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Renewable Energy as Solution to Energy Deficiency in Burundi

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Abstract

This study focused on the electrification of Burundi and how to equip Burundi with enough energy. Burundi is a member of various economic communities such as the East African Community (EAC), the Common Market for the East and South Africa (COMESA,) and the Economic Community of the Great Lake Countries (CEPGL). Burundi is still one of the poorest countries in the world, although it is a member of many economic communities. The most sensitive cause of this poverty situation is the lack of energy which slows down almost the entire economic chain.

In this study, using the natural (renewable) energy sources of Burundi, the development of the source of electric energy that influences the development of the country has been taken into consideration. As a result of this research, due to the geographical position of Burundi, solar energy was on focus as the most suitable energy source among renewable energy sources. In this context, it is envisaged to provide the transportation of electric energy to all regions that are not still used in electricity, and thus increase both economy and lifestyles.

Following this study, the Burundi Government, the Burundi economy operators, various partners, and investors will be able to overcome the development challenges and, as a result, this will lead to the improvement of this energy field, which is considered the pillar of a sustainable socioeconomic element in a worldwide area.

Keywords: *Solar energy, landlocked country, energy power, power plant, renewable energy, energy supply, energy deficiency.*

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1. Introduction

Burundi is located in Eastern Africa and extends between 28°58 ‘and 30°53’ east longitude and between 2°15 ‘and 4°30’ south latitude. It is bounded by Rwanda in the North, the Democratic Republic of Congo (DRC) in the West, and Tanzania in the South and East. It covers an area of 27834 km^2 of which about 2000 km^2 are occupied by the Burundian part of Lake Tanganyika and the population is 11,099,298 [1].

The majority of the Burundian population lives in the countryside and access the electric energy remains very low. The rural population is estimated about 90 percent [2]. Less than 5% of the population has access to the national grid. This implies a huge consumption of fuel wood as a source of primary energy, thus presenting serious negative consequences for the environment. Traditional biomass alone presents 99% of which 70% comes from firewood, 18% comes from agricultural residuals, 6% comes from coal, and 1% comes from bagasse [3].

The Burundian population living in the countryside needs to obtain basic energy; an essential energy especially for cooking and other activities requiring heating. This energy is obtained mainly from the combustion of biomass including firewood and charcoal. Despite this variety in energy sources, firewood and coal come first with a share of around 97.5% of Burundi’s overall energy consumption, while the remaining 2.5% is between electricity and oil [1]. The Burundian population lives mainly in the countryside and therefore has no access to the national electricity Grid. It is a population with a growth rate varying between 0% and 4% if we take into account the forecast of the population evolution from 2005 to 2045 [2].

Table 1: Prediction of Burundian population horizon 2045[2]

Year	Population	Density (Km^2)	Growth Rate
2005	7,423,289	266.70	3.01%
2010	8,766,930	314.97	3.38%
2015	10,199,270	366.43	3.07%
2020	11,939,227	428.94	0.00%
2025	13,810,006	496.16	2.95%
2030	15,798,849	567.61	2.73%
2035	17,970,195	645.62	2.61%

With the increase in the population, the energy consumption has increased so much that the energy system of Burundi has become weak due to the enormous energy demand. Also, the energy demands caused by rapid urbanization and the creation of industries and activities requiring electrical energy have led to the insufficiency of the Burundi ‘s energy system.

The amount of electricity being consumed in Burundi comes from the production of hydroelectric power stations and thermal plant built in Burundi. There are other news hydro power plants being built like Jiji Murembwe and Mpanda hydroelectric plant while another part of the electricity is imported from neighbouring countries power plants such as RUZIZI 1 and RUZIZI 2 in the Democratic Republic of Congo. Another important quantity of electricity will be imported from the RUSUMO FALLS hydroelectric power plant, which is being built between Burundi, Rwanda and Tanzania.

Despite this energy deficiency, Burundi's hydroelectric potential is 1700MW, of which 300MW are economically exploitable, but only 32 MW are developed [7,13]. Solar potential is estimated at an annual average of sunshine of 2000 KWh/.year; equivalent to the sunniest European regions of the Mediterranean [7,13]. However, despite all these potential energy supplies, Burundi has such a severe energy crisis that has a major impact on its ability to reduce poverty and achieve the Millennium Development Goals (MDGS).

Considering the current energy situation in Burundi; the little energy available in Burundi comes mainly from hydroelectric plants, fuel, solar energy, biomass, peat, firewood, coal, bagasse and wind energy.

Thermal Energy: In Burundi, thermal plants are less frequent. These use hydrocarbons as fuel. They are so expensive when compared with hydroelectric plants.

Solar Energy: By its geographical position, Burundi is one of the sunny countries throughout the year. The study conducted in 2013 by the Ministry of Energy and Mines of Burundi with the support of the United Nations Development Program in Burundi (UNDP) on the Diagnostic of the Energy Sector in Burundi in the framework of the initiative of the United Nations Secretary-General on Sustainable Energy for. However, despite this excellent solar distribution, this energy form is not exploited to the maximum. Some individuals, some hospitals and health centre, some schools, some rural households exploit this energy form using photovoltaic panels.

The Peat: The National Peat Office (ONATOUR) in the country has the mission to exploit and commercialize production and use of peat; primarily in industry and agriculture and conduct further research and studies of the peat potential

Bagasse: Bagasse is an efficient source of energy but not enough in Burundi. Only SOSUMO (Société Sucrière de Moso) has an electric power plant powered by biomass from bagasse. This power station of SOSUMO is a form of cogeneration unit fed by the residues of sugar cane known as bagasse.

Biogas: As defined by the book entitled "LIVRE BLANC DU BIOGAZ", biogas is an energy derived from the degradation of organic matter.

Firewood: In Burundi, wood in its raw form or in the form of coal is the main source of energy for cooking and other craft and commercial activities requiring heating.

2. Renewable Energy Resources: Solar Energy

All electrical power installed in Burundi remains below 100 MW. Demand is far higher than supply. The minimum power required by 2020 is of the order of 280 MW, whereas the new programs in progress expect to reach only about 180 MW more by this time; energy requirements for the mining sector are estimated between 300 and 800 MW in the next 10 years for the nickel industry alone and its associated minerals; the electrical installations are very old and cause a lot of losses [1]. The solar field of Burundi is very interesting. The average sunshine received annually is close to 2,000 kWh / m^2 year which is equivalent to the best European regions (southern Mediterranean) [20]. Despite the significant cloudiness due to the equatorial situation of Burundi and periods of rain, the exploitation of solar energy in Burundi is therefore an interesting solution to electrical energy deficiency. The production of electricity by solar energy can be achieved by photovoltaic technology or by thermal solutions. In the case of Burundi, only the photovoltaic option seems appropriate [20].

The different visions of the Republic of Burundi, whether Vision 2025, Vision 2045, and others, predict that Burundi will no longer be among the poorest countries but rather among the emerging countries. In this way, the energy sector is one of the key sectors for this change.

2.1 Implementation of The Solar Photovoltaic System in Burundi's Energy System

Taking into account the solar photovoltaic system in Burundi's vision for energy between 2020 and 2045 years, as a response to the Millennium of Development Goals, the largest number of people is planning to work in the electricity sector. An estimated inventory for the electrical load of all categories of consumers registered in Burundi's electricity grid as added to the existing one is made to be able to build the photovoltaic power plants that could considerably reduce the electricity shortage that Burundi faces. Thus, for households, villages, and neighborhoods, the electricity consumption forecasts for the next 10 years, 20 years, 30 years, etc. seemed to be resolved.Taking into account the data in the table of the projection of the population growth, it is enough to make an estimated inventory of the needs in electrical energy for a household considered modern and after to multiplying by the estimated number of households which can constitute a village or a modern neighborhood. However, as the population continues to increase, it will be sufficient to increase energy production according to new villages and neighborhoods that will be created as electricity consumption of a village, the modern neighborhood will be known (Table 2).

For the other categories of consumers, the forecast of electricity consumption also seems not to be complicated. The tables of the evolution of the electric consumption and the evolution of the number of subscribers for the 10 years run, give an idea of what will look like the consumption of electricity in the years to come (Table 3).

Table 2: Estimated Daily Electrical Load Table for a Single Modern Household and a Modern Village [1]

Watts-hour/per	Equipment	No. in use	Power(w)	Total Power	Hours/Day	Watt-hour/day
1	Lamps LED	12	5	60	6	360
2	Cell-Phones	3	5	15	3	45
3	Radios	1	10	10	8	80
4	Televisions	1	40	40	6	240
5	Refrigerators	1	75	75	20	1500
6	Iron	1	1000	1000	0.25	250
7	DVD Player	1	30	30	2	60
8	Water pumps	1	500	500	1	500
9	computer	1	100	100	3	300
10	Washing machine	1	2000	2000	0.25	500
Total						3835
No. of Households						100
Total for households						383500

During this study, a projection of the evolution of the Burundian population as well as its estimated energy consumption horizon 2045 following the Millennium Development Goals were made in order to allow any project developer to take this into account. The sun being available and emitting radiation everywhere in Burundi, it could contribute enormously in the increase of the electric energy in Burundi as it was found in this study. The solar potential of Burundi can be estimated at 5 kWh / m² / day in the Bujumbura region and 4 kWh / m² / day for the highlands. This potential offers the opportunity to build solar power plants connectable to the grid and can be photovoltaic type or thermal type.

To meet at least the needs of different subscribers in electricity and to give access to electricity to as many Burundians as possible, an installed electrical power estimated at **345.7 GWh** could be implemented by 2023 while the estimated power of **617.9 GWh** could be installed for 2032. Going beyond, a nearby installed electrical power of **1234.2 GWh** could be implemented by 2045.

It has been determined, so that households have the living standards that meet the Millennium Development Goals, a daily energy consumption of a modern neighbourhood should be 383500 watts-hour/day. The following example of a photovoltaic power station can be used to provide electricity in about 8 neighbourhoods with 100 modern households each one.

The storage capacity needed depends essentially on 2 parameters: the energy consumed per day and the autonomy of the system, that is to say the number of days that it will be able to support without sun.

Table 3: Recapitulative table of estimated daily electricity consumption for all categories of subscribers of the Burundi energy system horizon 2023, 2032, 2041 (in GWh)

Consumer categories	2005	2014	2023	2032	2041
Government	4.3	6.1	7.9	11.5	18.7
Common and public lighting	0.5	1.3	2.1	3.7	6.9
Trade	12.0	33.7	55.4	98.8	185.6
Industries and Craft	1.6	33.3	65.0	128.4	255.2
Households	45.9	105.3	164.7	283.5	521.1
REGIDESO	1.0	4.9	8.8	16.6	32.2
International Organizations	2.5	1.2	1.0	2.0	1.5
State Corporations	1.0	10.6	20.2	39.4	77.8
Administration, personalized management	3.4	12.5	21.5	39.6	75.8
Religious confessions and social organizations	2.9	4.3	5.7	8.5	14.1
Prepaid sales	4.7	9.8	14.9	25.1	45.5
Total	79.8	223	345.7	617.9	1234.2

Determination of desired autonomy

Autonomy generally varies between 3 and 15 days. Therefore, a higher autonomy is chosen to ensure the continuity of the activity: between 5 and 7 days, therefore a weak autonomy for 5 days is estimated and then the amount of energy consumed by the facility during the given time is as follows:

$$Eft = Dn \bullet Au = 3 \text{ MWh x 5 days \_15 } MW\text{h}. \quad (1)$$

The amount of energy that will have to be returned by the batteries is therefore, choosing inverter efficiency is 0.9):

$$ERb = Ec = \text{- (1-losses in line)=3/(0.9x0.97=3.436 MWh} \quad (2)$$

For our installation is taken as the maximum depth of discharge of 50%, the capacity of the batteries must therefore be:

$$C_B = Er/Maxxdd = 3.436\text{MWh}/0.5 = 6.872\text{MWh} \quad (3)$$

Batteries with voltage of 24V and capacity of 200Ah:

6.872MWh x 1000000 = 6872000 Wh

6872000/24 = 286333.333Ah

286333.333/200Ah = 1431.6665

Therefore; 1432 batteries of 24V is required.

Calculating total Watt-hours per day needed from the PV modules.

After carefully calculating the electrical energy consumed by each device connected to the system, calculating the total number of watt hours requested from the photovoltaic modules becomes simple.

Total watt hour from the photovoltaic modules;

$$E\_Pm = \Sigma E * 1.3Lt \equiv \Sigma (P*t)*1.3Lt \quad (4)$$

where $\sum E$ is the sum of the amount of energy consumed by each device in the system
Lt is the total losses that could happen in the system installations, t is working time per day.

Sizing of the PV modules:

Photovoltaic modules produce different amounts of power depending on whether their size and the material from which they are manufactured differ. Indeed, before pretending to know the sizing of the photovoltaic module, the determination of the total requirements in watt peak to be produced is an obligation.

Calculating of the total Watt-peak rating needed for PV modules:

During this step, the total peak power required for the PV panels must be determined to ensure the operation of the devices.

(5)

Where P_{Rp} is the Rated Peak Power, P_{Wpd} is the daily peak power (watts-peak/day) and PV_{Gfp} the generation factor of the photovoltaic panels

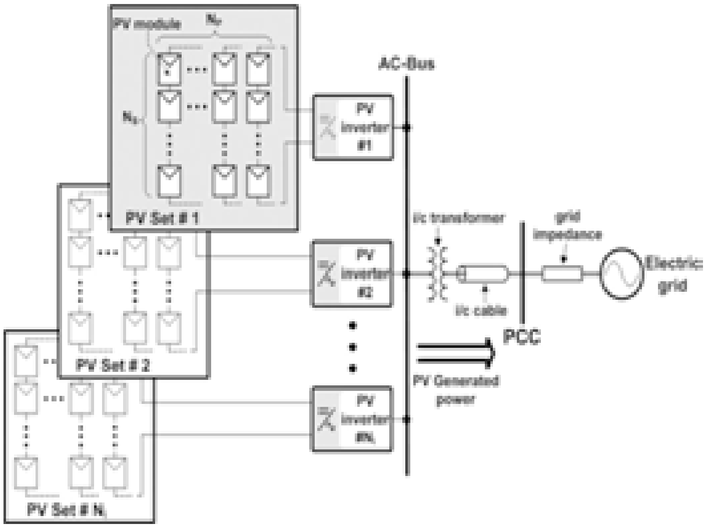

Fig.1 Block diagram of the large PV plant [31].

Calculating of the number of PV panels for the system:

A block diagram of the large PV plant that is considered in the proposed optimization process is illustrated in Fig. 1.

The PV modules are distributed in multiple PV inverters, and the generated power is injected into the electric grid at the point of common coupling (PCC) through an interconnection (i/c) transformer and cable, respectively. The total number of PV modules which must be installed in the PV plant N ı,o is calculated according to the PV plant power rating P plant, nom (MW p) that is specified by the PV plant designer, as follows:

$$N_{I,O} = \frac{P_{Plant,nom}}{P_{M,STC}} .10^6 \quad (6)$$

where $P_{m,stc}$ (W) is the power rating of each PV modüle.

3.CONCLUSION

During this study, a projection of the evolution of the Burundian population, as well as its estimated energy consumption horizon of 2045 following the Millennium Development Goals were made in order to allow any project developer to take this into account. The sun being available and emitting radiation everywhere in Burundi, could contribute enormously to the increase of the electric energy in Burundi as was found in this study. The solar potential of Burundi can be estimated at 5 kWh / m2 / day in the Bujumbura region and 4 kWh / m2 / day for the highlands. This potential offers the opportunity to build solar power plants connectable to the grid and can be the photovoltaic type or thermal type.

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