Stromproduktion aus erneuerbaren Energien in Deutschland, Universitätsverlag Göttingen, http://www.oapen.org/download ?type =document&docid =353968.

Michaelowa A. et K. Michaelowa (2011), Du neuf avec du vieux: la politique climatique influence-t-elle l'aide bilatérale au développement?, *Revue internationale de politique de développement*, 2, 75-104.

Motel Combes P. et E. Kéré (2015), Défis énergétiques en Afrique Sub-saharienne, 10ième édition des journées de l'Afrique, 2 avril 2015, Université d'Auvergne.

ONU Environnement and BNEF (2017), Global trends in renewable energy investment 2017, Frankfurt, Frankfurt School-UNEP Centre, http://www.fs-unep-centre.org.

REN 21 (2016), Rapport sur le statut mondial des énergies renouvelables 2016 - Faits essentiels, Paris, Secrétariat du REN 21, p. 32, www.ren21.net.

Ronneau C. (2013), *Énergie, pollution de l'air et développement durable*, Louvain, Presses Universitaires de Louvain, 249-277.