Renewable and Sustainable Energy Reviews 78 (2017) 731–742

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Energy savings and economic benefits of transition towards efficient lighting in residential buildings in Cameroon

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ARTICLE INFO

Keywords:
Energy
Efficient lighting
Cameroon
Light emitting diodes
Residential buildings

ABSTRACT

Lighting accounts for over 20% of electricity use in the residential sector of Cameroon. Due to the unreliable and inadequate energy supply in the country, there is a need for the efficient utilization of the available energy. This paper presents the current different technologies used for artificial lighting including the economic and environmental benefits associated with a switch from incandescent lighting to compact fluorescent lamp (CFL) and light emitting diode (LED) in residential dwellings in Buea, Cameroon. The study employed a survey of 100 residential dwellings in Buea. Results of the survey revealed that artificial lighting in dwellings is achieved through the use of the following technologies: incandescent lamps, CFLs and fluorescent tubes. The economic assessment for the substitution of incandescent lamps with CFL and LED considering an average daily lighting duration of six hours was also conducted using the net present value (NPV), benefit cost ratio (BCR), the simple payback period (PBP) and a life cycle cost analysis (LCC). The economic assessment revealed an NPV that ranges from $47 to $282.02, a BCR of 1.84 and a PBP of 0.17 year for the substitution of current incandescent lamps in dwellings with CFL while the substitution of incandescent lamps with LED revealed an NPV of the range $89.14 to $370, a BCR of 3.18 and a PBP of 1.92 years. The LED and incandescent technologies emerged with the lowest and highest LCC respectively. Substituting incandescent lamps with CFL and LED results in a reduction in lighting related greenhouse gas (GHG) emissions from dwellings by 66.6% and 83.3% respectively. From the results, a transition towards efficient lighting in the residential sector of Cameroon possesses great economic and environmental benefits. There is need for the government of Cameroon to expedite the uptake of LED through the formulation and implementation of favourable policies.

1. Background

The emissions of greenhouse gases (GHGs) from anthropogenic and natural activities since the onset of the industrial age have led to their increased concentration in the atmosphere. The absorption of radiations by these gases alters the amount of solar radiation reaching the earth and the amount of infrared radiation that is absorbed into space. The result is an energy imbalance in the atmosphere culminating in cooling or warming of the climate depending on the radiating forcing being negative or positive respectively [15]. Global climate change has in recent times raised serious global concerns and is currently one of the contemporary world's most worrisome problems.

The built environment is recognised for its high energy use and the relative share of total energy consumed for heating and operating buildings is constantly on the rise [41]. While the building sector provides facilities for human needs and benefits to the society at large, it has had detrimental impacts on the environment over the last decade [55]. The consumption of energy by this sector is not without environmental impacts [50] and implications on security of energy supply. While all stages of a building's life cycle including construction and demolition generates GHG emissions, the operational phase of buildings accounts for over 80–90% of emissions, emanating from energy use for heating, lighting, cooling, ventilation and appliances [48]. The operational energy of buildings is affected by the energy efficiency of the buildings and their systems, as well as the behaviour of the occupants [2,47]. As reported in Lucon et al. [27], the global building sector in 2010 accounted for about 32% of final energy use and over 8.8 $GtCO_2$ emissions, with energy demand projected to double by mid-century. According to studies by de la Rue du Can et al. [12], direct and indirect emissions emanating from energy use in the global building sector accounts for 31% of global carbon dioxide (CO_2) emissions originating from the combustion of fuel for electricity

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http://dx.doi.org/10.1016/j.rser.2017.04.068
Received 18 April 2016; Received in revised form 16 February 2017; Accepted 27 April 2017
1364-0321/

production and heat to end-use sectors. The residential sector accounts for 27% and 17% of global energy consumption and CO2 emissions respectively [35].

Cameroon's residential sector constitutes the second highest electric energy consumer after the industrial sector, accounting for 30% of total energy consumed [14]. This sector has grown tremendously, with strong evidence revealed through the housing boom and public construction sites observed in recent times in the country. With an envisaged projected increase in population from the current 23.34 million to 32.94 million in 2030 [49], there is likely to be an increased pressure on built environment services in Cameroon which will culminate in an increase in energy demand from the residential sector. This increase in energy demand will further put pressure on the energy infrastructure of the country which according to Nfah and Ngundam [36] is inadequate and unreliable. The envisaged increase in energy demand and consumption in the country is likely to be accompanied by an increase in GHG emissions based on the claims of Abanda [1] that the amount of CO_2 emission associated with energy consumption in Cameroon has since the 1980s been on the rise.

During the launch of the Global Alliance for Buildings and Construction at the 21st session of the Conference of Parties (COP) in Paris, the likely positive effects of energy efficiency in buildings was at the centre of focus [20]. Energy inefficiency in buildings results to the excessive consumption of energy which often culminates in high energy cost in low-income households. The excessive energy consumption also puts pressure on the grid electricity supply which is often generated from conventional fuel associated with greenhouse gas emission that drives global climate change. As the power crisis problem in developing countries exacerbates, culminating in an increase in the gap between energy demand and supply, measures are adopted to resolve the power shortage problem through the efficient use of the available power [6]. While the improvement of the behaviour of building occupants results to energy savings [38], the adoption of more energy efficient technologies in residential buildings equally have an important role to play. Reducing energy consumption in buildings through the implementation of cost effective energy efficient measures translates not only into a reduction in energy bills of households, but as well reduces GHG emissions [18,4].

Studies conducted by Batih and Sorapipatana [9] in Indonesia revealed that lamps employed in indoor lighting are among the appliances with the greatest potentials for electrical energy reduction in the built environment. Nallamothu et al. [37] noted that the energy efficiency associated with the use of high efficient LED bulbs is over 57.5%. A strategic area with potentials for energy savings and reduction in peak power demand in the residential sector of Cameroon is lighting which is still dominated by the use of incandescent lamps [45]. Lighting in 2007 and 2010 respectively represented 30% and 20% household electricity use in the country. Research related to the uptake of energy efficient lighting technologies have been stepped up in several countries. For instance, Khorasanizadeh et al. [24] investigated the energy and economic benefits associated with the transition towards LED lighting in the residential sector of Malaysia. Min et al. [33] studied the prospects and problems of energy efficient lighting in China, Martínez-Montejo & Sheinbaum-Pardo [30] analysed among others the impacts of minimum energy efficiency standards of lighting product on residential electricity consumption and carbon dioxide emissions in Mexico, while Figueroa [16] assessed the drivers of uptake and willingness to pay for an efficient lighting technology in the residential sector of Kenya. While studies about efficient lighting have been conducted in other countries, such studies have not been conducted for Cameroon. An extensive search of peer-reviewed articles about studies related to transition towards efficient lighting in Cameroon in popular databases such as Google Scholar, Science Direct and Emerald yielded no significant results. Studies conducted in other countries cannot be adapted to Cameroon due to differences in local circumstances. For example, housing types in Cameroon may not be the same like the housing types in the Middle East and Europe due to cultural differences and occupant behaviour. A study on the transition towards efficient lighting is therefore necessary for Cameroon as it would assist the government and other stakeholders in the adoption of appropriate strategies that would guarantee a transition towards efficient lighting and this constitutes the motivation based on which this study was carried out.

The purpose of this study is to investigate the benefits for the transition towards efficient lighting using light emitting diodes and compact fluorescent lamps in the residential sector of Cameroon as well as the possible factors that could affect the adoption of LEDs in the country, using the town of Buea as a case study.

The objectives are to:

- investigate the possible factors that affects the transition towards efficient lighting in the residential sector of the country;
- determine the economic and environmental benefits associated with the transition towards efficient lighting in the residential sector;
- assess the possible impacts of a government policy on the economic benefits of transition towards LED lighting.

To achieve the above objectives, a research methodology has been established which draws from the scarcity of secondary data on lighting technologies used in residential dwellings in Cameroon. The main research method included: a survey of residential dwellings in the case study area with a questionnaire to obtain the required data for the study-existing lighting systems; and an analysis of the economic and environmental potentials associated with a transition towards efficient lighting in dwellings.

2. A review of Cameroon electricity sector and residential buildings

2.1. Cameroon electricity sector

Cameroon has an enormous energy potential. According to Nfah and Ngundam [36], the country possesses the second largest hydroelectric potential (294 TW h) in Africa after the Democratic Republic of Congo estimated at 1000 TW h. However, only 5.5% of the technically-feasible capacity (115 TW h/year) has been developed. In Cameroon, electricity is generated from three hydroelectric power stations (Edea, Song Loulou and Ladgo) and nine thermal power plants [17]. In 2010, Cameroon had an installed hydroelectric power capacity of 729 MW while it had 776 MW installed capacity of thermal power plants (diesel and natural gas) owned by both AES SONEL and independent power producers [8]. Cameroon's electricity sector is currently poorly developed and this has slowed down socio-economic development in the country. The sector faces both structural and technical challenges, compounded by the low electrification rate in the country [3]. Out of over 14,000 localities, only 3000 are electrified giving a national electrification rate of 22%. This low rate of electrification is a major setback for the production of goods and services since energy constitutes an important factor of production. In a nut shell, the Cameroon electricity sector faces an annual deficit between the electric power demand and what the system is capable of supplying. This deficit is due to very high rate of losses incurred in the process of generation, transmission and distribution of electricity [14].

Cameroon's electricity demand in 2012 was estimated at 3710 GW h [14]. Electricity demand from low user and medium user consumer in Cameroon is on the rise. On an annual basis, the demand of electricity from these groups of consumers increases by an average of 6% with an estimated demand of 4700 GW h and 7600 GW h in 2015 and 2025 respectively [21]. On the other hand, industrial demand which is mainly determined by the energy requirements of the aluminium industry was estimated at 1315 GW h in 2010 with its demand estimated to triple by 2015. Based on recent studies conducted by the European Union Energy Initiative Partnership Dialogue Facility