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# Future energy demand for public buildings in the context of climate change for Burkina Faso

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ABSTRACT

This paper addresses the dual challenge faced by Burkina Faso engineers to design sustainable low-energy public buildings while still providing the required thermal comfort under warmer temperature conditions caused by climate change. In this article, we discuss current and potential future energy demand for public buildings air conditioning in the context of climate change. Past and projected future trends of electricity demand for air conditioning in public buildings from 2010 to 2080 have been investigated. Moreover, this paper highlights the fact that the predicted mean temperature using climate change SRES scenario B2 will increase by about 2 °C by 2050 which can cause a significant increase in air conditioning energy consumption. This paper then considers the impact of different shading devises and building envelopes characteristics on the demand for air-conditioning in Burkina Faso public buildings. It is estimated that with climate change, in order to maintain a thermally comfortable 25 °C inside public buildings, the projected annual energy consumption will have to increase by 56% and 99% respectively for the period between 2030 to 2049 and 2060 to 2079 compared to the base situation (energy consumption between 2010 and 2029). Moreover, the results have shown that shading devices could reduce the cooling load by up to 40%. Therefore shading devices could play a significant role in climate change adaptation in the built environment for Burkina Faso.


## 1. Introduction

Today, there is a large consensus among scientists to identify the increase of greenhouse gases concentration in the atmosphere as the probable cause of global warming. Global environmental trends have reached dangerous crossroads as the new century begins [1]. Furthermore, climate change will affect developing countries the most even though these countries contribute the least to the problem, because they are less well equipped to deal with global warming impacts due to the lack of financial and technical resources [2]. This is particularly true for those communities in sub-Saharan Africa who rely largely or totally on rain-fed agriculture or pastoralism for their livelihoods. Such communities, already struggling to cope effectively with the impacts of current climatic variability, will face a daunting task in adapting to future climate change [3]. The Burkina Faso climate is typical to many sub-Saharan countries; therefore its example could have significant help in outlining climate change adaptation policies for much of the region of sub-Saharan African countries which will be the most affected by climate change. In addition, due to the scarcity of its financial resources, Burkina Faso should explore cheap possibilities to reduce its energy demand.

Anqing Shi, (2002) used the STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) model to assess and forecast the impact of population change on energy consumption and carbon dioxide emissions for 93 nations over the period 1960–1996. It was found that population had a disproportionately large (highly elastic) effect on energy consumption and $CO_2$ emissions [4,5]. Furthermore, in a cross-sectional analysis of the carbon dioxide emissions of 111 nations, Dietz and Rosa (1997) have found that the effect of population on energy consumption exceeded unitary elasticity [6]. Burkina Faso has a fast growing population projected to increase from 14 million to 29.15 million between 2010 and 2030. Thus, population increase will put an additional pressure on its energy demand.

Climate change has become one of the main problems that the world is facing today. Recent reports by the Inter-Governmental Panel on Climate Change (IPCC) have raised public awareness on energy use and its environmental implications. It reports that the

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surface temperature will increase by approximately 1.4–5.8 °C by 2100 [8].

Burkina Faso is located 13° North latitude and 2° West longitude and about 1000 miles from sea. It has a primarily tropical climate with two very distinct seasons. In the rainy season, the country receives between 600 and 900 mm of rainfall, and in the dry season, the harmattan, a hot dry wind from the Sahara, blows. The climate is characterized by high temperatures, especially at the end of the dry season. The rainy season lasts approximately four months, May/June to September, and is shorter in the north of the country. Three climatic zones can be defined: the Sahel, the Sudan-Sahel, and the Sudan-Guinea. The humidity, which increases as one moves south, ranges from winter lows of 12–45% to rainy season highs of 68–99% as illustrated in Fig. 1. The harmattan, a dry east wind, brings with it spells of considerable heat from March to May, when maximum temperatures range from 40 to 45 °C from May to October, the climate is hot and wet, and from November to March, comfortable and dry. January temperatures range from 7 to 13 °C. Average annual rainfall varies from 115 cm in the southwest to less than 25 cm in the extreme north and northeast. The rainy season lasts from four months in the northeast to six months in the southwest, from May through October. The Sahel in the north typically receives less than 600 mm of rainfall per year and has high temperatures, 5–47 °C [7].

Fig. 2 represents the average daily solar radiation and clearness index in Burkina Faso. The average solar radiation is about 5.8 kWh/m$^2$/d, which is well above the average comparison in several cities around the world [8]. The country experiences a long summer lasting from March to October and during that period maximum temperature can reach up to 45 °C. As a result, air-conditioning is often required to maintain thermal comfort in buildings. According to the Burkina Faso National Institute of Statistics and Demography (INSD) air conditioning represents between 60 and 65% of the total electricity demand a typical public building [9].

The possible effect of climate change on energy demand has recently renewed the interest in the relation between energy demand and outdoor temperature [10,11]. S. Mirasgedis et al. (2007) estimated the impact of climate change on electricity consumption and have found that low temperatures correspond to relatively high energy demand for heating, intermediate temperatures correspond to lower energy demand, and high temperatures correspond to higher energy demand again for cooling [12,13]. Therefore, cooling demand in Burkina Faso public building is expected to rise with global warming.

Moreover, ASHRAE research projects conducted in different countries with different climate zones and geographical locations

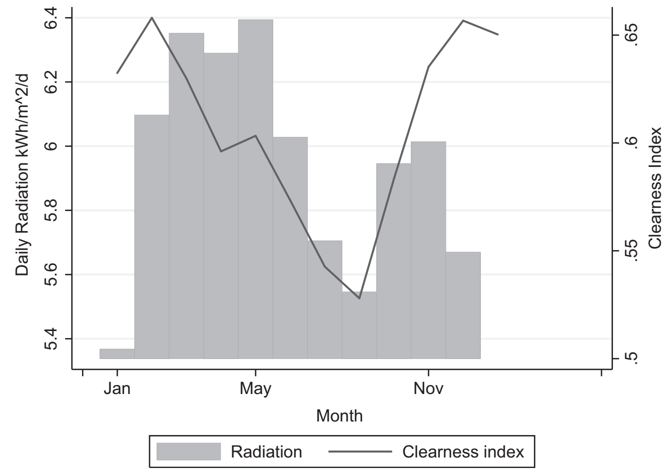


**Fig. 2.** Average solar radiation and clearness index from 1990 to 2010.

and based on the impacts of thermal environment on occupants' comfort in hot humid and cold climates, have shown that thermal dissatisfaction was associated with higher air movements based on ASHRAE standard 55 [10,11]. Dissatisfaction with the actual thermal environment is expected during building occupancy due to the personal behaviour of occupants and the difficulty in maintaining comfort conditions at all times. Low-energy opportunities are needed to ensure that building occupants remain comfortable in a period of changing environmental conditions in order to insure high productivity [14].

This paper will mainly focus on air conditioning in public buildings considering climate change impact and what can be done to reduce the cooling load significantly. The objective of the present work is, therefore, to investigate present and future weather trends and how it affect public buildings envelope and their cooling load under different climate change scenarios in the 21st century and discuss potential adaptation measures.

As illustrated in the flow chart in Fig. 4, this paper first discusses current and future development of the climate in Burkina Faso by performing different climate change scenarios using the Test Reference Year (TRY). Then climate change impact on public building energy demand for cooling was assessed using building energy consumption software IES VE to simulate current and predicted energy demand. Different building materials characteristics scenarios were finally used to perform cooling load simulation in order to identify which parameters are important for cooling

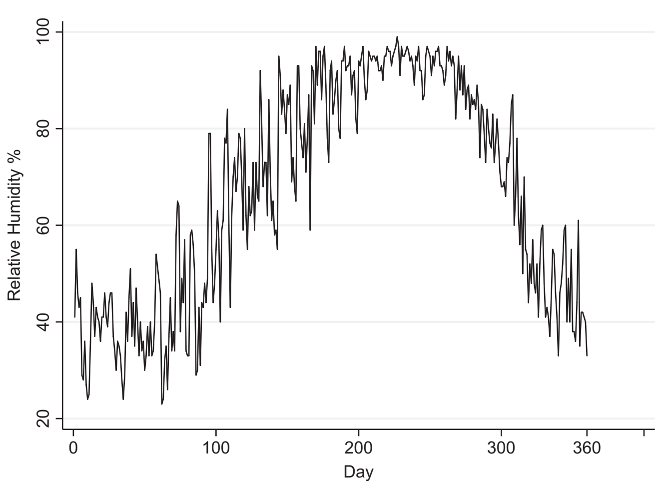


**Fig. 1.** Average daily relative humidity from 1990 to 2010.

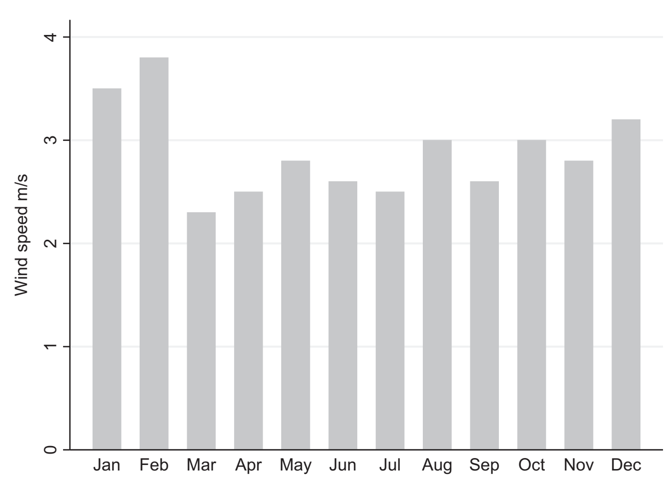


**Fig. 3.** Average wind speeds from 1990 to 2010.