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Renewable Energies in Africa, Context and Socio-Economic Challenge

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Abstract

In this paper, we have shown that Africa has an enormous wealth of renewable energy resources among the most important in the world such as the strong sunshine, Congo and Nile Rivers respectively among the most powerful and the longest in the world. We have underlined the presence of important forests, rich subsoil in mineral elements, and strong winds. In addition to a rapidly growing human capital, Africa, therefore, has at its disposal all the factors enabling it to initiate sustainable and inclusive socio-economic development. We have shown that the transformation of these renewable energies is an opportunity for Africa to reach its socio-economic challenges. The development of renewable energies in Africa will be a source of many financial benefits and advantages both in terms of improving living conditions and carrying out activities. The electrical supply of rural areas of Africa represents a considerable issue, which can be a propellant factor in long-term socio-economic development if the conditions of use of clean fuel and cooking technologies, especially sanitary are taken into account. The provision of modern energy services can contribute to the creation of jobs for young people upstream. Among other things, we can note the development of local skills, the creation of income-generating activities, and the improvement of hygiene and health measures which are necessary conditions for family and social well-being. This requires a policy focused, on research in general and in particular on semiconductors that participate in the transformation of photovoltaic solar energy. We have stressed that Africa which is currently experiencing a period of economic growth and sustained transformation must be very looking at in its energy policy and give pride of place to renewable energies to initiate sustainable socio-economic development, equitable and inclusive different social strata both in rural areas and urban areas.

Keywords

Africa, Renewable Energy, Photovoltaic Solar Energy, Semiconductor, Socio-Economic, Urban Area, Rural Area

1. Introduction

Energy in one form or another has been and remains an essential vital element for humanity. It is positioned as the essential propellant for the accomplishment of any human activity. Its sources have diversified over time to meet the ever-increasing needs of industry and consumers.

Nowadays, more than 80% of the energy used in the world comes from fossil fuel deposits (coal, oil, gas) or uranium, formed over time in good agreement with geological evolution [1]. In 2017, non-renewable energy resources constituted nearly 86% of global energy demand and 48% of African energy demand [2]. Given the consequences linked to the use of fossil-type energies, such as environmental pollution in addition to their limited nature, another source of renewable energy has emerged.

These so-called renewable energies all have the immense advantage of being of natural origin, inexhaustible and non-polluting since they do not emit gases that promote the greenhouse effect, which is harmful to the environment.

Renewable energies appear in this context as an interesting and powerful alternative for the development of living beings in a healthy and favorable environment. It is therefore understandable that the exploitation of the ecological environment to meet this need has experienced a notable improvement, particularly with about energies.

Sun, water, wind, wood, and other plant products are all natural resources capable of generating energy through man-made technologies. These renewable energy sources make it possible to obtain, after transformation, mechanical energy, electricity and heat or fuel. Coupled with the rational use of energy, they make it possible to reduce the consumption of fuels of fossil or fissile origin, and consequently to reduce the environmental and socio-economic impacts of our energy needs. In recent years, the changes observed concern both the improvement of transformation yields and the reduction in the cost price of the useful energy produced as well as the quality of the energy service and increased operating comfort.

The African continent experiences strong sunshine covering almost the entire year and rivers that are among the most powerful in the world in terms of flow (Congo River: 4.1×10^4 $m^3 \cdot s^{-1}$ on average and an area of drainage of approximately 3.7×10^6 km^2) [3] [4], among the longest in the world (Nile River: approximately 6895 km with a drainage area of 3×10^6 km^2) [3]. In addition, we note the presence of important forests, especially in Central and Southern Africa, rich subsoil in mineral elements, a much-diversified fauna, and strong winds blowing throughout the year in most of the continent. Renewable energies in this context will contribute in the short and long term to sustainable socio-economic development if a policy of exploitation and serious management of these different resources is put in place by African leaders.

In this paper, our objective is to study the socio-economic challenges of the transformation of renewable energies for Africa. In the rest of our work, we first approach the concepts of semiconductors and the process of solving the equations that govern the operation of the solar cell. Then, we are interested in the socio-economic context, the socio-economic impact, and the evolution of the exploitation of renewable energies for a continent in strong demographic growth. Finally, we study solar PV energy which is available in the different countries of the continent because of its accessibility to the different layers of society.

2. Materials and Methods

2.1. Semiconductors

Semiconductors are n or p-type doped materials, if the two semiconductors are of the same material, the p-n junction thus formed is called a homo-junction (case of silicon). Unlike the homo-junction, the combination of materials of type (I), (II), (III), and (IV) makes it possible to naturally obtain the formation of the p-n junction. The main pathways are cadmium telluride (CdTe), gallium arsenide (GaAs), copper indium sulfide (CIS), and its variant copper indium gallium sulfide (CIGS). Solar cells from this type of so-called hetero-junction are more promising for photovoltaic conversion and allow obtaining better efficiency.

The structure and operating principle of CIGS-based solar cells are presented in our previous articles [5] [6] [7] [8]. The differential equations whose resolution makes it possible to describe the operation of solar cells in general and of photovoltaic solar modules, in particular, are the so-called charge transport equations in semiconductor materials and are reduced to three in number, these equations are described in [1] [5] [7].

2.2. Equation-Solving Process in Solar Cells

The development, characterization, modeling and simulation of PV solar cells involve a certain knowledge of the energy source concerned, but also of the technological tool to be used **Figure 1** [1]. Numerical simulation is an effective

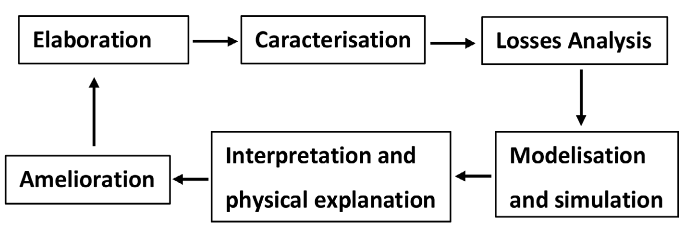

Figure 1. Process of characterization in improving the performance of solar cells [1].

tool used to understand and solve very complex problems related to the structure of solar cells. It makes it possible to effectively model and improve the conversion efficiency of solar devices, in particular CIGS-based solar cells [1].

2.3. Simulation Software

Digital simulation is an efficient means which permit to analyze and to understand physical phenomena. This takes more importance in applied research. Indeed, to properly describe the behavior of a system, it becomes necessary to use the digital models of its different components. The digital simulation makes it possible to guide the choice of approximations in analytical approaches and to obtain results directly comparable to those of the experience. In the field of digital simulation, several software has been developed by different institutions for simulation, dimensioning, and analysis of hybrid non-hybrid energy systems.

Simulsen software is used for hydraulic energy. It is mainly intended to simulate the operational management of multiple objective dams over a long period, by a calculation carried out in a daily time step. It makes it possible to assess the satisfaction of these objectives, depending on the water intake and the management instructions envisaged. The software is organized into three main parts: management of parameters and data, calculations, and exploitation of the results.

SAM (System Advisor Model) software is a technical and economic model that calculates the performance and financial parameters of renewable energy projects. SAM simulates the performance of photovoltaic solar energy (PV), thermodynamic solar power plants, solar heating of water, wind energy, geothermal energy, and biomass.

Homer dimensioning software is a tool known for its reliability in the design and analysis of hybrid energy systems, which contain a group of conventional generators, wind turbines, photovoltaic generators, and hydroelectricity [9].

SCAPS-1D and AMPS-1D are the most used simulation software for the modeling and characterization of thin-film solar cells and silicon-based solar cells. Available free of charge for research, this software is the pride of researchers. Detailed studies concerning this two software are presented in [10] [11] [12].

In the rest of our work, in addition to the results of the digital simulation, we will use the literature to defend our theme.

3. Results and Discussions

3.1. Renewable Energies

We consider energy renewable, any source of energy that is renewed quickly enough to be considered inexhaustible on the scale of man but also in certain cases of humanity (solar for example). Renewable energies come from regular or constant natural phenomena caused mainly by the sun (solar, hydraulic, wind, and biomass energy), the moon (tidal energy), and the Earth (deep geothermal energy).

The Sun provides enough energy each year to meet more than 7500 times the needs of the world's population [13]. Our planet receives in the space of one hour the energy equivalent of the annual consumption of the world population. Unfortunately, electricity production is ensured by structures that are sometimes only a few micrometers thickness: photovoltaic cells, the heart of solar panels [13].

In addition to sunshine, Africa has immense potential for different types of renewable energy, particularly hydropower thanks to the many rivers that crisscross the continent, wind power through the winds blowing with different intensities throughout the year in almost the entire continent [14]. Similarly, we note the biomass thanks to the primary forest of Central Africa as well as those encountered across the continent and the bagasse from sugar cane plantations in the different countries. There is also thermal energy and deep geothermal energy which are also exploited in different countries across the continent. Africa therefore has the potential and the capacity to make renewable energies the main driver of its economic and social growth.

3.2. Socio-Economic Context of Renewable Energies in Africa

The deployment of renewable energies in Africa has important issues. Over the past two decades, the continent has indeed experienced sustained growth, both in terms of gross domestic product and population. This growth should lead to an increase in primary energy demand and also fossil energy resources. If the reduction in technological costs of renewable energies observed on a global scale is more pronounced in Africa, renewable energies will then have to play an important role in the African energy landscape as Rih Berahab notes in its report [2]. A comparative study of the rate of access to energy in different countries in the world carried out by the Montaigne Institute in 2019 [15] shows that only South Africa presents a good report in terms of individual energy consumption (4475 MW/year) (**Figure 2**). According to **Figure 2**, we note that North Africa is also doing with individual consumption of around 1287 MW/year. Sub-Saharan Africa recorded the lowest consumption rate with an average of 181 MW/year.

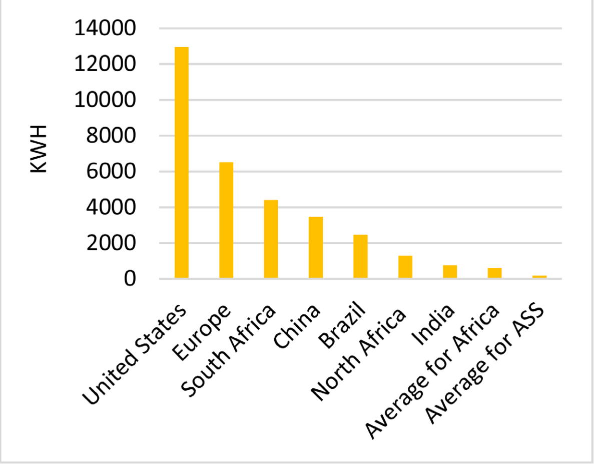

Figure 2. Annual consumption per capita around the world in 2012 [15]. Source: World Bank and African Development Bank, 2016.

A more detailed study shows that the ASS countries encounter enormous difficulties in terms of access to energy. These difficulties vary from one region to another, from one country to another, and from one area to another, showing sometimes very complex socio-economic inequalities (**Figure 3**). The price of the kilowatt-hour (KWH) is also very high as well as household rate and company rate and is not within the reach of all citizens even in urban areas, most of which have a daily income below the poverty line (1.9 - 2 USD/day). We can cite most African countries and in particular Burkina Faso, a country where the price per kilowatt-hour is among the most expensive in the world and amounts to 0.213 USD for household tariff and 0.471 USD for company tariff [16]. **Figure 3** shows an unequal distribution in terms of energy access in certain countries of Sub-Saharan Africa with individual consumption varying from (57 to 181 KWH/inhabitant in 2012).

These prices remain very expensive compared to the international average which is respectively 0.137 USD household rate and 0.125 USD company tariff [16]. When renewable resources are abundantly used in different sectors of everyday life, they help save significant quantities of fossil fuel. Since 2015, the World Bank had confirmed the installation of several thousand MW by the Independent Power Project in several countries of the ASS (**Figure 4**) [14].

In 2017, 4.6 TWH (terawatt-hours) of electricity from solar was produced on the continent, this represents only 2% of its electric mix while its theoretical potential is estimated at more than 60 million TWH per year [17]. **Figure 5** shows the forecasts in terms of access to electricity 2030 [18]. In comparison, Asia has a theoretical potential of 37.5 million TWH/year and Europe, only 3 million TWH/year. While Africa is largely under-equipped in terms of energy production, we emphasize that it has not yet taken the way to catch up because on 80 GW installed, the photovoltaic represents only 1.5 GW [17]. Recent studies dating from 2018 and conducted by Arnaud Rouget, Africa Analyst at the International Energy Agency confirms that almost half of Africans, or about 600 million people do not have access to electricity, and around 80% Sub-Saharan African

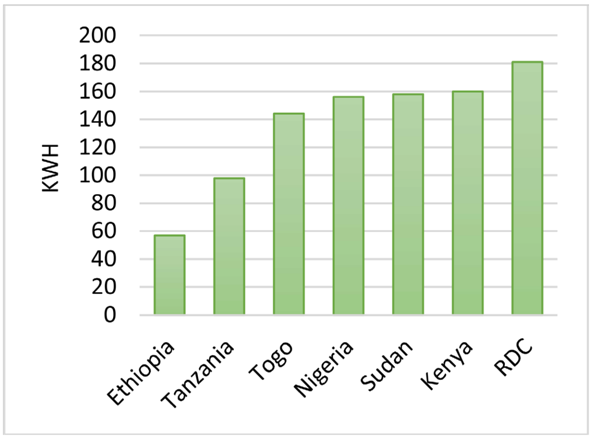

Figure 3. Electricity consumption in certain countries of the ASS in KWH/inhabitant in 2012 [15]. Source: World Bank and African Development Bank, 2016.

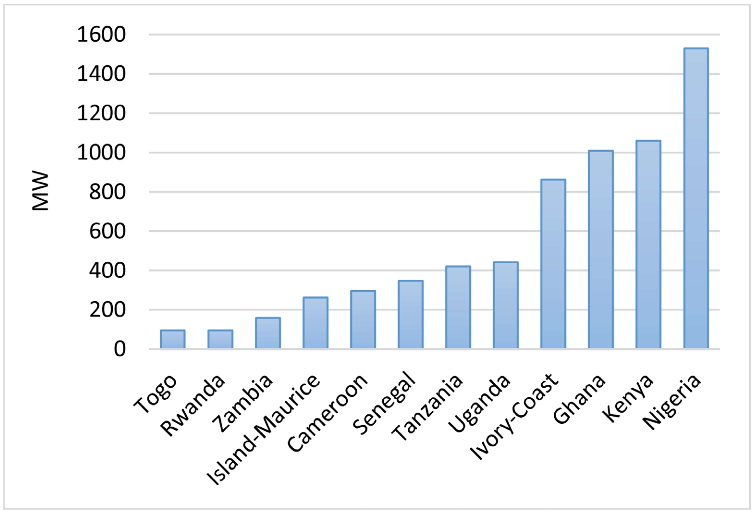

Figure 4. Capacity installed by Independent Power Project in ASS in (2015) [14] World Bank Source.

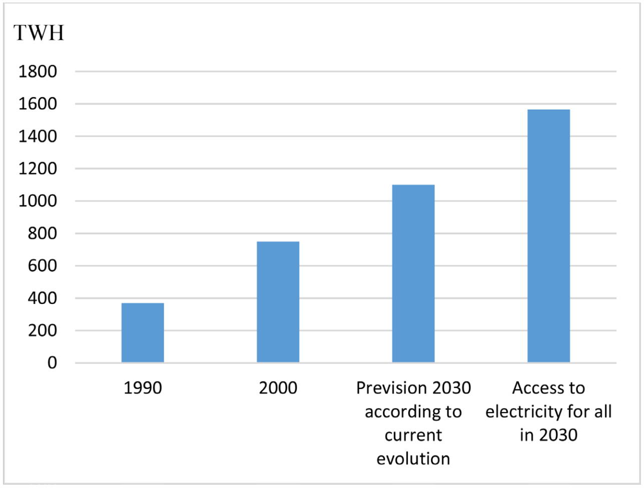

Figure 5. Current and provisional consumption of energy in 2030 [18]. Source: AIE 2012.

companies are undergoing frequent cuts, causing substantial economic losses [19]. A very interesting aspect of the energy investment efforts of African countries is existing interconnection projects which already make it possible to make up for load shedding in the countries least wealthy in energy resources. As an example, the Ivory Coast alone exchanges interconnection lines with six countries in the West African sub-region, namely Benin, Burkina Faso, Ghana, Liberia, Mali, and Togo [20] allowing these different countries to overcome a little bit to their energy needs.

Nevertheless, more than 90% of the renewable energy potential of the African continent remains unexploited. Ethiopia, South Africa, Egypt, and Angola are home to 37% of hydroelectric capacity. Although it remains below its potential, the consumption of hydroelectricity still experienced significant growth per year during the period 2000-2017, which testifies to the efforts of African countries to invest in this technology.

3.3. Socio-Economic Impact of Renewable Energies in Africa

Studies have effectively shown that the African subcontinent has an unqualified potential for renewable energy, including solar (10 TW) and hydraulics (350 GW, or 10% of the world potential), which rallied to off-Grid technologies, can quickly and low cost the problem of access to electricity in rural areas [14]. One of the scenarios developed by IRENA, estimates that the share of renewable energies in Africa can drop from 17% in 2009 to 50% in 2030 and almost 75% by 2050. Electrical production from these sources could go from 28 GW in 2010 to 800 GW by 2050 with 245 GW generated from photovoltaic solar, 242 GW hydroelectricity, 94 GW of the solar thermal energy, 69 GW of biomass, and 8 GW geothermal energy [2]. This scenario takes into account the objective of achieving universal access to modern energy services by 2030, while considerably reducing long-term costs [2].

The electrical supply of rural areas of Africa represents a considerable issue, which can be a propellant factor in long-term socio-economic development if the conditions of use of clean fuel and cooking technologies, especially sanitary are taken into account. The provision of modern energy services can contribute to the creation of jobs for young people upstream, thus resolving the issue of unemployment. Downstream it will cause large-scale development of African cities both economically and socially. Among other things, we note the development of local skills, the creation of income-generating activities, and the improvement of hygiene measures which are necessary conditions for family and social well-being. This is why in 2013 the International Agency for Renewable Energies in its report stresses that the economic integration of rural and urban areas is crucial to support the sustainable growth of the continent and promote the convergence of living standards of all Africans in the future [21].

The observation is that the rural areas of African countries are very disadvantaged in terms of electrification as can be seen in **Figure 6**. **Figure 6** shows a very

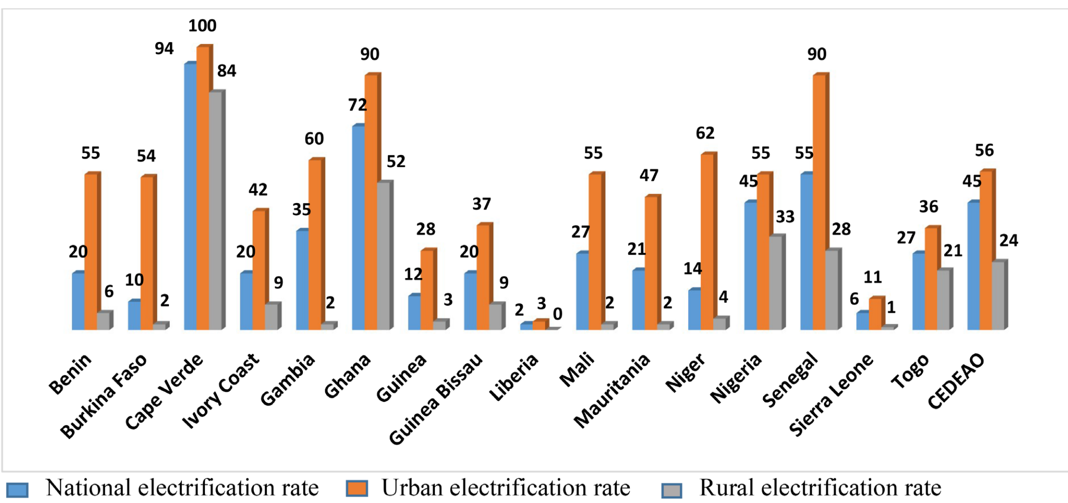

Figure 6. Electrification rate of ECOWAS member states in 2012 [22]. Data source: IEA, World Energy Outlook 2014.

low, even almost non-existent electrification of rural areas in most ECOWAS countries, these results are widespread in almost all countries on the continent. For example, in Nigeria (the first economic power on the continent) the rate of access to electrification drops from 36% of urban areas to rural areas [18]. This creates a social and economic imbalance, making populations living in rural areas very dependent on those in urban areas. A study conducted by the International Institute for Water and Environmental Engineering (2 IE) shows for example in 2015 that the electrification rate in Burkina Faso is 16.4%, the 12th position in the classification of Economic Comunateum of West African States (ECOWAS) (**Figure 6**) [22]. On the other hand, we note that only 112 departments are served on the 350 that the country has [22]. There is a significant gap between the rural environment and the urban environment regarding access to modern energies; thus the rate of access to electricity in Burkina Faso in rural areas is only 2.2% against 54.0% in urban areas (**Figure 6**) [22]. Any long-term approach for Africa must take into account two kinds of different energy issues, namely:

1) Those with African cities are faced: lack of energy in sufficient quantity for the transformation of raw materials and their industrialization;

2) In rural areas: the energy necessary for the production, processing, and transport of local products.

The energy supply of isolated communities is essential, not only to improve the quality of life of individuals but also to give impetus to local businesses and industries. To ensure the development of renewable energies at the rural level, it is necessary to set up specific and sectoral public policies focused on energy and to invest in the long term in research and innovation. This is why projects entering into the context of renewable energies are constantly created, such as the "Desert to Power" project which aims to generate 10 GW of solar capacity in eleven (11) countries in the Sahel region [23].

3.4. Evolution of the Exploitation of Renewable Energies in Africa

Figure 7 and **Figure 8** present the production capacity of the four most exploited renewable energy types in Africa. According to the two figures, we compare the production capacity of solar energy, wind energy, bioenergy, and hydraulic energy between 2008 and 2018. We note from **Figure 7** that the production capacity of bioenergy is greater than those of solar and wind energies between 2008 and 2012. Beyond 2012, the production capacity of wind energy becomes more important until 2017. In 2017, the most important is solar energy production capacity. In **Figure 8**, we note that between 2008 and 2010, the production capacity of hydraulic energy is significantly equal to the production capacity of all exploited renewable energies (solar, wind, bioenergy, hydraulic). Beyond 2010, the production of the whole becomes more and more important. In short, the results of this study show that investment policies in renewable energy are becoming more and more interesting. We note a production capacity

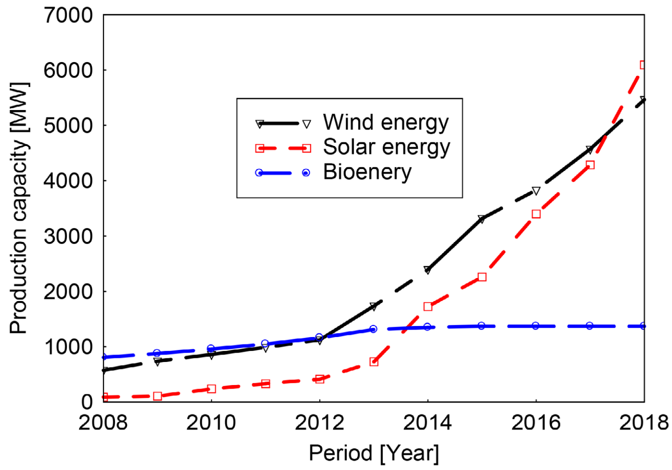

Figure 7. Evolution of the production capacity of solar, wind, and bioenergies [2] [24].

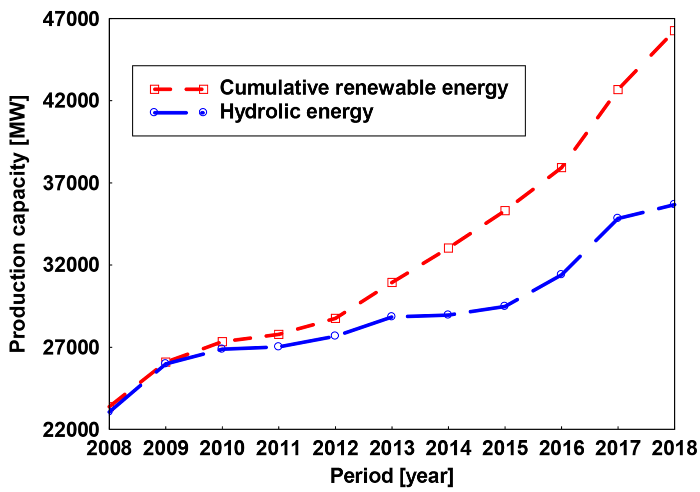

Figure 8. Evolution of the production capacity of hydraulic energy and cumulative of all renewable energies [25].

that increases exponentially over time. As an advantage, there is a significant decrease in the cost of renewable technologies as IRENA points out. Indeed, studies carried out by IRENA Costing Alliance show that the total cost of solar energy projects in Africa between 2013 and 2014 varied in the range of 0.13 to 0.26 USD per kilowatt (KWH).

For example, in South Africa, the lowest cost for utility photovoltaic systems was less than 0.075 USD per KWH, which is among the most competitive photovoltaic projects in Africa. Wind energy in this country has also been subcontracted at prices less than 17% of the prices provided for the two new coal power plants in the country [2].

Still, in comparative dynamics, we note a hydraulic energy production capacity of 25,987 MW in 2009 and 35,681 MW in 2018 against the production of 739 MW in 2009 and 5464 MW in 2018 for wind energy. For solar energy, we note production of 108 MW in 2009 and 6093 MW in 2018 while for bioenergy the production capacity amounted to around 600 MW in 2009 and 1400 MW in

2018. In 2009, Africa totaled a renewable energy production capacity of 26,097 MW, this production exceeded 46,000 MW in 2018 [24] [25]. Other studies carried out by [14] show that in 2016, the energy mix in ASS was 23.7% hydraulics, 1% geothermal energy, 0.9% wind, 0.6% solar, and 0.3% bioenergy [14].

Morocco is one of the few African countries that are increasingly interested in large-scale development of renewable energies. Since 2009, Morocco has embarked on an ambitious energy transition aimed at developing renewable energies, supporting energy efficiency, and reaching a renewable energy mix of at least 52% by 2030 [26]. With an additional installed capacity of 2965 MW since 2018, the energy mix had almost crossed the 35% mark. For the achievement of its objectives, the country has launched large projects and plans to produce an additional 10^4 MW of renewable energy with the production of 4500 MW of photovoltaic and thermal solar electricity, 4200 MW of wind turbines and 1300 MW of hydraulics at the horizon of 2030. This will permit the Morocco mixt energetic to atteint 20% for solar energy, 20% for wind energy and 12% for hydraulic energy [26].

It emerges from our study that hydraulic energy is the most exploited through the African continent, but with regard to the availability and simplicity of exploitation of PV solar energy, we will study it in the next section.

3.5. PV Solar Energy

Photovoltaic conversion is still the only one that is effective in directly converting solar radiation into electrical energy. In developing countries, such as African countries, the mastery of this technique for high-performance and low -cost production rightly deserves researchers in this area. The work carried out in the field of renewable energies in particular in the field of photovoltaic solar energy in the third world in general and more particularly in the West African sub-region aims to advance scientific and technological knowledge so that energy policy in our countries can benefit from advances in this sector. Several research works have been carried out to promote the popularization of this energy category [1] [5] [6] [7] [8] [27] [28] [29] [30] [31].

3.5.1. Characteristic Density of Current-Tension J-V

The simplest strategy to describe the performance of a solar cell is its characteristic current-voltage density. It is a standard method to assess the electrical performance of solar cells. The characteristic of current-voltage density of the solar cell is described by the standard diode equation:

$$J = J_0 \exp\left(\frac{qV}{AkT}\right) - J_{Ph}$$

where A is the quality factor, J_0 is the density of diode saturation current, J_{ph} is the density of photo-generated current, J and V are respectively the density of current and the voltage of the device.

In agreement with Söderström [32], the measurement of J-V current-voltage curves is the most convenient characterization technique to determine the electrical parameters of the solar cell that are: short-circuit current density (J_{SC}), Open circuit voltage (V_{OC}), the fill factor (FF) and the conversion efficiency (**Figure 9**). Other parameters are also extracted from the J-V characteristic: series resistance (RS) and Shunt resistance (RSH) which greatly influence the performance of the photovoltaic solar cell [33]. **Figure 9** obtained below presents the curves of the characteristic density of current-voltage in Illumination and in darkness.

Under darkness, the J-V characteristic follows the exponential law of the diode (**Figure 9**), under illumination, the J-V characteristic is offset down a negative quantity (**Figure 9**), the cell then supplied with energy. We note very interesting values of the different electrical parameters, and series and shunt resistances. However, we note a low value of the series resistance (Rs) (0.1 Ω * cm^2) and a great value of the shunt resistance (Rsh) (1000 Ω * cm^2) [1] [5], which is a source of good performance for the PV solar module in general and in particular better electrical parameters for the PV solar cell as indicated by the **Table 1**.

3.5.2. Temperature Influence

The effect of the temperature on the functioning of solar cells was addressed by several studies [12] [5] [8] [27], it appears that the temperature is a limiting factor for the proper functioning of photovoltaic solar devices. Operation at the lowest possible temperature makes it possible to obtain better electrical parameters and in particular a very important electrical conversion yield of the PV solar modules [1] [5] [12]. The innovative perspective of Ivory Coast is to be greeted, in reality Ivory Coast plans to install a photovoltaic field floating on the free surface of water (**Figure 10**).

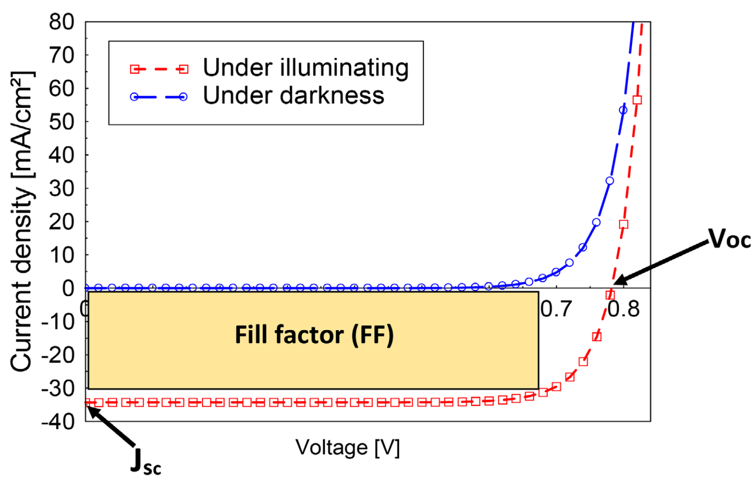

Figure 9. J-V Characteristics under darkness and under illumination.

Table 1. Values of the electrical parameters of the solar cell model studied.

Electrical parameters	V_{OC} (V)	J_{SC} (mA/cm^2)	FF (%)	η (%)	R_S (Ω * cm^2)	R_{Sh} (Ω * cm^2)
Values	0.782	34.30	79.80	21.42	0.1	10^3

Figure 10. Floating photovoltaic field whose Ivory Coast plans to install. Source: Young Africa of 06/12/2018 [34].

The idea of a cooling system for PV modules allowing the lowest possible temperature operation has long remained a large-scale problem for researchers from around the world in general and in particular for African researchers. The Ivorian project of the floating photovoltaic will end the many questions related to the significant drop in performance due to the rise in temperature. This type of installation will make it possible to optimize the electricity efficiency of the photovoltaic panels as much as possible. Indeed the installation will take place on a shadeless water area with an incident radiation of water and will avoid over-heating of the panels thanks to a significant decrease in the operating temperature, a guarantee of better efficiency of electric conversion. African countries in general but, especially coastal countries in particular must take into account the innovative example of Ivory Coast for an improvement in the yield of their photovoltaic solar heritage. This PV field with a capacity of 4 MW [34] will be very useful to the population which is found in a crucial situation of energy. We also note the existence of other projects in progress and which should allow the Ivory Coast to increase the share of renewable energies to 42% of its energy mix in 2030 in accordance with the commitments made at the 21st Conference Parts (COP21) [20] [34].

Several studies have been carried out in order to optimize the performance of PV solar cells, this will allow to have very good yields of photovoltaic solar panels. Some of these studies have been interested in the phenomena of defects [6] [27] [28] [29] [30] [31] [35] [36] and recombination of load carriers [1] which severely affect the performance of PV solar cells. Other studies have been oriented on parameters whose variation positively affects the performance of PV solar cells, among these parameters we can cited: the thickness of the buffer and absorber layers [6] [7] [12] [30], the Gap of the absorber [1] [7] [28] [31], the energy of the discontinuity of the valence and conduction bands [8] [37] [38] [39], the series resistance (Rs) and shunts resistance (Rsh) [1] [7] [27] as well as doping of layers [6] [29] [31]. The nature of the buffer layer is also a parameter for optimizing performance but also environmental protection against pollution due to the presence of toxic materials such as indium (In) and cadmium (Cd).

The research concerning alternative buffer layers has become an essential challenge in the field of photovoltaic solar energy [8] [12] [38] [39] [40] [41].

4. Conclusions

In this paper, we have studied the socio-economic context, the socio-economic impact and the evolution of the exploitation of renewable energies in Africa. Of the same we have studied the PV solar energy. We note an important effort of African investments in the area of the renewable energy about the various projects that have been carried out, which are in progress, and to this are added future projects which seem very ambitious. We note, among other things, important capacities installed in the different countries of the continent, the interconnection which allows the exchange of large capacity for energy between several countries. Exceptional efforts in terms of investment and exploitation of renewable energies were carried out, especially in Morocco.

Given socio-economic problems which the African population encounter in general and in particular those living in rural areas, African investments in the short and medium-term remain insufficient. Regarding the demographic explosion of the continent, long-term investments are largely insignificant in the face of the future energy needs of the continent. We have also done case of the African initiative on renewable energies which aims to help the achievement of the objectives of sustainable development and to strengthen family well-being. This initiative, which uncounters to ensure substantial economic development, guaranteeing universal access to sufficient quantities of clean, appropriate, and affordable energy, struggles to meet the real needs of the population.

Finally, we have stressed that Africa which is currently experiencing a period of economic growth and sustained transformation must be very looking at in its energy policy and give pride of place to renewable energies to initiate sustainable socio-economic development, equitable and inclusive different social strata both in rural areas and urban areas.

In view of the socio-economic issues of the exploitation of renewable energies which are very favorable to the development of Africa, in our future investigations we will optimize the performance of a solar cell with an alternative buffer layer of zinc selenide (ZnSe) that we have studied in our previous papers. Other articles will concern hydraulic energy or we will develop simulation programs under matlab Simulink inspired by SIMULSEN software. The objective of this work is to take into account certain aspects that will improve the irrigation of vegetable crops in the dry season.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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