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Renewable Energy Dissemination and Analysis of the Energy Needs for the Poor in Burundi

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Abstract : ***Today, there is a significant lack of information in the open and grey literature pertaining to energy scenarios and development in addressing the energy needs for the poor in Burundi.The role of the energy sector in the implementation of the socio-economic development policies is enormous and cannot be achieved as long as the development of the renewable energy is low. The energy problems in Burundi are both serious and widespread. The lack of access to sufficient and sustainable energy supplies affects much of the majority of the population of Burundi. More than 80 percent of Burundians do not have electricity and the rate of accessto electricity is very low. This number remains dependent on traditional biomass to meet their energy needs. Food security, energy security, economic growth and environmental protection must be the national energy policy drivers of Burundi since the country's population growth was 3.1% in 2020.Without efficient and clean energy, people cannot engage effectively in productive activities or improve their quality of life. Burundi is facing two crucial problems in the energy sector. The first is the widespread inefficient and unsustainable production, and use of traditional energy sources which pose economic, environmental, and health threats. The second is the high inequality distribution and use of modern energy sources, such as electricity and petroleum products, which pose important issues of economy, equity, and of life quality. To address these issues, we present a successful analysis and recommend that the government should support market-oriented approaches that would make energy to be equally accessible and attractive to local and international investors and consumers. Besides, the paper presents the renewable energy technologies disseminated in Burundi and evaluates the potential of renewable energies in meeting the energy needs for the poor. For readers who are unfamiliar with Burundi, we introduce the paper with an overview on the geographic and social-economic profiles of the country. Access to renewables in Burundi has been hindered by a combination of factors which include poor infrastructures, inadequate renewable energy technologies planning policies, high initial capital costs, weak dissemination strategies, lack of skilled manpower, poor baseline information, and weak maintenance service and infrastructure. This paper is useful to policy makers, local and international investors, scientists and engineers in the energy sector.***

Keywords: Renewable energy, policy implications, household, energy needs, poor, Burundi

1. Introduction

Burundi is an East African country, located between Rwanda to the North, Tanzania to the East and South and the Democratic Republic of Congo to the West. The country lies between $3^0$30' S (latitude) and $29^0$89' E (longitude). According to the Burundi National Statistical Office (BNSO), more than 13.36% of the country's population resides in urban areas. The majority of the low-income urban and poor rural households are without access to electricity.

In Burundi, the economy is predominantly agricultural, with subsistence farming dominating commercial farming. Agriculture accounts for over 30% of gross domestic product (GDP) and this sector employs more than 90% of the population[1].

Limited access to modern and affordable energy services is an important contributor to the poverty levels in developing countries. Access to modern forms of energy is essential to overcome poverty, promote economic growth and employment opportunities, support the provision of social services, and, in general, promote sustainable human development. It is also an essential input for achieving most Millennium Development Goals (MDGs)[2].It is arguable that a lack of access to appropriate level of energy services is a major cause of the slow social-economic growth in Burundi. The MDGs cannot be met without affordable, accessible and reliable energy services. Burundi has abundant renewable energy resources for production and development of the energy sector: a major hydropower potential and extensive periods of sunshine for solar-power. Furthermore, it has an interesting wind power potential that should be evaluated. Likewise, the geothermal resources and other possibilities within biomass should be assessed.

Although nature has endowed the country with massive natural energy resources, a large number of these have remained unexploited. The Burundi's hydropower potential is 1700MW. Currently, only 77.14 MW are harnessed for electricity supply.

Figure 1: The map of Burundi showing the provinces

Consequently, the country faces serious energy deficit due to poor investment in energy infrastructures. The inadequate provision of energy services in Burundi has been cited by the United Nations Economic Commission for Africa[3]as a limiting factor for economic growth and poverty alleviation efforts. Predominantly, the rural populationand theurban poor do not have access to modern energy services; a situation which has resulted in the majority of the population living at a GDP per capita of 265 US dollars in 2021[4]. In Table 1, we have tabulated the annual income of rural and urban areas of Burundi in 2020.

Table 1: Annual rural and urban areas incomes in Burundi

Areas	Annual household income (US$ in 2020)
Rural	183.6 US $
Urban	274.01 US $

The dispersion of the population in rural areas poses a substantial challenge insofar as it complicates the process of connecting communities to the transmission and distribution networks of the grid connected. Electricity is basically an urban product and its consumption is heavily concentrated in the capital Bujumbura. Most of the country's electricity supply is generated through the hydroelectric plants, which have a combined installed power capacity of 77.14 MW. The country's energy supply therefore depends on 85% hydropower.

In order to meet daily energy needs, the majority of the population of Burundi relies on traditional biomass sources such as wood, agricultural residues and other primitive energy sources that in turn yield the problems of environmental and land degradation. Research indicates that heavy dependence on biomass fuel in developing countries causes serious deforestation, constrains the delivery of social services, limits opportunities for women and hampers the achievement of MDGs [5]. The dependence on biomass and traditional cook stoves called *Imbabura* that has low efficiency which emit smoke into kitchens lead to low quality of life for most rural women, children and elders in Burundi.

The energy poverty affects all aspects of life. Many schools and health centres are not electrified in rural villages; children are unable to study after sunset; women giving birth at night do so by under candlelight;

The dependence on kerosene, candles, and wick lamps in rural and poor urban areas in Burundi, for lighting is affected by uncertain supply of the fuel which leads to low quality and intermittent lighting.

Despite the policies taken by the Burundi government in terms of households getting electrified, many households of poor populations will remain without electricity connections or will not be able to afford electricity for lighting, cooking and heating into the foreseeable future. However, improving access to modern energy sources, e.g., such as electricity, clean fuels and clean cooking technologies, is important in order to improve health, education and reduce risks of burn injuries.

The aim by Burundi to achieve 35% access to hydroelectric and 20% access to solar photovoltaic (PV) power in rural public infrastructures by 2025[6] will require more effective mobilization and use of both domestic and external investments.

2. Barriers to renewable energy technology growth in Burundi.

Experience showed that the introduction of renewable technology dependents on the existing government policies [7]. Government policies are an important factor in terms of their abilities to create an enabling environment for renewable energy technologies dissemination and mobilising resources, as well as encouraging private sector investments.

A summarized number of barriers in Burundi have been identified and readily highlighted. They include: institutional, political and regulatory barriers, technical barriers, economic and financial barriers and environmental barriers. These are explained as follows:

Institutional, political and regulatory:
The limited role of renewable energy policy reflects inadequate data availability and unavailable power planning tools and methods to more effectively integrate renewable energy options, especially distributed generation. The policy and regulatory framework for renewable energy are incomplete. In addition, unregulated biomass resource extraction from forests has led to unsustainable harvesting of firewood and charcoal.

Social, **economic and financial:** Limited policy support for renewables is further demonstrated by the low budgetary allocations to renewables. The government places more emphasis on the petroleum and power sectors, which supply a small portion for the population of cities, than on renewables which supply a large portion of energy for the population.

The lack of government policies to encourage access to credit for the private investors in renewables does not allow them to improve productivity as well as stimulating the small-scale trading. Increased credit helps expanding renewable energy technology markets to rural areas, thus promoting rural development.Some countries like South Africa and Germany have introduced a policy instrument called "Renewable Energy Feed-In Tariff" (REFIT) to

support the renewable energy technologies [8]. This mechanism should be introduced in Burundi to stimulate the success in promoting investment and the consumption of renewable energies.

The rural poverty is often a product of poor infrastructure that hinders development and mobility of renewable energy technologies. This is the cause of the lack of paying capacity from the consumers to access to new renewable technologies.

A lack of access to markets whether due to poor infrastructure or productivity, limited education or insufficient information prevents the development of renewable energy technologies[9]. In many Burundi rural societies there are few job opportunities outside agriculture, often resulting in food and income insecurity due to the precarious nature of rural activities. Without access to other labour markets, rural poor workers continue to work for extremely low wages in agricultural jobs that tend to have seasonal fluctuations and thus little income security that causes the relying on traditional biomass. In addition to labour, the rural poor often lack access to capital markets and financial institutions, hindering their ability to establish savings and obtain loans to develop their energy needs. Financing plays a major role in the formulation of renewable energy technology policies [10]. Studies shows that one of the main obstacles to implement renewable energy projects is not often the technical feasibility of these projects but the absence of low-cost, long-term financing [11].

Limited policy support for renewable energy technology in Burundi is indicated by minimal budget allocation to renewables at the government level. Banking institutions have unfavourable requirements for renewable energy technologies. Some Burundian banks have insufficient funding to support the private sector to harness the renewable energy resources. Financing banking institutions normally lay down strict conditions for renewable energy technology investors and this deters potential users. Financial conditions required include a feasibility study conducted at the applicant's expense, due to the limited knowledge on renewables by the banks.

Public awareness, information, knowledge, capacity and environmental education: Credit policy will be most effective when provided in conjunction with other services such as technology and market training. The country has a high energy potential to harness. This potential cannot be exploited without clear vision with efficient scientific and technological support.

The introduction of modern technologies such as Renewable energy technologies requires the development of technical skills [12]. Burundi encounters a shortage of qualified personnel in the energy sector resulting in the reliance of expatriates. The technical knowledge is important in order to build over the long term, a critical mass of professional policy analyst, economic managers, scientists and engineers who will be able to manage and coordinate all aspects of renewable energy technology development process. This deficit is largely responsible for the generally under developed research and technological capability and the poor management of renewable energy programmes.

The lack of research and development in the renewable energy technology sector makes very difficult the adoption and the growth of renewables in Burundi and the consumers remain misinformed and there is a notable lack of awareness on technology information especially in rural people. Education and information dissemination related to renewable energy technologies must include resource studies on the strategies and adequate comprehensive government policies necessary for the growth of the renewable energy sector [13].

Up to now, the absence of strong comprehensive studies on the potential use of renewable resources has hindered the development of this part of the energy sector in Burundi.

The costumers have insufficient information to make informed choices. Most utilities provide little or no information about their missions or fuels they use. Since renewable energy technologies are new, most consumers know little about them. Sustainable energy programs, efficient dissemination of information based on new methods and consisting of public relations, training and counselling are missing in Burundi.

3. Potential of Renewable energy resources in Burundi

Like many African developing countries, Burundi has a dualistic economy: one part very monetized and modern, the other non-monetized and traditional. This dualism is an important determinant of energy supply and demand, and of the county's energy structure [14]. Wood fuel is the predominant energy source in the traditional sector. The modern sector including commerce, industry and the urbanized communities depends largely on fossil fuels and electricity.

Wood fuel is the major source of energy in Burundi, accounting 94% of the net energy supply [15]. It is consumed in two different forms: as fuel wood and as charcoal. The charcoal is predominantly used in cities, while firewood is predominantly used in rural areas. It is estimated that only 6% of the country's total land area is forested.

Biogas has a considerable contribution in the energy production in Burundi. Up to 0.8% of Burundi's electric power is generated from bagasse, a by-product of the sugar industry based on cogeneration technology. The bagasse is used to produce both thermal energy and electricity. Wind power is more or less completely unexploited in Burundi.

3.1 The profile of renewable energy in Burundi

The Burundian economy depends on five different types of renewable energy sources: wood fuel(Bio-energy), hydropower, solar radiation, and wind energy. Hydropower is the most important technology for power generation in Burundi, representing 85% of the total national generation capacity. Table 2 shows the total national and international capacity of plants currently operating in Burundi.

Table 2: The total capacity of plants currently operating in Burundi

N/S	Name of Plants	Types of Plants	Capacity (MW)
1	National	Hydropower	48.84
2	National	Bioenergy	4
3	National	Solar Power	8
4	International	Hydropower	16.3
	Total currently capacity		**77.14**

Burundi also benefits from imports from the regional hydroelectric plants of Rusizi I and II. Currently, these energy imports account for 30% of the electricity consumption in Burundi. A number of hydropower projects are underfunding and awaiting investments in Burundi as it can be seen in table 3.

Table 3: Main hydropower projects awaiting investments in Burundi or under funding.

Name	Capacity (MW)
Ruzizi III	147.0
Ruzizi IV	285.0
Rusumo-Falls	80
Mpanda	10.4
Kaburantwa	20
Kagunuzi	12
Mulembwe	17.1
JiJi	32.5
Ruzibazi	15

Solar energy would be the most common off-grid electricity source in Burundi, although the number of photovoltaic (PV) systems installed is very low. Burundi has a very interesting solar potential. The average annual solar irradiation is close to 2000 KWh/m^2 per year[16]. The development of solar energy in Burundi should be a very interesting option. In Table 4, we have tabulated the number of PV systems in rural and urban areas in 2020. The largest PV project encountered in Burundi is the one constructed at the University hospital of Kamenge in Bujumbura. The plant has a peak capacity of 403 KWp and is connected to the national grid. The project has been financed by the Japanese International Cooperation Agency (JICA). In addition, the solar plant of 7.5 MW is operatingin Gitega province.

Table 4: PV systems in rural and urban areas in 2020

Areas	Estimated number PV systems	Estimated KWp
Urban	3000	980kWp
Rural	34430	7660KWp

3.2 Access to electricity in Burundi

Demand for electricity is expected to continue to rise readily as the economy improves. Peak demand occurs during the evening hours due mainly to household lighting demands.Due to the increased demand caused by strong demographic pressure, development of urban centres and progress in industrialization, one of the government's priorities will be to adapt supply and demand, in particular, by increasing the national capacity for electricity production[17]. The increased capacity will come from numerous projects already programmed, including the construction of a series of hydroelectric plants as seeing as seen in table 3.The following graphic shows the rate of access to electricity in Burundi on the ten last years.

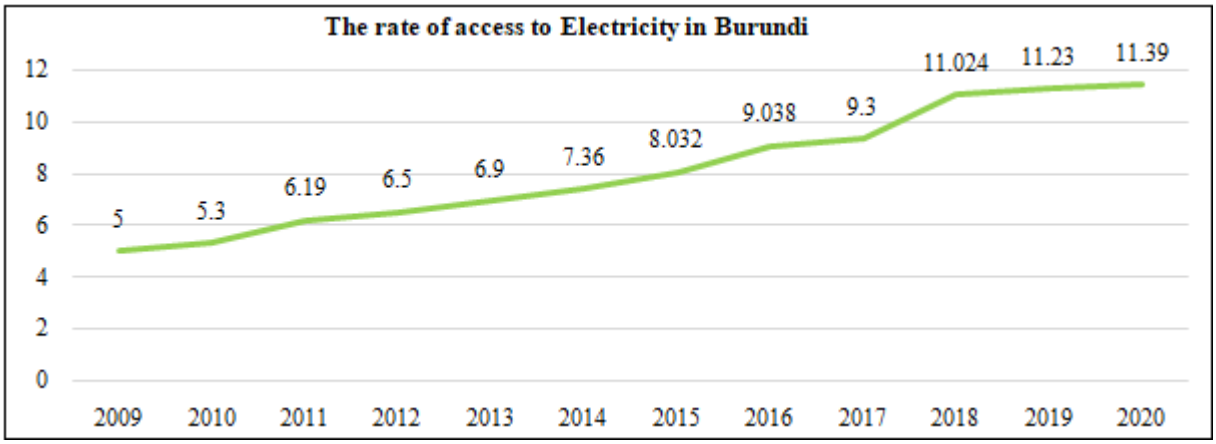


Figure 2: The graphic of the rate of access to electricity in Burundi

3.3 Energy sector management and regulations in Burundi

The government of Burundi has established a range of energy sector reforms with the aim to attract private sector investment to boost electricity supply. Key policies and legislation include law N0.1/014 of 1 August 2000 related to the liberalization and regulation of the public services of water and electricity, Decree N0. 100/320 of 22 December 2011 on the control and regulation agency for water and electricity, and Decree N0. 100/318 of 22 December 2011 on rural electrification agency.

The Ministry of Energy and Mining (MEM) has overall responsibility for the energy sector. The policies and programs of the ministry are implemented through the Directorate General of Energy. There also exist a number of privately owned plants that produce 2% of national electricity. These plants are run by companies, individuals as well as religious communities.

3.4 International investments in renewable energy sector

The following countries and institutions have been identified with mandate to invest, promote, and develop the renewable energy sector in Burundi:

The World Bank (WB), the African Development Bank (ADB), the European Union (EU), the French Development Agency (FDA), the United Nations Development Program (UNDP), German International Cooperation (GIZ), the European Investment Bank (EIB), number of donor countries intervening in specific areas: Japan through the International Cooperation Agency (JICA), Belgium through the Belgian Technical Cooperation (BTC), China and India through construction, rehabilitation and maintenance of hydroelectric power plants and dams.

4. Energy needs for the poor dominated by traditional biomass

Improving energy services for poor households in Burundi remains one of the most pressing challenges facing the government of Burundi. The dependence of the households on traditional forms of energy leads to significant health impacts as well as other major disbenefits. The energy situation in poor areas in Burundi is characterized by low quality of fuel, low efficiency of use, low reliability of supply, leading to low quality of life and environmental degradation.

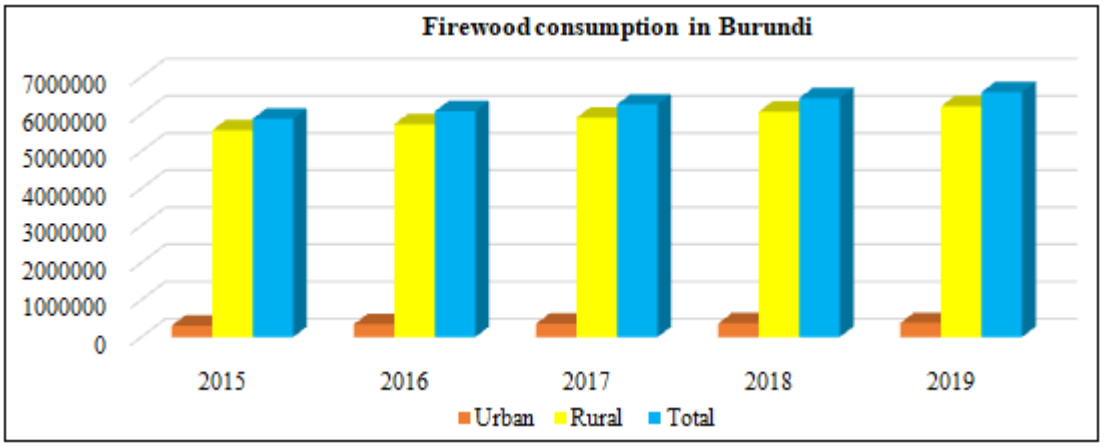
Deforestation is one activity that is exceptionally harmful to the natural environment as it results in decreasing in biodiversity and increased rates of soil erosion[18]. The clearing of trees for wood fire setting also interrupts the natural water cycle, as trees participate in the absorption of ground water and evaporation of water vapour [19]. Deforestation, therefore, results in increased level of CO_2, the primary greenhouse emitted by human in the earth's atmosphere. Jing et Al.[20]highlighted the main pollutants associated with energy consumption: CO_2, CH_4 and N_2O which have direct greenhouse effect; CO, NO_x and non-methane volatile organic compound (NMVOC) which are indirect greenhouse gases; SO_x and particulate matters. The authors point out that NO_x and SO_X cause acidic rain, while CO and particulates have negative health effects. The agricultural sector in Burundi is responsible for 91.4% of the country's greenhouse gas emissions.

4.1 Household energy use: Fuels and Technologies

The poor communities in Burundi predominantly use wood, kerosene and charcoal to meet their basic energy needs. In Burundi, 91 %of the population use firewood for cooking and beer brewing with open fire (three-stone stove) being the main cooking technology. The following Tables 5 and 6show the firewood consumption and the charcoal consumption in tons from 2015 to 2019.

Table 5: Firewood consumption in tons in Burundi

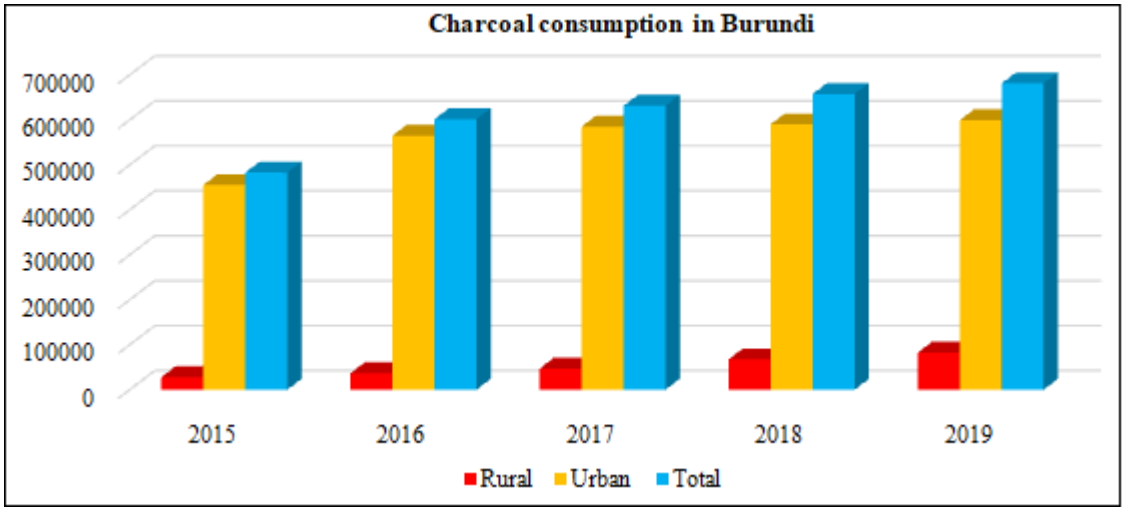
Areas	2015	2016	2017	2018	2019
Urban	307674	344521	356618	368215	381120
Rural	5566501	5733496	5905500	6064949	6210508
Total	5874175	6078017	6262118	6433164	6591628



Firewood is the principal fuel for economic activities like commercial cooking and local beer (*Urwarwa*) brewing. The use of multiple fuels provides a sense of energy security.

Table 6: Charcoal consumption in tons in Burundi

Areas	2015	2016	2017	2018	2019
Rural	27674	36521	46617	67414	82110
Urban	455128	564891	584653	589890	599018
Total	482802	601412	631270	657304	681128



The commercial production and distribution of fire wood and charcoal generates significant employment and income in rural areas.

4.2 Cost of fuels and their technologies in Burundi

The price of the cooking device can influence the choice the user makes on whether to buy that device or not. Many households in Burundi use the three-stone fire for cooking and this technology does not require skilled expertise to construct. The majority of Burundians are willing to adopt an improved cookstove (ICS) because of its quality and durability. The price of an expensive ICS ranges between 8000 BIF and 10000 BIF and the price of the cheapest is less than 2000 BIF.

Table: The cost of fuels in Burundi

Type of fuel	Unit of sale	Price/unit	Market
Wood	10 kg	535 BIF	Local
Charcoal	5 kg	2500 BIF	Local
Kerosene	1 L	2200 BIF	Local
Candle	each	400 BIF	Local
Electricity	1Kwh	399 BIF	Local

BIF is the currency code of Burundi where 1 USD is equivalent to 2001 BIF.

The study showed that firewood is the least expensive fuel, while charcoal is the most expensive energy carrier. Candles have the least cost per unit compared to all other energy carriers. However, candles are used only for lighting purposes, and in some households, they are substituted with kerosene wick lamps. The electric lanterns are a status symbol in the community as they come with a high purchase price of 12000 BIF.

4.3 Fuel collection by Poor communities in Burundi

The majority of the poor people collect firewood free of charge, while some process charcoal from firewood to sell in the nearby cities. In Burundi, in poor communities relying on biomass, women and children are responsible for wood collection, a time-consuming and exhausting activity. Concerning firewood,90 % of the people collect the wood free of charge, and 1.8 % purchase it from firewood vendors, while 0.2 % collect and purchase.

Table 5: The fuel use in Burundi

Type of fuel	Cooking	Grilling Meat	Lighting
Wood	90%	8.5%	0.5%
Kerosene	-	-	56%
Charcoal	18%	72%	-
Candle	-	-	29%
Rechargeable Electric lanterns	-	-	3%
Electricity	2%	-	18%

Firewood is gathered from natural forests due to increased deforestation in the country. Today, about 3 million households rely on traditional biomass for cooking in Burundi.

Charcoal, on the other hand, is usually produced from forest resources in an unsustainable manner. It is parked in the normal 50 kg feed bags and stored along the roads, where heavy trucks, pick-ups and automobiles carry it into the cities for purchasing process. Unsustainable production of charcoal in response to urban demand increases the burden on forest resources, by leading to localised deforestation and land degradation including soil erosion and siltation effects.

The average firewood load in Burundi is around 20 kg per head load. Domestic firewood head load carrying is a poverty indicator of the Burundian poor communities. Carrying heavy firewood loads has severe health implications for young girls, given their physical immaturity. Over time, the children may experience inflammation or damage to the head, neck, and the spine. Women can suffer serious long-term physical damage from harmful work without sufficient recuperation. The average distance travelled for wood collection is 4 km and the time taken to bring up the load of firewood varies between 3 and 4 hours.

Many children, especially girls, are withdrawn from school to attend to domestic activities related to biomass use, reducing their literacy and restricting their economic opportunities. Modern energy services promote economic development by enhancing the productivity of labour and capital. More efficient technologies provide higher-quality energy services at lower costs and free up household time, especially that of women and children, for more productive purposes. Modern energy services help reduce poverty and can play a critical role in improving educational

opportunities for children, empowering women and promoting gender equality.

4.4 Improving the way Biomass is used

For many households in Burundi, switching away from traditional biomass is not feasiblein the short term. The provision of electricity alone may not replace traditional fuels such as wood and charcoal. Replacing traditional fuels completely with modern alternatives will not necessarily create a sustainable energy model for these marginalised communities [21]. Improving the way biomass is supplied and used for cooking, lighting and heating is, therefore, an important way of reducing its harmful effects. This can be achieved either through transformation of biomass into less polluting forms using two main biomass conversion technologies: thermo-chemical conversion (combustion, gasification and pyrolysis) and biochemical conversion (fermentation, anaerobic digestion and mechanical extraction) or through improved stoves and better ventilation.

Charcoal and agricultural residue briquettes have higher energy content than firewood and so reduce the amount of fuel needed [22]. Although charcoal is often produced using traditional techniques, with low transformation efficiencies, there is an evidence that firewood supply in Burundi can be adequate, even in densely populated areas, if resources are well managed. Another approach is to improve the efficiency of biomass use through provision of improved stoves and enhanced ventilation. Adding chimneys to stoves is the most effective improvement to be made from the point of view of health[23].The lack of appropriate ventilation mechanisms for burning biomass is a major health concern and contributes to short life expectancies in much of poor communities in Burundi. A study of indoor air pollution levels in Bangladesh confirms that kitchen design and ventilation play a key role in reducing emissions [24]. Particulate levels in houses using wood, but with good ventilation, were found to be lower even than those in houses using LPG [25].

5. Conclusion and Policy Implications

The study focused on renewable energy and analysis of the energy needs for the poor in Burundi. This is the first work on this nature in Burundi. The consumption of energy in Burundi is predominantly composed of exploitation of traditional biomass, oil products and small amount of electricity in the cities. This work shows that wood is the primary energy carriers for low-income households to meet their basic energy needs. Kerosene and candle are widely used for lighting while the firewood and charcoal are used for cooking but charcoal is mostly used for grilling the meat than cooking. The study showed also that people use multiple fuels to meet their energy needs. Improved cooking technologies could play a significant role in the poor communities of Burundi.

The paper suggests that meeting the investment challenge will require increases and more effective use of both domestic and external funding, and the development and implementation of innovative policy framework. Different modern technologies such as biomass gasification, combustion, fermentation and pyrolysis must be actively initiated to promote conversion of biomass material such as agricultural, forestry and agro-industrial residues into electric power or biofuels.

Making available to the populations the reliable and efficient energy systems requires a search for flexible and innovative local solutions. This is a necessary condition for improving the lives of the poor rural populations but also for exploiting in a sustainable and durable manner the forest resources of the country.

In the agricultural domain, lightweight, off-network or micro-network production systems could be used such as micro hydraulic irrigation projects, pumping and drying systems powered by solar or wind energy and use of agricultural residues for the energy generation. Some of those could be done by small and medium enterprises, which would boost the local sector. The success of these mechanisms requires the creation by the Burundi government ofan integrated energy policy which encourages improvement of existing structures and infrastructures, promotion of new initiatives in most of the most deprived populations and international cooperation.

The government is asked to implement clear policies of the perceptive of renewable energy in the making of strategies for sustainable development. The strategies will involve energy savings on the demand side, efficiency improvements in the energy production and the future replacement of fossil fuels by various sources of renewable energy. An energy-poverty alleviation fund must be established to promote the cleaner use of biomass or other advanced renewable technologies. The emphasis in energy research and development must be promoted towards solar energy applications.

In this aspect, the involvement of research institutions and universities is the key driver in exploring new sources and their possibilities of utilization. They have to focus especially on energy conservation, energy efficiency, and their access to poor populations.

The government of Burundi must create an attractive environment to local and international investors by introducing the subsidies in renewable sector. The policy implication suggests a good mobilizing of domestic financial resources and making better use of external inflows[26].The government must ensure the equity including gender in the energy sector management, making sure if the poor populations have access to modern energy services.

The government of Burundi has formulated a series of policies on renewable energy development including laws, regulations, and economic encouragement. These policies remain insignificant. There is a lack of coordination and consistence in policy framework, lack of regional policies innovation, and inadequate investment in technical research and development of renewable energy. The lack of energy subsidies has resulted in energy price increasing, hindering the foreign direct investment, and leading the poor populations not to afford the increased energy prices. It is

argued that the removal of duty and import taxes combined with the introduction of credit systems would make PV systems more affordable to the rural poor households. This argument would also apply to alternative application of investments. For many rural households, the capital required to purchase a solar PV system represents a huge investment. In Burundi, the typical cost of a monocrystal Si solar panel of 250 W capacities can purchase up to 3 cows, which can transform the lives of a typical rural family.Strong policies can improve this situation by promoting more efficient and sustainable use of traditional biomass, and encouraging people to switch to modern cooking fuels and technologies.

References

[1] World Bank, 18184 Street, NW Washington, DC 20433, USA (2020).
[2] UN-Energy. The energy challenge for achieving the Millenium Development Goal (MDG). New York, United Nations (2015).
[3] UN. ECA Conference of Ministries of Finance, Economic Planning and Development, Kampala-Uganda (2004).
[4] World Bank. Annual Report, NW Washington DC USA (2015).
[5] Lusambo LP. Household Energy Consumption Patterns in Tanzania. Journal of Ecosystem and Ecography (2016).
[6] Manirakiza, C. Investment opportunities inrenewable energy in Burundi. Ministry for energy and mines, Republic of Burundi (2012).
[7] Karekezi, S. Poverty and energy in Africa. Energy Policy, Vol 30: 915-919 (2002).
[8] Kala,O O, Edson, LM., Obeng M., Letsoalo, JLH.Implementation A Renewable Energy Feed-In Tarrif in South Africa: The Beginning of A New Dawn. Sustainable Development and Policy (2011).
[9] Hassan, OG. Lack of Infracture: The Impact on Economic Development as a case of Benadin region and Hir-Shabelle. Somalia,Developping Country studies (2017).
[10] Christopher, F et al. Study on the Development of the Renewable Energy Market in Latin America and the Caribbean. IDB, Office of Evaluation and Oversight (2014).
[11] Seetharaman et al. Breaking barriers in deployment of renewable energy, ScienceDirect Heliyon, Vol.5 (2019).
[12] Karekezi S. and Kithyoma W. Renewable energy strategies for rural Africa. Is a PV-led renewable energy strategy the right approach for providing modern energy to the rural poor of sub-Saharan Africa? Energy. Vol 30: 1071-1086 (2002).
[13] Phebe AO. and Samuel AS. A review of renewable energy sources, sustainability issues and climate change mitigation.Congent Engeneering (2016).
[14] Bednarczuk L, Brzozowska K., Luscinski S. Determinant of Energy Development Based on Renewable Energy Sources in Poland. Energies (2021).
[15] Sabuhungu E. G., Ndimanya P., Lebailly P. Analysis of Urban Consumption of Charcol by Household: The Case of the City of Bujumbura in Burundi. International Review of Research in Emerging Market and the Global Economy. (IRREM) Vol 1: 430-440 (2011).
[16] Burundi. Power Generation Masster Plan in Burundi-Enabling Environment -SEFA. Appraisal Report (2020).
[17] Nsabimana R. Electricity Sector Organization and Performance in Burundi.Proceedings, vol. 58, . (2020).
[18] Sarah, D. Deforestation: Facts, Causes and Effets. Live science Newsletter (2022).
[19] Peter R. and Leah V. Where Deforestation Leads to Urbanisation: How Resource Extraction is Leading to Urban Growth in Brazilian Amazon. National Library of Medicine, Natioal Center for Biotechnology (2015).
[20] Jing W., Yan Z., Libo, W., Wechumm, M., and Limin, C. CO_2 Air Pollutants Emissions under Different Scenarios Predicted by a Regional Energy Consumption Modeling System for Shanghai. China, Atmosphere (2020).
[21] Niyongabo P. and Tafadzwa M. Analysis of Household Energy Uses in Mubuga Informal Settlement, Gitega, Burundi. Journal of Human Ecology, Delhi, India (2017).
[22] Timothy S. and Sam B. Fuelwood and Charcoal Use in Developing Countries, Ann. Rev. Energy, Vol 10: 407 - 429 (1985).
[23] Megha T. et al. Impact of improved cookstoves onWomen's and Child health in low and middle income countries. A systematic review and meta-analysis,Environmental exposure (2018).
[24] Gabriel O. et al. Factors predisposing Women and Children to indoor air pollution in rural villages. Western Kenya, Archives of Public Health, Vol 46, (2022).
[25] Ye H. et al. Household $PM_{2,5}$ Pollution in rural chinese homes: levels, dynamic characteristics and seasonal variations. ScienceDirect, Elsevier, Vo 817 (2022).
[26] Anna P. Renewable energy in South Africa: Potentials, barririers and options for support. Energy Policy, Elsevier Vol 38: 4945-4954 (2010).