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Energy Smart Buildings: Potential for Conservation and Efficiency of Energy

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1. BACKGROUND

Energy is the basic ingredient for economic growth and development [Lorde, *et al*. (2010)]. Presently demand for energy has significantly increased due to the overall expansion of economic and industrial activity in all important economic sectors e.g. industry, agriculture, and services. In addition to the expansion of economic activity and subsequent increase in energy demand at industrial level, population growth and increased consumption are also adding to the demand for energy [OECD (2011)]. In other words, modern economy has become highly dependent on energy resources. In order to meet the increased energy demand and ensure its sustainable supply, there is a need to have strong and robust plans with all options to consider at various levels.

Pakistan is going through the severe energy crisis [Javaid, *et al*. (2011); Masood, *et al.* (2012)] which has seriously hampered the economic growth and development progress of the country. Aziz, *et al*. (2010) estimated that, due to power shortages in the industrial sector alone, the loss was over $3.8 billion in 2009 that was approximately 2.5 percent of the gross domestic product (GDP). Therefore, it is crucial to resolve the present energy crisis to avoid the further economic problems and social unrest in the country. In order to manage the present energy crisis, concerned departments and agencies are trying to reduce the current shortfall. There are two sets of strategies, which are being used by the authorities; demand management and production expansion.

In this context, potential of energy conservation cannot be neglected as it can yield significant results in demand management. One important avenue of energy conservation is buildings, where large amount of energy can be conserved to achieve the energy conservation and efficiency. Buildings consume a lot of energy especially in heating and cooling systems. This consumption can be reduced by modifying the building structures and making them energy smart. Because energy smart buildings have relatively reduced energy demand and more energy efficiency, which can play a vital role in achieving the goal of energy conservation.

Around the world countries have adopted energy conservation policies in buildings, for instance Dutch government aims at reducing the energy use by 50 percent in the existing housing stock by 2020 [Hoppe, *et al*. (2011)]. Similarly European Union

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has the goal to reduce 20 percent of the total building energy consumption by 2020 [European Commission (2011)]. The European Commission also estimated that the energy saving potential for residential and commercial buildings is up to 30 percent [European Commission (2006)].

It has also been estimated that the energy smart buildings can save 30 percent or even more in energy costs over a conventional building designed [Zainordin, *et al.* (2012)]. Present research aims to investigate the energy conservation and efficiency potential of energy smart buildings, their monetary benefits, and likely impact of improved thermal performance to increase the energy in the light of government's proposed conservation strategies and building energy code of Pakistan.

2. DATA AND METHODOLOGY

2.1. Data

Data for the present research was collected from two sources. One source is National Energy Conservation Centre (ENERCON), which is an organisation that deals with energy conservation at domestic as well as commercial level in Pakistan. Second source is UN-HABITAT guidelines on energy efficient housing, which was formulated by UN-HABITAT along with the Ministry of the Environment Pakistan, ENERCON, and the Capital Development Authority Islamabad Pakistan. These guidelines are specifically about the improved rooftop thermal performance and its potential for conservation of energy. This data was generated from an experiment, which was conducted on few houses of Islamabad.

2.2. Methodology

Present research is a policy paper which highlights the importance, scope, and potential of energy smart buildings in terms of energy saving and associated gains. Study followed the descriptive analysis method to highlight the energy efficiency and conservation potential of energy smart buildings. Descriptive analysis is an approach that provides the simple summaries of the variables and their features in the form of Tables and graphs, which present data and information in such a way that any phenomena can easily be observed and analysed. With descriptive statistics we can simply describe what the data shows.

3. ENERGY CONSERVATION AND EFFICIENCY SYSTEMS

A building is classified in a number of energy systems presented in the following (Table 1). Each of these energy systems has the potential for energy efficiency and conservation that can be achieved by various ways such as; altering the designs and structures of the systems, introducing the new technologies, which are more energy efficient, and reducing the consumption of energy. In Pakistan, to date, no significant work has been done to adopt any of the aforementioned techniques to achieve the energy efficiency and conservation.

Table 1

Buildings Energy Systems

Building Envelope (Type, Geometry and Location)
Lighting
Heating, Ventilation and Air Conditioning
Mechanical and Electrical Systems
Service Water Heating

Source: ENERCON (2013).

Construction industry in Pakistan is still following the old traditional designs and structures, which are highly energy inefficient. This energy inefficiency is found in almost all systems ranging from building envelope, lighting, mechanical, to electrical systems. It increases the consumer demand for energy and subsequently puts burden on the energy supply sources. It is worthwhile to mention that government has the energy building code of Pakistan prepared in 2010 by a number of government departments, which deals with the energy and buildings. A significant amount of energy can be conserved by following the energy building code of Pakistan for new buildings. Moreover, UN-HABITAT guidelines can also be instrumental to improve the thermal performance of rooftops of traditional buildings.

4. POTENTIAL CONSERVATION AREAS

A number of areas of energy efficiency and conservation are presented in (Table 2) along with their efficiency and conservation potential. This possible energy conservation potential has been estimated by the ENERCON after identification of a number of potential areas. In this regard first prospective area in buildings is building envelope, which consists of building type, geometry, location, walls and roof specifications, and windows. Building envelope has 40 percent energy conservation potential, which means that almost 40 percent energy can be conserved or saved if standard building energy code is followed in buildings envelope.

Table 2

Potential Energy Conservation Areas

Conservation Areas	Saving Potential
Building Envelope	40%
Overall Lighting Potential	29%
High Efficiency Lighting (LEDs)	72%
Fluorescent Tube Ballasts	83%
Lamp Fixtures or Luminaries	50%
Air Conditioner	18%
Printer	19%
Heaters	17%
Copier	10%
Fan	5%
Computer	2%

Source: ENERCON (2013).

Next potential area of energy conservation and efficiency in buildings is lighting. Overall energy conservation potential of lighting is about 29 percent that means there is still lot of room for improvement and technological advancement in the area of lighting. Majority of the people still use the energy inefficient lights at domestic as well commercial level, which puts burden on energy demand as well as electricity bills.

Next area of energy saving potential is Air Conditioner (AC) usage which has increased with improved incomes and changed lifestyles. AC has 18 percent energy conservation potential, which means that use of inefficient AC is also putting burden on household energy demand that can be reduced by adopting the recommended technologies for energy efficient buildings. Heaters are a big source of energy inefficiency and losses, which can also be improved by adopting better technologies to reduce the demand of energy. Potential for energy conservation of heaters is approximately 17 percent that can be unleashed by choosing appropriate technologies. In the same way fans' energy conservation potential is 5 percent and computers' energy conservation potential is 2 percent.

Above presented Table of potential areas of energy conservation shows that these areas can contribute significantly to the energy demand management. In this regard energy smart buildings have great importance as their structure and design can yield lots of energy saving at domestic and commercial level.

5. SENSITIVITY ANALYSIS OF ENERGY CONSERVATION AND MONETARY SAVING

The energy conservation potential presented in preceding section (Table: 2) gives an idea of overall energy saving potential of energy smart buildings in terms of reduced consumption and demand. In order to translate the energy efficiency and conservation potential into monetary incentives, some extrapolations have been done by using few hypothetical values of electricity bills. The purpose of the exercise is to highlight the monetary savings, which can be generated from energy smart buildings.

Following (Table 3) presents the sensitivity analysis approach, which has been used to assess the monetary savings from energy conservation. Overall savings of aforementioned three potential energy conservation areas is 29 percent that means roughly 29 percent of the energy consumption can be reduced and saved. Therefore, same percentage of the energy cost can be saved in terms of electricity bills.

Table 3

Energy Conservation and Monetary Saving Sensitivity Analyses

Electricity Bills in Traditional Building	Monetary Value of 29% Energy Conservation	Electricity Bills in Energy Smart Building
1000	290	710
2000	580	1420
3000	870	2130
4000	1160	2840
5000	1450	3550

First column of Table 3 presents different hypothetical amounts of electricity bills of various dwelling units, which are traditional buildings. Second column illustrates the monetary savings in terms of reduction in electricity bills due to energy conservation potential of the energy smart buildings. And last column of the Table demonstrates the electricity bills of energy smart buildings and the amounts of bills in energy smart buildings are significantly less than those in the first column. Hence, this sensitivity analysis shows that energy smart buildings can yield the monetary savings, in addition to the energy conservation and efficiency.

6. IMPROVEMENT OF ROOFTOPS THERMAL PERFORMANCE

Improvement of rooftops thermal performance means maintaining the temperature inside the buildings by modifying the rooftops of the buildings. In building envelope, it is a useful method to conserve the energy. There are various techniques, which are used to improve the thermal performance of rooftops. The techniques are based on the application of different solutions on roofs. These techniques are divided into following categories; insulative techniques, reflective surface techniques, and radiant barrier techniques.

(a) Insulative Techniques

Insulative techniques are effective in maintaining heating and cooling both in summer and winter. These technologies reduce the heat transfer from the top by slowing down the conduction of heat. Following are the some of the insulative techniques, which have been tested and applied; stabilised mud (cement stabilisation), mud with high density styrofoam (thermo pole), brick tiles with stabilised mud, polystyrene (jumbolon) with plain concrete screed, concrete wizard insulating tiles, cellular light weight concrete (CLC) tiles, smart concrete tiles (aerated concrete with thermo pole used as sandwich between concrete layers), terrazzo mixed white apoxy with thermo pole sheet, fired clay extruded hollow tiles, and green netting.

(b) Reflective Techniques

These techniques are used to reflect the sun radiations and reduce the absorption of heat into the rooftops. According to technical guidelines [UN-HABITAT (2010)] reflection of the sun radiations depends upon the color of the slab. The reflective techniques, which are applied to reduce the heat of rooftops include; lime wash, white enamel paint, weather shield white paint, OCEVA-MOL chemical, aerosol heat reflective paint etc. It is advised that the surfaces must be cleaned frequently in order to attain maximum efficiency of the technologies. The durability of the reflective surfaces varies according to the conditions of weather and material reliability.

(c) Radiant Barrier Techniques (False Ceiling)

Radiant barrier techniques reflect the direct sun radiations. When the rooftops become hot, these technologies radiate the heat directly into the room below and a radiant barrier stop this heat from coming into the inside of the buildings. Radiant barrier is usually an additional layer of false ceiling provided underneath the roof to stop the heat from radiating into the building. The false ceiling may either absorb the heat, or play the role of reflection of the heat. According to the UN-HABITAT guidelines there should be an adequate and ventilated air gap between the slab and the radiant barrier to be most effective. Radiant barriers techniques consist of; gypsum board false ceiling, gypsum board with aluminum foil on the back, paper board false ceiling, and thermo pole false ceiling. These techniques can be used as a decorative finish and solutions are more appropriate if the room height is adequate.

7. REDUCED TEMPERATURE AND IMPROVED THERMAL PERFORMANCE

UN-HABITAT conducted an experiment on improvement of the rooftops thermal performance, in collaboration with Capital Development Authority (CDA), and ENERCON. The experiment was conducted on few selected households in Islamabad, where a number of thermal performance techniques were applied to examine the results in from of reduced temperature.

Analysis of the data on temperature changes due to the use of the technologies revealed that there is significant difference in temperature after the application of these solutions. Following Table 4 present the temperatures in control and treated scenarios. Control is the condition of temperature before the application of the solutions (insulation technologies were not applied) and treated is after the application of different solutions (insulation technologies were applied). The top highlighted row is of control condition that presents the normal temperature of the building inside before the use of any technology to improve the thermal performance.

Table 4

Reduced Temperature and Improvement in Thermal Performance

	Without Solution	**Temperature**
Control	Normal Temperature (Inside)	36.2
	Solution	
	Stabilised mud	35.3
	Mud with thermo pole	33.6
	Brick tiles with stabilised mud	33.1
	Extruded Polystyrene (Jumbolon)	32.2
	Concrete wizard tiles	34.7
	Sachal CLC tiles	34.0
	Smart concrete tiles	33.7
Treated	Munawar AC tiles	33.0
	Alnoor tile	34.1
	Green netting	35.1
	Lime wash	33.1
	Weather shield paint (white)	33.7
	White enamel paint	33.1
	Aerosol heat reflecting paint	34.2
	OCEVA-MOL chemical	34.7
	Gypsum board false ceiling	34.6
	Gypsum board with aluminum foil	34.9
	Paper board false ceiling	32.2
	Thermo pole false ceiling	34.4

Source: UN-HABITAT (2010).

After the treatment of the rooftops with different insulation techniques average temperature has significantly decreased. The temperature of the houses where insulation techniques were applied has decreased by 2 to 3 degrees, which is a significant change in temperature due to improved thermal performance. It is worthwhile to mention that this change in temperature has occurred only due to arrangements made for rooftops insulation. And if we apply the same techniques to the walls, the temperature may further reduce by enhancing the energy conservation and efficiency of the buildings.

1. Cost Estimates

In order to assess the efficiency and effectiveness of the improvement of rooftops thermal performance, per unit cost of the insulation material has been computed. Table 5 presents the initial costs of the each insulation technique used in enhancing the energy efficiency of the buildings. However, some of these techniques are relatively more cost effective than others. Moreover, suitability of the adoption of these technologies also depends on a number of factors such as; average temperature, nature of material and its life, type of rooftop, building type etc.

Table 5

Cost Estimates of Different Solutions

Solution	Initial Cost Rate/ Sft (PKR)
Stabilised mud	32
Mud with thermo pole	52
Brick tiles with stabilised mud	39
Extruded polystyrene (jumbolon)	76
Concrete wizard tiles	78
Sachal CLC tiles	80
Smart concrete tiles	70
Munawar AC tiles	80
Alnoor tile	81
Green netting	60
Lime wash	30
Weather shield paint (white)	80
White enamel paint	80
Aerosol heat reflecting paint	39
OCEVA-MOL chemical	35
Gypsum board false ceiling	44
Gypsum board with aluminum foil	45
Paper board false ceiling	22
Thermo pole false ceiling	30

Source: UN-HABITAT (2010).

Apparently the most economical insulation technique is paper board false ceiling (Rs 22 per square foot), and it is due to its material being relatively less expensive. On the other hand, paints insulation is the most expensive solution (Rs 80 per square foot) in above presented options for insulation to enhance the thermal performance of the rooftops. It is worth mentioning that the presented costs were estimated in 2010 and one may expect the effect of inflation due to increased material costs. However, because of lack of technical information the relative effectiveness of each technology could not be ascertained.

2. Benefits

Energy efficiency and conservation is undeniably a crucial business for domestic as well as commercial consumers. Following are some of the direct and indirect benefits of energy efficiency and conservation in energy smart buildings. The direct benefits of energy smart buildings are as follows; the reduced energy consumption and demand due to potential for conservation, monetary saving in terms of reduced electricity bills, and demand management. In addition to this there are a number of indirect benefits of energy smart buildings such as less carbon footprint due to reduced energy consumption.

In this way these buildings can qualify for carbon credits, as they are the source of reduction in carbon emissions and pollution. Moreover, due to reduced carbon emissions and exposure to extreme weather conditions energy smart buildings are environment and climate friendly or climate compatible.

3. Missing Link in National Housing Policy

National Housing Policy 2001 is the main document of government on housing sector in Pakistan. This housing policy provides detailed and comprehensive course of action based on strategies and guidelines on different aspects of housing. However, this document has not been revised since its formulation in 2001. Due to which the present issues and problems such as energy and climate change aspects are not reflected or could not receive adequate attention of the policy makers. Specifically, there are no policy guidelines in housing policy for newly constructed housing schemes on energy conservation and efficiency.

Although ENERCON has produced some guiding material but Ministry of Housing and Works Pakistan has no strategy for energy efficient housing. However in present energy crisis situation in Pakistan, there should be greater emphasis on energy efficient housing and it must be reflected in the national housing policy of Pakistan. Present research presents the policy recommendations in the following section, which can be instrumental to produce the guidelines for energy efficient housing.

8. CONCLUSION AND POLICY IMPLICATIONS

Present research concludes that a significant amount of energy can be conserved and saved if building structures are modified according to the standard policy guidelines for energy efficient or energy smart buildings. In Pakistan UN-HABITAT has developed the guidelines on building envelope in collaboration with Capital Development Authority and ENERCON to improve the thermal performance of already constructed houses. There are a number of insulation technologies, which have the potential to reduce inside temperature of the buildings by 2 to 4 C^0. Findings of the present research have revealed that insulation technologies are instrumental in improving the thermal performance of buildings. These technologies have the potential to maintain the temperature of the buildings. Use of such technologies helps in energy conservation and yields monetary saving in terms of reduced electricity bills. Lastly energy smart buildings play important role in reducing the carbon emissions and problems associated with emissions.

Following are some of the policy implication emerging from present analysis of energy smart buildings;

- There are standard guidelines on energy smart buildings formulated by relevant departments; however, there is lack of implementation due to a number of factors such as lack of information. In this regard awareness can play very important role.
- Rewards for conservation and efficiency of energy should be given in terms of reduced electricity bills to attract the people for energy conservation.
- Government should set the annual targets for energy conservation in buildings and prepare the action plan to achieve them.
- Media should promote the idea of energy smart buildings as it can play a crucial role in sensitising people about their responsibilities on energy conservation in buildings.
- Energy conservation and efficiency aspects and their effective implementation should be included into the construction bylaws.
- There should be strict criteria for monitoring of energy consumption in the domestic as well as commercial buildings to implement the guidelines on energy smart buildings.
- Energy efficient structures of the buildings should be encouraged by introducing the incentives for energy conservation in buildings. Moreover, violation of regulations and guidelines should be punished.
- Finally research should be encouraged on different energy systems within the buildings to promote the energy conservation.

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Comments

The idea is very interesting and if implemented then can help to overcome Pakistan energy crises.

(1) The issue is not properly introduced in the introduction. Further the argument is built without proper references support. After the first two paragraphs the author suddenly comes to the issue without giving the proper specific background.

(2) This is a policy paper and "Building Envelop" is suggested by the author. But in a developing country like Pakistan, where almost one third population is spending their lives on or below the poverty line, building envelop is not a good suggestion. This is a good suggestion but for a developed country.

(3) In a policy paper it is more important to know that how this policy will be implemented. The author suggested a policy but the implementation process is missing which is the only significance of a policy paper.

  (i) How the policy will be formulated and implemented?

  (ii) Who are the main stakeholders and how to deal the obstacles (if any) for the implementation?

(4) Annual shortage of energy (Difference of Demand and Supply of Energy) is not given.

(5) The source of Table 3 is missing. Whether the author has made his own calculations are this table is taken from sum source.

(6) The author claims that these buildings are environmental friendly but did not estimate or explained that how much it will benefit the environment in terms of CO_2 reduction etc.

(7) The author has not provided the cost benefit analysis of the phenomenon and did not further analyse the feasibility of these building in Pakistan.

(8) Very few references are available. More intensive review of literature on the subject can improve the paper.

(9) The reader is lost to know about the data, the type of buildings, the location of the buildings etc.

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