DESIGN OF THE BUILT ENVIRONMENT: ITS IMPACT ON ENERGY DEMAND AND CONSUMPTION IN SAUDI ARABIA

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ABSTRACT Although Saudi Arabia empowers the world with energy, the country is faced with unprecedented demand on electric energy. The issue, however, is neither affordability nor shortage but the exponential growth of demand on electricity, which reached an annual rate of 17% [Ministry of Industry and Electricity (MIE), 1995]. This figure indicates that we need to double the number of our power generation plants within few years in order to meet the kingdom's present and near future demand. By considering the costs of these power plants, their useful life, the costs of oil and gas to run them, inflation, manpower and all the other related direct and indirect installation and operating costs, one can realize the financial scale of the issue. However, we are now searching for all possible solutions to moderate the electricity demand in order to reduce these tremendous and incremental costs in this primary sector of our economy.

As an Architect, I strongly believe that the current critical situation is due to the serious conflict of our artificially growing urban environment with our harsh climate. Accordingly, the aim of this paper is to point out the major design factors that are largely contributing to the present situation and how they can be improved.

1 Introduction

One fundamental objective of the design of the built environment is to provide comfort, while minimizing energy demand. Recent planning and building for Saudi Arabia, however, have largely overlooked this important fact. As a result inappropriate urban model has been adopted for the various climatic zones of the country. Moreover, a large number of thermally inefficient buildings have been constructed with no attention paid to their lifetime impact .

There were three reasons for this past neglect. The first reason was that, due to the urgent need for rapid development and the absence of qualified local manpower, planning and development have been given to foreign consultant firms who were not accustomed to our local conditions. The second reason was because of the availability of cheap energy; conservation was not incorporated into the development process. Lastly, under the name of "modernization", energy-intensive buildings (glass and concrete architecture) were permitted to go up in our desert environment.

However, the current energy problem facing Saudi Arabia today is how to moderate the present electricity demand and how to sustain a reasonable power supplies expansion. According to MIE recent plan an estimated total investment of Saudi Riyals 438 billions is needed to increase the capacity of the existing power stations for the next twenty-five years [Al Riyadh 1998]. Although the ministry expects to collect part of this money from the interested private investors, it is striving to reduce this huge investment through conservation in the major end-use sectors including building. Fig.1 gives a broad breakdown by category of our 1995 electricity consumption. One can see that the residential sector uses the largest share, which account for 83.3 %. What is not shown in the figure is the fact that between 60% and 80% of this share is consumed for space cooling in our buildings [Davies 1984]. The energy problem, then is in some measure an environmental problem. In other words, the design of our buildings is in serious conflict with our climatic conditions.

Nonetheless, since the built environment has an enormous role to play in our energy use, the aim of this paper is to highlight the serious impact of the urban design, building envelope and climate on its thermal performance and consequently upon our energy demand and consumption.

2 Urban design

Forty years ago, Victor Olgyay clearly noted " ...The architectural patterns familiar to Western civilization have not often considered the problems and solutions inherent in buildings of distant regions and climates" [Olgyay 1963]. Twenty years later, Allan Konya in his distinguished book 'Design Primer for Hot Climates' openly wrote: "Architecture and planning know-how cannot be exported as if they were some standard consumer product and its essential for any one wishing to work abroad (whether in a foreign land or another region of one's own country) to appreciate and understand the unique situation of the area concerned..." [Konya 1980]. Similarly, the irrationality of these architectural patterns is visible today in every city of Saudi Arabia. Their serious conflict with our climatic conditions gives a good example on how the built environment can be unintentionally spoiled by mistakes in planning and building.

Due to the recent urgent need for rapid development and the absence of qualified local manpower, planning and development have been given to foreign consultant firms. They have prepared master plans, action plans and the institutionalization of the planning process for twenty-five cities of the kingdom [Ibrahim 1979]. To encourage more uniform urban growth and to help local authorities, these plans were accompanied by a set of zoning and subdivision regulations. As these companies were not accustomed to our desert climate, most of these regulations favored modernization at the expense of our national energy consumption. Now, our energy sector is suffering from the direct consequences of this past experience.

2.1 Urban pattern

Saudi Arabia has a dominant hot, dry desert climate with two dominant seasons, long summer and very short winter. High solar radiation, extreme heat, bareness, sandstorms and scarcity of water characterize it. Daytime air temperature ranges between 28°C and 48°C. Accordingly heat is the major problem. Due to this harsh climate, the layout of our old urban settlements is characterized by an organic and compact urban grouping of buildings to minimize their exposure to the sun. Also, it is distinguished by its irregular, narrow, and winding streets, which provided very necessary shade, ventilation and protection, while regulating the outdoor temperature. Main streets usually take a north-south direction at right angles to the path of the sun to keep them in shade most of the day. Secondary streets get east-west direction and are shaded by the exterior walls of adjacent buildings. These streets are usually bent and have dead ends for providing security, privacy and protection from sandstorms, as shown in Fig.2.

During the last two decades, these magnificent concepts of adaptation have been replaced by the adoption of the western concept of external display and interaction (The concept of a garden city). Today, our cities are dominated by this uniform gridiron pattern of streets and plots to which cubical-buildings are fitted, irrespective to climate. As a result, we have no way, but to survive in an artificial air-conditioned environment.

2.2 Zoning regulations

These regulations mainly dictate standards for setbacks, densities, and building heights, lot sizes, uses and frontage requirements. The setback requirement is one of the major factors influencing our present high-energy consumption in buildings. Its concept is to have unbuilt space around the building. Climatically, exposing all the building to be hit by the sun during the whole day. Since all our buildings are made of concrete, they become huge stoves, which radiate heat during the day and night because of the storage capability of concrete. So, the only way to conquer this uncomfortable situation is by increasing the cooling load of the building.

2.3 Subdivision regulations

These regulations mainly dictate standards for street widths and construction, sidewalks, parking, drainage, and other site development requirements. Their enforcement of spacious gridiron arrangement of streets is another important factor that affecting the current energy uses in our buildings. massively asphalted and heavily occupied streets make up a large portion of our built environment. So, in addition to our concrete buildings and clear sky, they are creating an intense 'urban heat island' phenomenon. Hence, worsening our urban temperature. For this reason, no real potential for conservation can be expected with the implementation of these regulations.

3 Building envelope

The diagrams in Fig.3 give an insight into our traditional architecture. It shows that, the building structure was the main mechanism of controlling the thermal environment. Due to the limited energy resources and building technology, however, local builders had to smartly use it as the principal means of providing comfort conditions during the daily and seasonal cycles of the climate. Their main objective was to utilize natural energies (namely sun and prevailing wind) to cool and heat the buildings while minimizing their exposure to the sun especially during summer. Environmental factors, which largely contribute to human comfort such as sunshine, temperature, humidity, ventilation and radiation from walls, floors, ceilings, and other surrounding surfaces, had been cleverly handled as is evident in our old buildings.

The whole building process, in fact, was to a large extent the responsibility of the local communities. The result was appropriate passive cooling systems for controlling the environment of every region of the kingdom, often based on climatic differences and life-long building experiences of the region: "courtyards" in the hot-dry; "rowshans" or "mud and thatch roof" in the hot-humid; "badgirs" in the composite and "mud and slate" in the temperate climate.

However, the recent intent on modernization coupled with the growing advancements in building technology and cheap energy changed all of that. With these changes, architects were and still less concerned with the energy costs associated with their design decisions. Design factors, which affect the use of energy in buildings such as site conditions, orientation, shape and structure, have not been seriously considered in their designs. They relied heavily on air conditioning, forced ventilation and artificial lighting systems in order to bring interior comfort to our buildings. Consequently, many air conditioning systems were added, lighting levels were increased, single-pane windows were used and buildings with minimal insulation were built. These shortcomings have made it too difficult to assess realistically the potential for energy conservation in the existing energy-intensive buildings.

However, serious efforts have been initiated in recent years by MIE and research institutions to gather information on energy consumption and to promote measures for increased energy conservation and efficiency in the building sector [IEEE 1997].

4 Climate

It is obvious from the foregoing that the above mentioned astronomical investment and consumption could have been saved and most economically cut, if our recent urban development had been grown with our kingdom's severe climate in mind. Unfortunately, it is the negligence of this basic design criterion, which have led to the current irreversible situation.

5 Summary and conclusions

In the preceding sections, the state of energy in our physical environment has been discussed. It can be seen that the uneconomical demand and consumption for electricity in our buildings is real. It has, also shown how the design of the built environment can be spoiled by unintentional mistakes in planning and building. So, an immediate need for change in our urban and building design practice is now evident. Moreover, unless far more attention is given to this problem, the operating costs and consumption are here to stay, and more and more expensive power stations will be needlessly imported and planted all over the kingdom at the expense of generations to come.

However, three lessons to be learned from our recent urban development experience. The first lesson is the acknowledgement of the lifetime impact of the built environment on our energy demand and consumption. The second lesson is the admission that there is no substitute for the collective know-how of our past generations. Finally, It is too easy to adopt new building technologies without fully considering its future impact. Therefore, one genuine way of moderating the demand and consumption for electricity in our buildings would be achieved by molding our past experiences of design with new building technologies while keeping the effects of climate in mind.

Energy conservation in buildings is a well-established subject. The technology already exists to make our buildings far more efficient in their energy use. But, the way in which our buildings is operated at present limits the use of this technology for two reasons: electricity is generously subsidized by the government and the absence of energy performance codes based on our climatic conditions. As an example, in recent years the use of insulation has been strictly imposed on our new buildings with no attention paid to their window design.

For the time being, however, we can technically reduce the energy demand of the existing buildings through three important steps: by sealing and insulating them completely, by improving the efficiency of their mechanical and electrical systems, and by introducing sunshading devices wherever applicable.

In conclusion, with this situation our building industry is faced with a tremendous challenge and responsibility of constructing energy-efficient and cost-effective buildings. In fact, both the planning and building sectors will be under an enormous pressure to achieve more sustainable built environment in the next few years. Accordingly, new environmentally responsible architecture will inevitably come to life again.

6 References

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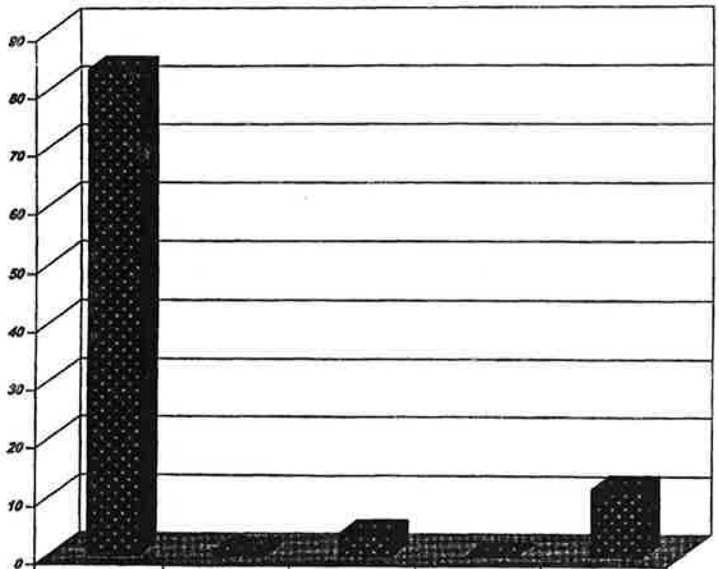


	Residential	Agricultural	Government	Industrial	Commercial
■ Series1	83.3	0.9	4	0.1	11.7

Fig.1 Electricity consumption (%) categories (source: Ministry of Industry and Electricity Report, 1995)

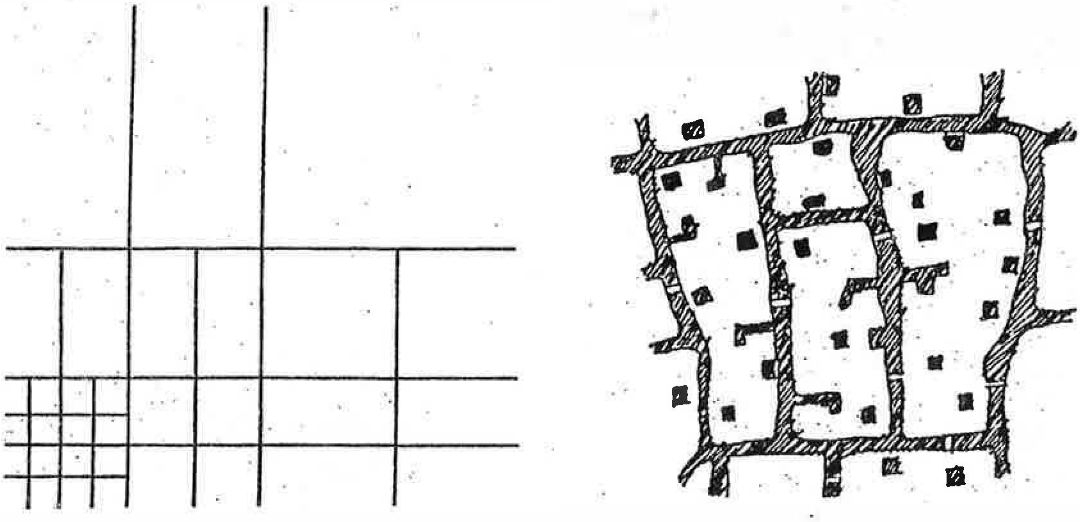
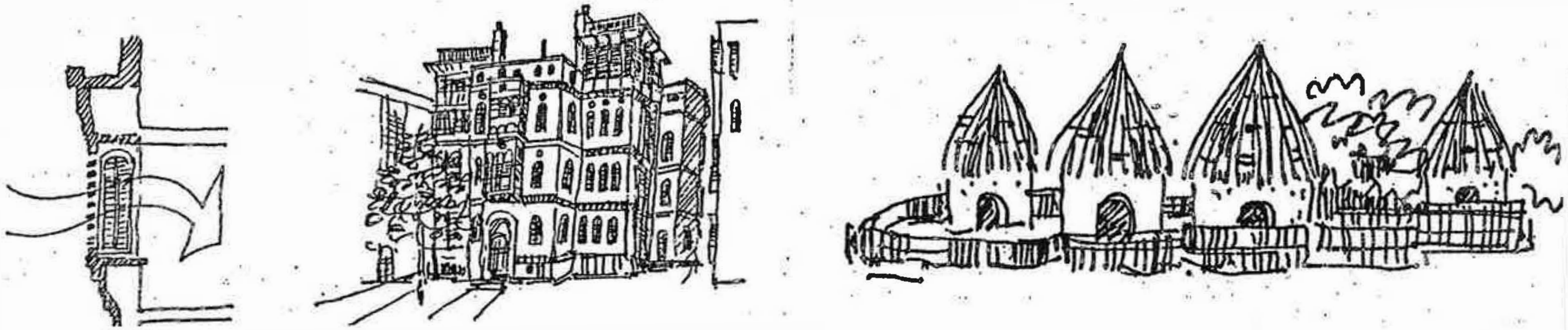
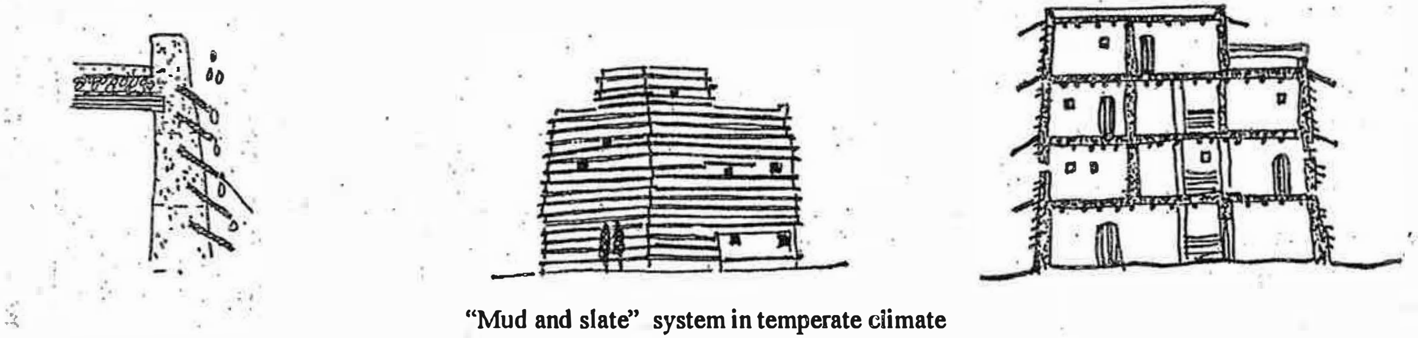


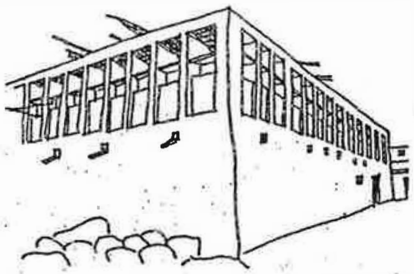
Fig.2 System of streets in new settlements **System of streets in old settlements**



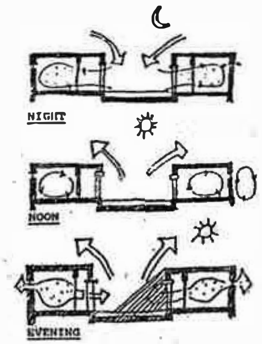
"Roshans" and "Mud and thatch roof" systems in hot – humid climate



"Mud and slate" system in temperate climate



"Badgirs" system in composite climate



"Courtyard" system in hot – dry climate

Figure (3) – Passive Cooling Systems in Saudi Arabia
Source : Kiazer Talib (1983) "Review of climatic Design Concepts and Details in Traditional Architecture in Various Climatic Zones – Saudi Arabia", the International Conference on Passive and Low Energy Architecture, China.