

PUBLIC PERCEPTION OF SUSTAINABLE, LOW ENERGY HOMES IN A SUBSIDIZED DEVELOPING COUNTRY: SAUDI ARABIA AS CASE STUDY

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ABSTRACT

Developed countries must conform to international sustainable and low energy building targets. Saudi Arabia, which has a hot climate, necessitating consumption of high levels of energy to operate domestic building air conditioning systems, has high CO₂ emission levels. This study focuses on assessing the public's perception, knowledge and awareness of sustainable housing in a developing economy, using Saudi Arabia as a case study, because of the high energy demands from its domestic sector combined with high CO₂ emission rates. The paper explores (a) the public's perception and awareness of low energy housing, (b) the typology of residential stock, including architectural style, (c) energy consumption patterns, and (d) the role Islamic culture plays in architectural design and cultural barriers preventing the institution of pure low energy housing. For the study, a comprehensive public survey was performed across Saudi Arabia (over 500 participants) involving participants of different ages, both genders, and varying educational levels. The results confirmed limited public awareness, and highlighted cultural barriers to sustainable, low energy housing designs. Moreover, this paper will also highlight the willingness of the public to retrofit their existing homes to enhance energy conservation.

Keywords: Sustainable housing, Energy consumption, Environmental design, Public perceptions and socio-cultural blockers.

INTRODUCTION

Interest in energy-oriented research has increased, resulting in recent concerns about energy saving as well as economy [1]. Saudi Arabia is known for the high levels of energy consumption and CO₂ emission rates of its residential buildings. This energy use is a consequence of the region's hot climate, which drives high energy consumption to operate traditional air conditioning systems [2, 3]. The building sector is the largest consumer of electrical energy, thus changes to it represent a major potential contribution to reduced energy consumption [4]. Indeed, official sources, such as the Ministry of Electricity in Saudi Arabia, have confirmed that over 50% of energy in the form of electricity is used within the domestic sector. In addition to addressing the high level of energy consumption, to reduce CO₂ production it is also important to exploit available renewable energy sources, such as solar radiation and wind energy, especially in view of fluctuations in the price of crude oil and the expendable nature of fossil fuels [5]. Natural energy resources, such as solar and wind power are abundant in the Kingdom of Saudi Arabia, yet the energy used is predominantly generated (in the form of electricity), by burning fossil fuels, which causes CO₂ emissions. At present, there is no utilisation of on-site renewable energy techniques (generation techniques), such as PV, to provide energy [6, 7].

Solving this problem by reducing energy demand and using natural resources instead of burning fossil fuels will contribute to savings in energy costs; increased oil income resulting from using resources other than oil to operate buildings; and reduced CO₂ emissions. Many developed countries have pursued energy savings through the development of sustainable energy consumption codes, based on local climatic conditions. Thus far, there are

no such codes available for Saudi Arabia, although they are an essential tool for controlling energy consumption and saving energy to supply future needs [8, 9].

To address the problem of energy saving in the domestic sector in Saudi Arabia, it is important to examine the local public perceptions and cultural barriers that prevent the establishment of sustainable dwellings. Thus, this paper will investigate the public perceptions concerning energy conservation, ascertain the extent of the problem, and clarify the cultural barriers to establishing sustainable dwellings in Saudi Arabia. To achieve this, an in-depth analysis will be conducted, using a questionnaire distributed to members of the public of different ages, with different levels of education, and residing in different cities in Saudi Arabia. The questionnaire focuses on type of dwelling, including shape, area and the behaviour of occupants, as well as on perceptions surrounding the establishment of sustainable dwellings by breaking down cultural barriers in Saudi Arabia.

METHODOLOGY

In order to achieve the goals set, the research design employed a quantitative methodology. A large body of information was sought in relation to building design, area, cultural image and respondents' perceptions. It was also essential to collect data from people in different age groups, including those with different education levels, or from different locations (cities). The details required for analysis and discussion included data relating to dwelling (area and design); current energy consumption and satisfaction level with heating, ventilation, and air conditioning (HVAC) used; data relating to cultural images, as these affect the architectural design; and data relating to people's perceptions regarding sustainable homes and their ability to retrofit their dwellings to save energy. To obtain this information, a questionnaire was designed, established and distributed to members of the public in Saudi Arabia.

Applying the above considerations, the questionnaire was divided into four main sections: (a) Determination of problems in domestic homes in Saudi Arabia resulting in high-energy consumption, such as property types and sizes, dwelling areas, number of rooms, etc. The questions in this category can result in the identification of some issues that explain higher levels of consumption, such as property size, and large occupancy numbers leading to high energy consumption. (b) Many questions about the use of HVAC in dwellings, such as the type of cooling system, existence of natural ventilation, heating system, and period of air conditioning usage. The scale of the problem (reasons for high energy consumption) can be determined by the questions raised in the first two categories. The third category (c) contained questions designed to determine people's ability to ensure sustainable dwellings in future and to retrofit their existing dwellings, as well as the public perception regarding sustainable dwelling. Finally, (d) questions designed to identify cultural barriers, such as faith, social status or position in society, that might affect architectural design in Saudi Arabia, thereby preventing the establishment of sustainable dwellings in future. The questionnaire included all four categories, and was distributed to the public to encompass the sampling of individuals of different ages, educational levels, and from different locations across Saudi Arabia, to deliver a true picture of the situation.

The results of this study outputted were analyzed using both Microsoft Excel and SPSS tools, in order to carry out in-depth analysis and link the questions. Survey monkey can be used to analyze results; however, the selected tools allow deeper analysis.

RESULTS AND ANALYSIS

After distributing the questionnaire via SurveyMonkey using the Snowballing technique, it became apparent that one of the greatest benefits was that this method delivered a huge number of respondents offering a more accurate portrayal of the situation at present. The number of respondents who began the questionnaire was 502, of whom (80.7%) had completed and submitted the questionnaire. As mentioned, the respondents were all of different ages, different educational levels and different locations spread throughout the cities across Saudi Arabia (Table 1).

Table 1: Respondent's details and description

Characteristic	Percentage	Characteristic	Percentage	Characteristic	Percentage
Age		Education Level		Gender	
From 18 - 34	67.58%	High school	14.8%	Male	83.79%
From 35 - 49	28.09%	Diploma	9.3%		
From 50 - 64	3.21%	Bachelor's Degree	47.4%	Female	15.25%
More than 64	1.12%	Master's Degree	20.7%		
		PhD	7.7%	Rather not say	0.96%
Characteristic			Percentage		
Location of Respondents					
Central Region			36.82%		
Northern Region			12.86%		
Southern Region			11.25%		
Eastern Region			10.93%		
Western Region			28.14%		

Public perception and current problems

An in-depth analysis of public perceptions, and a review of the current situation regarding high energy consumption, revealed that many factors were responsible for high energy consumption in the Saudi residential sector. These included the size of the building, the cooling system used, etc. The following paragraphs describe those factors identified as causing problems.

Typology of buildings: Many different questions were designed to identify, assess, and determine the factors that cause high energy consumption in domestic buildings in Saudi Arabia. Based on the survey output, these factors were found to relate to building size, number of additional rooms, and the number of household members in each property. Firstly, it is important to state that the majority of respondents live in houses (two-storey houses), with just under half living in flats. Many other official sources provide the same figure: [10] stated that 41.1% of properties are flats, 54.8% of properties are houses, and 4.2% fall into other categories. The results showed about half the respondents live in properties with areas of 300 to 1000m² (Fig. 1).

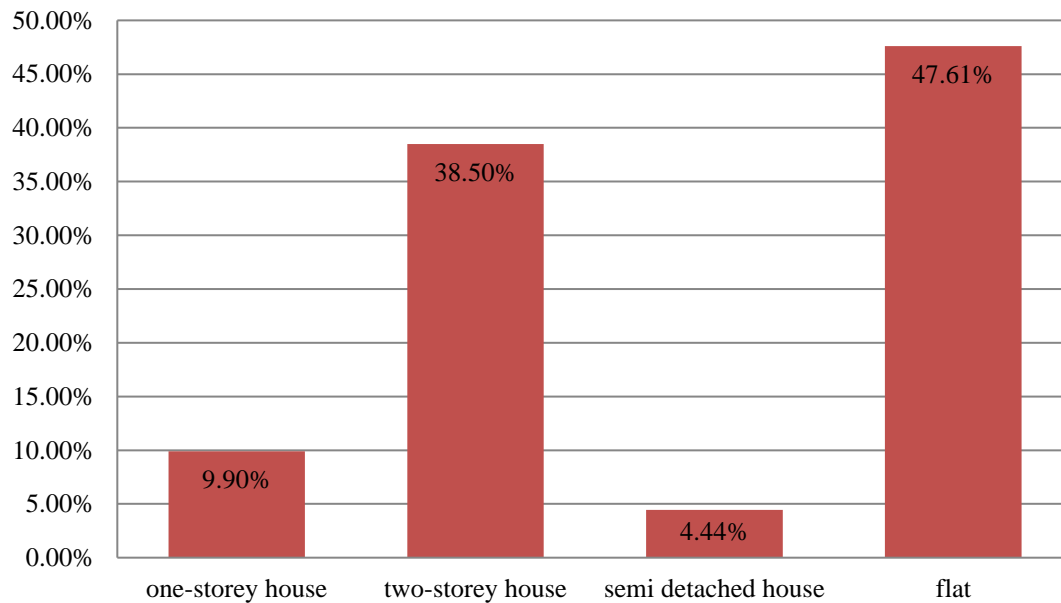


Fig. 1: typology of buildings

Cooling system used: it was found by employing the survey, that the cooling system (air conditioning) is a major problem as a source of high energy consumption, because Saudi Arabia’s very hot, inhospitable environment creates the need for air conditioning, to provide internal thermal comfort. Firstly, air conditioning is used as the main cooling system, without any supporting technique, such as natural ventilation (see Figure 2).

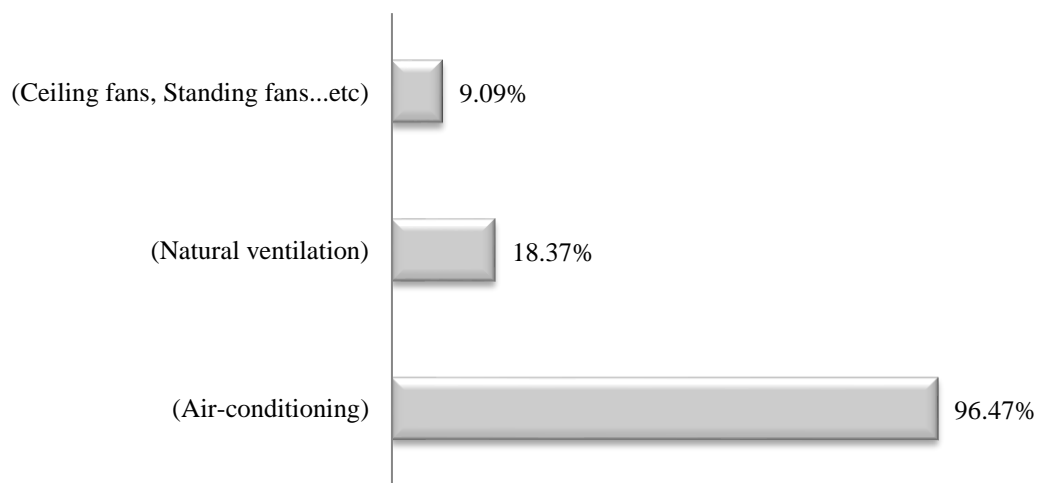


Figure 2: Cooling system used

The figure describes the techniques used for cooling systems. This part of the questionnaire was designed to allow more than one answer, because in some parts of Saudi Arabia, such as in the high mountainous regions in the south, people use ventilation in summer at night. Furthermore, about 35% of the population do not need to use a heating system, because many parts of Saudi Arabia are hot in summer and warm in winter, while the majority of cities are hot in summer and cold in winter, but with a very limited winter period. The home is occupied for a long time each day, with air conditioning used in all or most rooms. Therefore, homes are occupied for over 18 hours a day, and the air conditioning is run throughout this time during hot seasons, resulting in high energy consumption. In addition, the data revealed many occupants are unwilling to rely on only natural ventilation and/or fans during the hottest seasons. The majority, 90%, of respondents are not satisfied by using

these methods alone; thus, the challenge posed appears to be to achieve the lowest possible energy consumption by improving the use of air conditioning.

Public Perception: The survey highlighted a lack of public knowledge regarding the importance of sustainable low energy housing in Saudi Arabia. Figure 3 illustrates their views regarding sustainable homes. Through an in depth analysis of public perception, and by determining the current problem associated with high energy consumption, many factors resulted in high energy consumption in the residential sector in Saudi Arabia. These factors included, among others, the size of the building, the cooling system used.

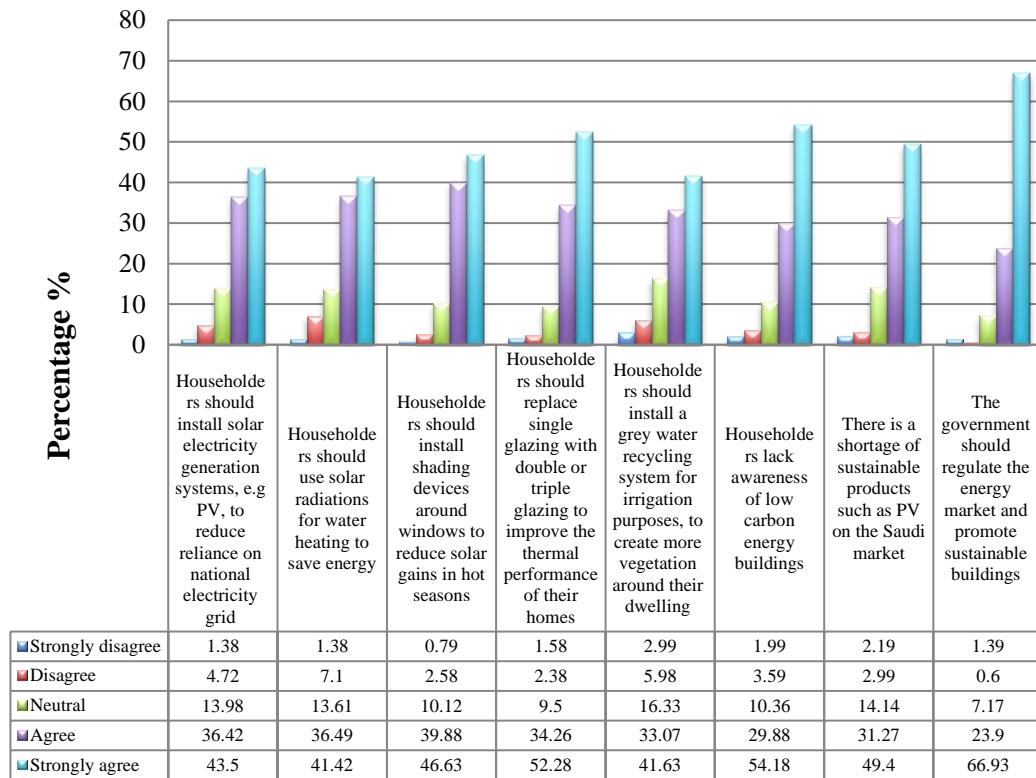


Figure 3: Public perception

Retrofitting existing housing: The survey output reflected a positive response regarding people’s willingness to live in sustainable homes in the future and to retrofit their homes to save energy. First, it is important to mention, that over half of respondents were well informed about sustainable homes with less energy demands; however, this means about 42.5% of respondents had no knowledge of this option, which is a significant proportion. The respondents who know about sustainable homes had heard about them via internet websites, the media, news, television programs, background knowledge, friends, and advertisements, while others were specialists in areas related to sustainability.

Cultural Barriers: Many studies highlight the effect of culture on the home design i.e. [11-14]. Many cultural barriers were identified by the survey. Some of these barriers are rooted in the religion (Islamic culture). For example, the idea of mixing genders in the same place is contrary to Islamic culture, and domestic buildings are designed to allow the division of genders; typically providing one guest room for males and another separate one for females. Figure 4 presents the cultural barriers discovered, and the willingness of the public to compromise these to have sustainable homes.

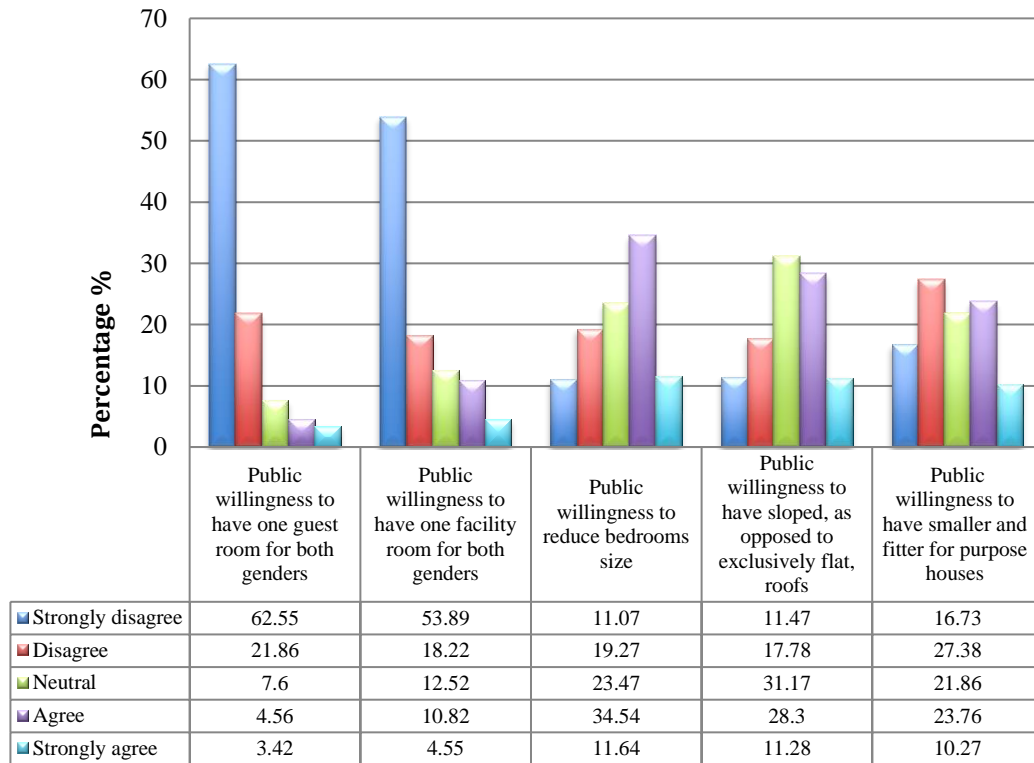


Figure 4: cultural barriers discovered

In economic terms, the fact that 50% of energy is consumed by the residential sector makes understanding the public’s energy use crucial [15]. This figure presents both an opportunity and a challenge, the aim being to burn less fossil fuel to support investment through sales of oil. Saudi Arabia is rich in solar radiation, and it is possible that this natural resource could be used to cover its needs. By both reducing energy demand and using natural resources to mitigate its use it will be possible to reduce the volume of fossil fuel burned, and increase income as a strategic objective.

Ecologically, many benefits proceed from the prospect of establishing environmentally friendly (sustainable) domestic buildings in Saudi Arabia. Saudi Arabia has abundant solar energy resources [16], and PV panels could be added to housing stock to reduce dependence on fossil fuel and reduce Saudi Arabia’s relatively high CO2 emissions per capita, as reported in the literature [2, 17]. Therefore, any energy reduction will not reduce the financial costs of electricity, but also the environmental costs.

CONCLUSION

This study has presented the public perceptions regarding sustainable homes in Saudi Arabia, and identified key factors leading to high energy consumption, as well as touching on the cultural barriers that can prevent the establishment of sustainable homes in Saudi Arabia some of which relate to Islam. An in-depth survey was used as the main research instrument, taking into account the need to reach people in different age groups and of different educational levels to obtain a realistic image of public perceptions. The results have illustrated and identified multiple factors, which were discussed individually to provide some guidance for proposing solutions to avoid high energy consumption and minimize CO2 emission rates as far as possible. Solutions were presented along with economic, social, and environmental benefits, and suggestions for their implementation. This study will conclude with some general recommendations for house owners and future researchers in this field.

RECOMMENDATIONS

- Existing homes should be retrofitted according to the solutions suggested in this study, to reduce energy demand and minimize CO₂ emission rates;
- Install PV systems in existing housing stock, to generate electricity via solar heat instead of electricity provided from burning fossil fuel, which will reduce the cost of utility bills;
- Install smart techniques (e.g. sensors) to control and manage energy consumption in properties;
- Future homes must be designed under sustainability criteria, to ensure the lowest possible energy demand under the supervision of expertise teams;
- Raise the public awareness's of the importance of sustainable low energy housing;
- Establish controls on the built environment (residential stock) in Saudi Arabia; and
- Establish environmental assessment approaches i.e. BREEAM & LEED to rate existing homes and future homes, in terms of environmental aspects and considerations.

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