Thermal Comfort and Energy Resilience of Urban Households Facing Climate Change: A Case Study in Dakar

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Abstract

In the context of acceleratedclimatewarming and rapidurbanization, the thermal comfort of urbanhouseholdsis a major issue for energysustainability and quality of life. This article analyzes the perceptions and thermal adaptation strategies of households in Dakar, an emblematic city of sub-SaharanAfrica. Based on a quantitative surveyconductedamong 354 residentsacross the five departments of Dakar, we examine energy practices, housing conditions, and motivations related to energyconsumption.

The resultsrevealthatwhile 66.1% of households report beinggenerallycomfortable, nearly 29% experiencerecurrent thermal discomfort. The preferredstrategies are openingwindows (95.8%) and using fans (91%), while air conditioningremains marginal (18%). The reduction in energyconsumptionisprimarilymotivated by economicreasons (61.9%), althoughenvironmentalconcerns are growing (48.3%). The structural limitations of housing, particularlyinsufficient thermal insulation, exacerbatehouseholdvulnerability. The discussion places theseresults in an international comparative perspective, highlighting the specificities of Dakar compared to otherAfrican and Asian cities. The studyunderscores the need to align public policies, technical innovations, and community practices to promotesustainable and equitable thermal comfort.

Keywords: Thermal comfort – Energy resilience – Urbanization – Climate change – Dakar

1. Introduction

Climate change intensifies heat waves in urban areas, increasing the vulnerability of populations and the pressure on energy systems. The building sector, accounting for over 40% of energy consumption in Senegal (Figure 1) [1], is particularly affected. The capital, Dakar, illustrates these dynamics, with accelerated urban density and population growth.

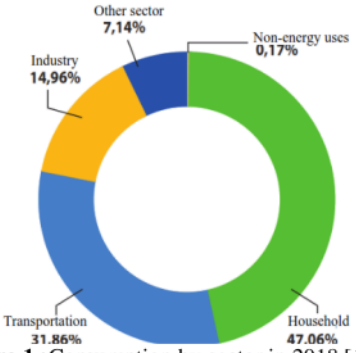

Figure 1 : Consumption by sector in 2018 [1].

Residential energy demand, driven by thermal comfort needs, is expected to more than double between 2013 and 2030 (Figure 2) [2]. This trend, coupled with the high dependence of the tertiary

sector on air conditioning (Table 1), underscores the urgency of developing strategies that reconcile energy efficiency, thermal comfort, and sustainability [3].

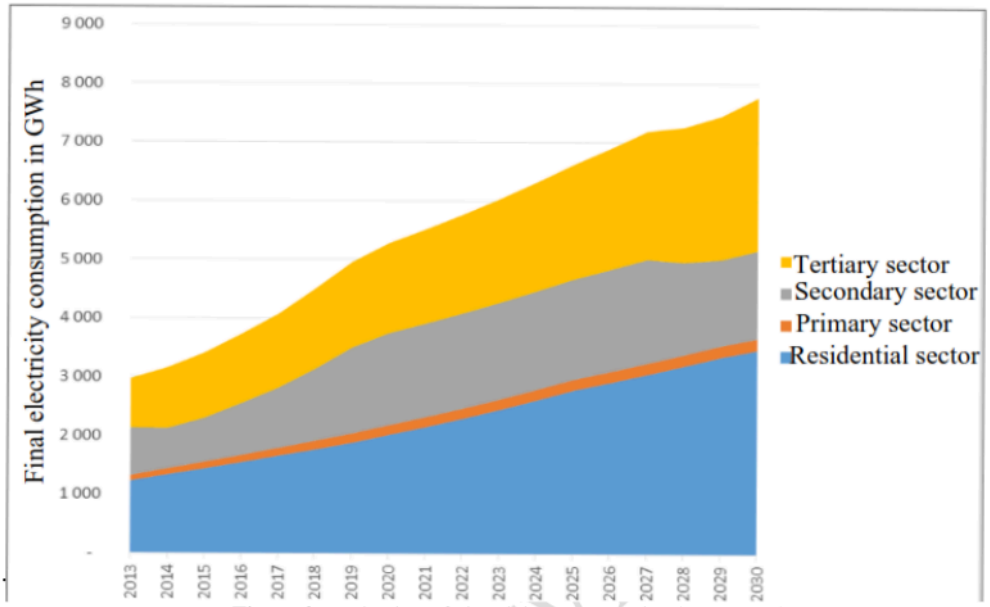

Figure 2 : Projection of electricity consumption by sector [2].

Table 1: Share of air conditioning consumption in the public sector by building function [4].

Type of building	Share of electricityconsumptionfrom air conditioning in the energy balance (%)
Administrative buildings	18 % - 60 %
Schools, colleges, and high schools	1 % - 30 %
Health centers	10 % - 55 %
Training centers	3 % - 5 %
Universities (administrations and lecture halls)	15 % - 44 %
Studentresidences (U residences and university restaurants)	1 % - 13 %
Leisure centers and theaters	1 % - 5 %

Moreover, thereis a strongcorrelationbetweenelectricityconsumption and outdoortemperature (Figure 3) [5], exacerbatinghouseholdvulnerability. This researchaims to fill the gap in local empiricalstudies on the perceptions and thermal adaptation strategies of urbanhouseholds in Dakar.

Likewise, the energysector in Senegal isundersignificant pressure, both in the building and transportation sectors, whichalsorepresent a substantialshare of demand [6].

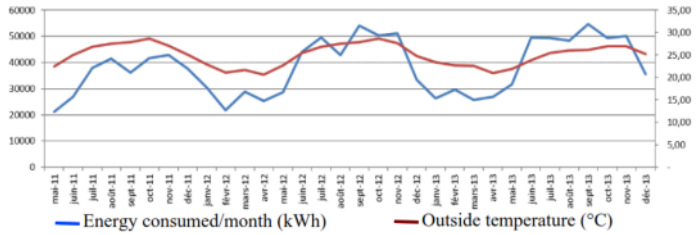

Figure 3 : Correlation between electricity consumption and outdoor temperature [5]

2. Theoretical Framework

Thermal comfort is defined as the state of satisfaction of an individual regarding their thermal environment [7]. It depends on both objective factors (temperature, humidity, ventilation, materials) and subjective factors (perceptions, habits, social practices). In industrialized countries, technological solutions dominate (insulation, air conditioning), whereas in sub-Saharan Africa, practices remain predominantly passive and behavioral. This makes households particularly vulnerable to prolonged heatwaves.

3. Methodology

The study is based on a quantitative survey conducted from March to May 2024 among 354 residents of the five departments of Dakar (Dakar, Pikine, Rufisque, Guédiawaye, Keur Massar). Stratified sampling took into account income, density, and type of housing. A structured questionnaire collected data on ventilation practices, household appliances, electricity bills, and perceptions of thermal comfort. The data were analyzed using SPSS, employing descriptive and multivariate methods (correlations, regressions).

4. Results

The main results are presented below.

4.1. Respondent Profile

The majority of participants are young adults (16-30 years: 75.1%). Young households show a strong tendency towards cohabitation. Presence at home varies between weekdays and weekends (Figure 4).

4.2. Perception of Thermal Comfort

66.1% of residents report feeling comfortable, while 28.8% report discomfort. The kitchen is perceived as the hottest room, while the living room is seen as the most temperate (Figure 5).

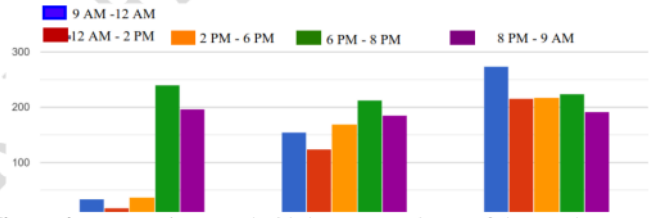

Figure 4: Presence in Households by Hour and Day of the Week
(Source:Survey Data)

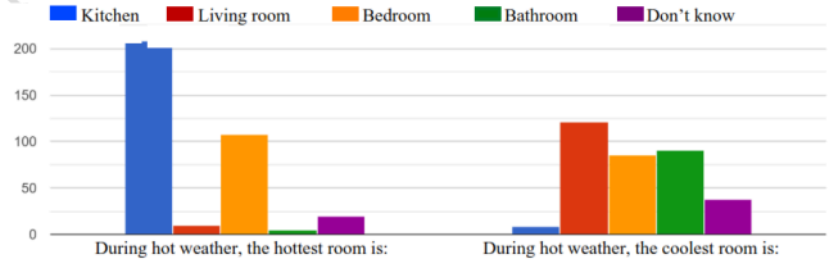

Figure 5 : Experience on Room TemperaturesDuring Heat Periods
(Source:Survey Data)

4.3. Adaptation Strategies

Householdsprioritizeopeningwindows (95.8%, Figure 6) and using fans (91%). Air conditioningremains marginal (18%). Adaptation practices alsoincludesolar protections (65.3%, Figure 7) and clothingchoices (63%, Figure 8).

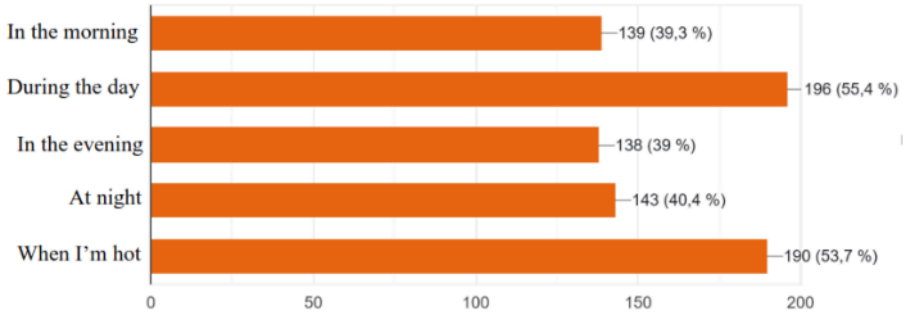

Figure 6 : Times of the Day When Windows Are Opened to Cool Down
(Source:Survey Data)

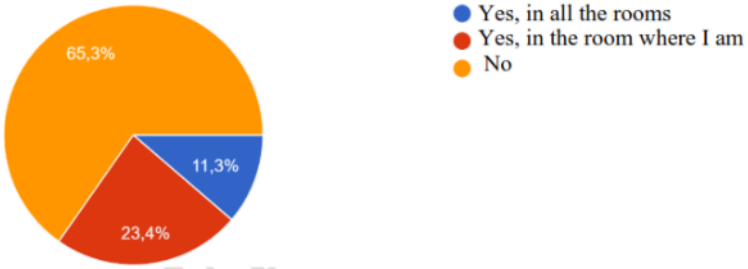

Figure 7 : Use of Solar Protections to Shield Against Heat
(Source:Survey Data)

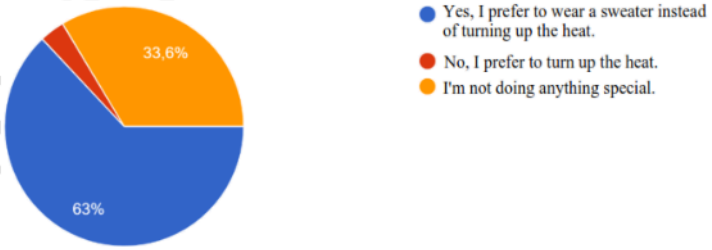

Figure 8 : Clothing Adaptation According to the Season Inside the Home
(Source:Survey Data)

4.4. Economic and EnvironmentalConsiderations

The reduction of energy consumption is primarily driven by economic reasons (61.9%, Figure 8), while environmental concerns are also increasing (48.3%).

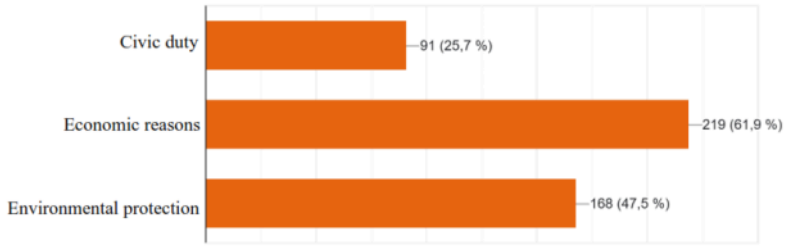

Figure 8 : Motivations for Reducing Energy Consumption (Source: Survey Data)

5. Discussion

The resultsconfirm the predominance of natural and low-cost strategies, in line withEconoler (2019) [4], which highlights the lowpenetration of air conditioning in Senegal. However, thisreliance on natural ventilation underscores the vulnerability of low-incomehouseholds, whose homes sufferfrominsufficient insulation [8][9]. In comparison, studiesconducted in South Africa and India show a more pronounced adoption of mechanical solutions whenincomeishigher and public policies support energyefficiency [10][11].

Economicsensitivityclearlydominatesenergybehaviors in Dakar, but thereis a growingopenness to environmentalconcerns. This reflects a similardynamicobserved in Accra and Nairobi, wherehouseholdsassociateclimate adaptation withrationalizingenergyexpenditures. Finally, the lack of ambitious public policies to support appropriate building standards, energyefficiency, and green infrastructure increases the vulnerability of urbanhouseholds [12][13]

6. Conclusion and Perspectives

This study highlights the diversity of thermal adaptation strategiesamonghouseholds in Dakar, revealingsignificant social and economicinequalities. It emphasizes the need to integrate public policies, technical innovations, and community practices within a vision of urbansustainability. To maximizeurbanenergyresilience, werecommend:

- Establishing minimum standards for insulation and naturalventilation;
- Providingfinancialincentives for the use of insulatingmaterials and energy-efficient equipment;
- Promoting eco-friendly neighborhoodsthatincorporateenergyefficiencyfrom the design stage;
- Conductingwidespreadawarenesscampaigns on sustainableenergy practices.

Future research perspectives include thermal modeling of housing, prospective analysis of consumption profiles based on climate scenarios, and experimentingwith innovative low-cost solutions for vulnerablehouseholds.

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