

ENVIRONMENTAL ISSUES AND ENERGY CONSERVATION IN BUILDINGS IN PAKISTAN: ROLE OF ARCHITECTURAL INTERVENTION

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Energy shortage and environmental catastrophe is the severe problem globally and particularly important for the developing countries like Pakistan. There is a serious need to solve the problem for a sustainable building environment as the building sector has become a major consumer of energy. An attempt has been made for the building professionals and building users for adherence into their design and construction the energy conservation measures to reduce environmental problems more easily after the thorough review of the famous authors' research work and findings in this field. The ultimate aim is the establishment of awareness for the building professionals for delivering sustainable buildings in Pakistan. Through the implementation of design measures to mitigate the urban heat island, the general public can decrease their demand for energy and effectively cool the urban landscape. In addition to the economic benefits, energy conservation leads to reductions in CO₂ emissions.

Keywords : Environment, Buildings, Electricity, Energy conservation, Sustainability

1. Introduction

Buildings are important and play an important role in shaping the physical environment of a society. Buildings, as they are designed and used today, contribute to serious environmental problems because of excessive consumption of energy and other natural resources [1]. In urban areas, paved surfaces and buildings have gradually replaced existing natural setting of vegetation. As a result, solar energy is absorbed into roads and buildings fabric, causing the surface temperature of urban structures to become 50 ° - 70 °F higher than the ambient air temperatures. Until the past few decades the environmental consequences of buildings design and construction went unnoticed. Energy consumption now is the biggest environmental concern. The close connection between energy use in buildings and environmental damage arises because energy intensive solutions sought to construct a building and meet its demands for heating, cooling, ventilation and lighting cause severe depletion of invaluable resources. As surfaces throughout an entire city become hotter, overall ambient air temperature

increases. This phenomenon, known as an "urban heat island," can raise air temperature in a city by 2° to 8°F, according to the World Meteorological Organizations. Office buildings besides industrial buildings, can significantly impact climate change by introducing energy efficiency measures to improve operations of the building [2]. The resulting higher temperature caused by the urban heat island has the effect of increasing demand for cooling energy in commercial and residential buildings which can cost consumers and municipalities thousands of additional rupees in air conditioning bills in order to maintain comfortable conditions.

In addition, an increased electricity generation by power plants leads to higher emissions of sulfur dioxide (SO₂), carbon monoxide (CO), oxides of nitrogen and suspended particulates, as well as carbon dioxide (CO₂), greenhouse gases known to contribute to global warming and climate change.

However, buildings can be designed to meet occupants' need for thermal and visual comfort at reduced levels of energy and resource

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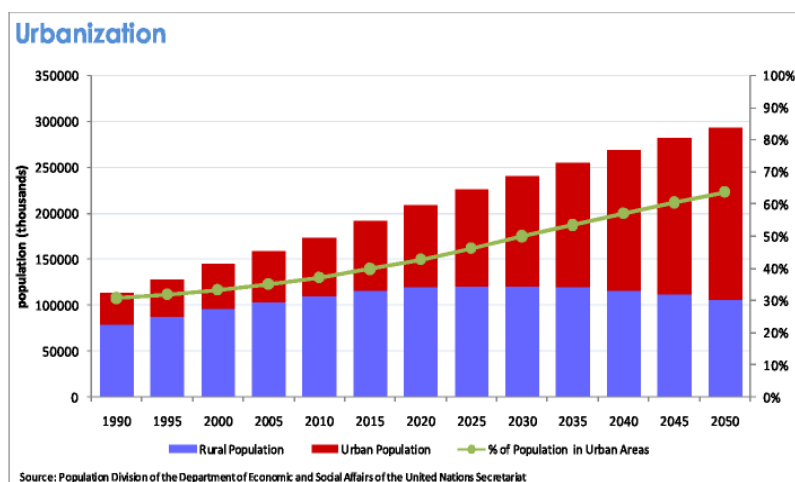


Figure 1. Urbanization trend in Pakistan.

consumption. Energy resources' efficiency in new constructions can be affected by adopting an integrated design approach to building design for reducing global warming. A better understanding of the energy efficient design process can help building professionals making environmental preservation by shaping buildings' future energy demands as there is a growing evidence of global warming and climate change caused by green house gas emissions [3,4]. Pakistan is experiencing a vigorous energy and environmental degradation as compared to many countries as consideration for energy conservation is not given in buildings and modern trend in building construction is to provide comfort at the cost of natural environmental degradation.

2. Environmental Pollution, Energy Use and the Buildings

By urbanization, about 63% people will be living in cities in Pakistan putting more pressure on energy resources including clean air (Figure 1) in cities in future. An atmospheric condition in which harmful gases and the radioactive material can affect the human environment is undesirable.

There has been a considerable interest in recent years with regard to the sustainable architecture and energy consideration besides health factor. Climatic responsive design conditions are absent in the new buildings built in last few decades, they are heavily dependent on mechanical heating and cooling for achieving a certain range of thermal comfort. They consume electricity at a massive scale resulting in building sector a bigger energy consumer sector [5]. One of

the options to obtain a sustainable future is to implement energy conservation and energy efficiency in buildings for the adherence by the building professionals. Pollution that causes global warming is linked to electricity consumption. Fossil fuels are burnt to produce electricity. Fossil fuels are made of dead plants and animals, e.g oil and petrol. Some of the sources like petroleum are used mostly for transportation, making electricity and many other products. In U.S.A, this source of energy used 38% for producing electricity though it gives off pollution [6]. Electricity is used to run television, to turn on lights, stereo, washing machines, hair drying, riding a car, heating a meal in microwave oven, playing video games, using dish washers and using air conditioners for heating or cooling of buildings. The least we use it is the better. Burning of garbage also adds to the greenhouse gases. Cutting trees, as they collect carbon dioxide (a greenhouse gas), results in lesser air to survive on with. Carbon dioxide collects heat and light (radiant energy) from sun. When we pollute the layer of atmosphere, the radiant energy does not escape from the earth's atmosphere thus, causing a rise in earth's temperature. The economic growth and urbanization can be related to the environmental pollution, the link is evident in Figure 2. The buildings in big cities are not planned and designed to meet the energy efficient design guidelines to achieve indoor thermal comfort which is resulting in heavy energy demand by this sector.

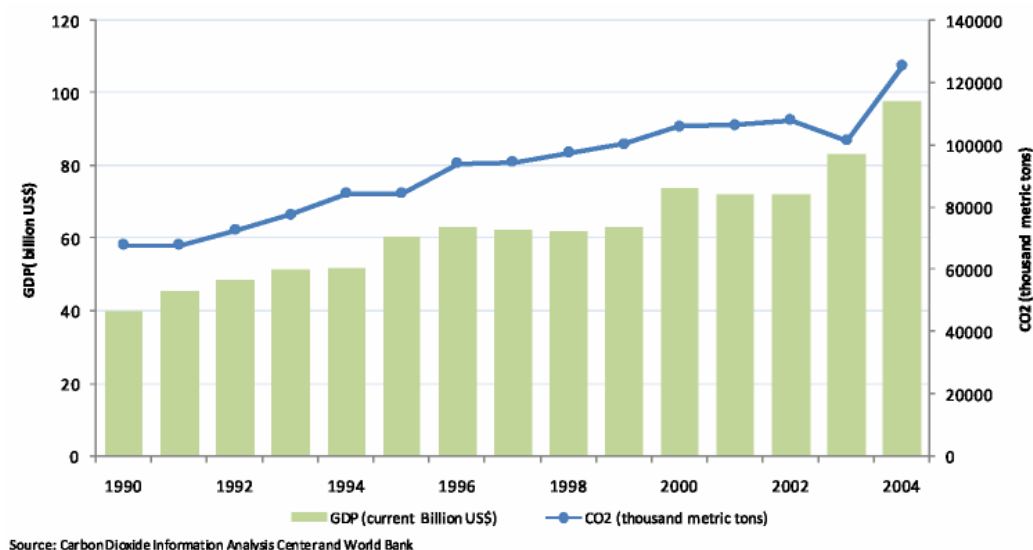


Figure 2. Relation between economic growth and the CO₂ emission in Pakistan.

(Source: Economic Survey of Pakistan (1989-90) Government of Pakistan, Islamabad, 1990)

3. General Strategies

The general strategies for controlling environmental pollution include:

- Energy efficiency improvements in residential electric appliances and lighting can play a key role in assuring a sustainable energy future and at the same time mitigate climate change. Energy efficiency measures related to residential appliances and lighting are among the most cost-effective CO₂ emission reduction actions, to increase the security and reliability of energy supply and to reduce pollution. Electronic devices like TV, mobile phone chargers, computers and electric lights should be turned off when not in use.
- Increase vegetation and tree plantation and landscaping in and around the buildings.
- Car pooling to reduce the environmental and traffic problems.
- Recycling of trash/garbage. Thus, less garbage will go in the dump and less trash gets burning.

Governments make laws called Clean Air Act in many countries and many manufacturing companies are advised through the act to decrease this problem and causing pollution. Hair sprays and deodorants have some volatile organic compounds contain ozone depleting chemicals like (CFCs) and

related chemicals. By 2015, all products will have labels on them regarding their use for environmental conservation. Smog caused by vehicles is responsible of dangerous pollutants or chemicals leading to different kinds of health issues dealing with lungs. NO₂ affect respiratory system and it also causes acid rain [7].

4. Architectural Intervention

As very little attention was paid to pollution and environmental issues in Pakistan until the early 1990s and even the central government's Perspective Plan (1988-2003) and previous five-year plans do not mention sustainable development strategies. However, National Conservation Strategy Report attempted to rectify the previous negligence to the nation's mounting environmental problem in 1992 in Pakistan. The government outlined the current state of environmental health, its sustainable goals and viable program options for the future.

To determine the real energy impact of buildings, residential and commercial, consume 48% of all energy as compared to industrial and transportation [8] and GHG emissions annually, globally the percentage is even greater. Seventy-six percent (76%) of all power plant-generated electricity is used just to operate buildings. Electricity generation in USA accounts for 75% of SO₂ emission only. The annual embodied energy of

building materials and the energy used to construct buildings is estimated at 1.146 MBtu/ sf for new construction and half of this for renovation [9]. An immediate action, therefore, in the building sector is vital if we are to evade hazardous climate change. These gases can cause acid rain, smog and global warming. Based on a recent national inventory of Hazardous air pollutants are released into the air by electric power plants, and the coal and oil fired generating units represent a major source of several major hazardous air pollutants [10] according to EPA, (Environmental Protection Agency) . The pollution associated with these gases can be reduced by the application of energy efficient technologies and the design practices. Architects and building designers can give take up proper architectural and urban design, responsive to the climate and aiming to improve thermal comfort in hot periods even when the building is not mechanically conditioned, or to lower the equipment size and energy consumption in air-conditioned buildings.

4.1. Primary Steps for Sustainable Building Environment

Review of different literatures on building energy conservation, practical works on design and construction reveal that there should be a design approach for the building professionals towards a sustainable design. The primary steps, therefore, for architectural design approach towards sustainability can be:

- Low embodied energy materials should be used in buildings. Adobe bricks (14"x 10"x4") have 2500 Btu's as compared to Common bricks of 13,570 Btu's and concrete blocks of 29,018 Btu's as found in different building applications.
- The buildings' heating and cooling loads can be reduced by designing the buildings in response to its climatic variations and the indoor thermal comfort requirements using local climate data and the sun charts.
- External surface absorptivity is the main factor in determining the temperature response to short-wave (solar) radiation, and is dependent largely by color as shown in a study [11], (Figure 3).

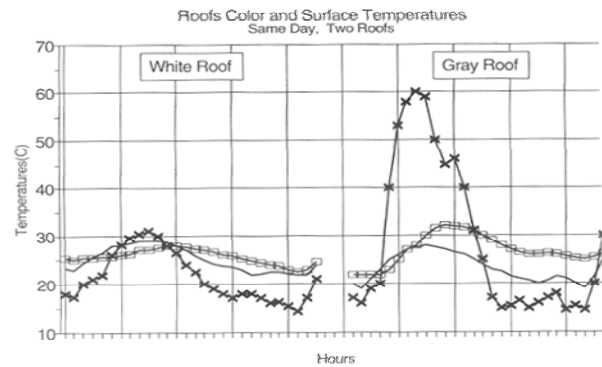


Figure 3. Temperature difference of roofs as a result of its colour's absorptivity.

(Source: Bansal, N., Passive Building Design, Elsevier Science, 1994)

- Today, passive techniques such as thermal mass are ironically considered "alternative" methods to mechanical heating and cooling, yet the appropriate use of thermal mass offers an efficient integration of structure and thermal services by increasing the time lag. Thermal mass can be used effectively to absorb daytime heat gains and release the heat during the night.
- Windows surface to solar aperture ratios between 6:1 to 3:1 for passive solar heated and cooled buildings with more south facing glazing in cold areas and less glazing in hot areas [12].
- Insulation of walls and roof can cause temperature drop at the extreme temperature rise happens inside. An energy simulation study was conducted for the Campus residential buildings at the undergraduate level, which showed a decrease of cooling load from 366 kWh to 259 kWh (29%) in the month of June after simulations when an insulation of polystyrene was added. The heating load was reduced from 638 to 283 wh (maximum at 8 a.m. on 11th January, 2010).
- The optimum Building Form for the entire seasons is an elongated shape in north and south orientations according to many researches.
- Shading of buildings can help architects in designing for inviting winter sun but cutting down the summer sun radiations. Optimum shade depth can reduce the energy consumption. Similarly shading of roof can

reduce the temperature difference up to 5°C between inside and outside temperatures [12].

- Lighting is the dominant load which has the potential of energy and cost saving by the application of high efficiency tubes and ballasts [13].
- Landscaping and wind direction can be used for natural cooling in summer and away from the buildings to warm in the winter.
- Infiltration reduction helps saving energy and a rate of 0.5 to 0.7 ACH is found in energy efficient homes [13].
- Reduction strategies can be used in locating indoor spaces and interior shading.
- Designing for day lighting is often ignored in working environments of buildings but it can improve thermal performance at no or reduced consumption of electricity.
- All the design considerations through architectural intervention can reduce the building loads significantly and thereby can reduce energy consumption for improving the environmental pollution in the urban centers.
- Computer programs can be used for the assessment and data logging the environmental conditions inside and outside the buildings.

5. Conclusions

Though the low per capita energy consumption in Pakistan as compared to the developed countries is low and the problem of contributing CO₂ emission to the global warming seems to be not significant. But Pakistan needs to provide energy to meet its socio- economic development requirements immediately. Hence, there should be an immediate apprehension to utilize energy efficient technologies, measures and renewable sources which are environmental friendly. The energy demand could be reduced by conservation measures in buildings and thereby contributing to the environmental protection plan.

6. Future Recommendations

1. The above Energy efficient improvement/ measures should be the part of buildings bye-laws for implementation in building sector.
2. Energy efficient appliances should be proposed in building electricity plan.

3. The design strategies should be disseminated to the building professional in Pakistan.
4. Other electricity generating sources including solar photovoltaic (PV), wind, geothermal, hydroelectric, wave, tidal, nuclear, and coal with carbon capture and storage (CCS) technology should be encouraged for their application in buildings in Pakistan.
5. The availability of Software and scientific instruments should be ensured at building research centers for the requisite study and control.

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