Energy Smart Buildings: Potential for Conservation and Efficiency of Energy

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Abstract

Globally demand for energy is escalating with the passage of time due to increased population and consumption. In order to meet the increased energy demand and ensure its sustainable supply, different options are being considered. Pakistan is also facing the severe energy crisis from last couple of years. This energy crisis has seriously hampered the economic growth and development progress. In this situation intensive efforts are being invested by concerned departments and agencies to enhance the production and supply to reduce the current shortfall. However, there are certain demand side issues which can be worked out to achieve the energy conservation and efficiency. Keeping energy conservation and efficiency in view, present study focuses the energy smart buildings. These buildings have relatively reduced energy demand and better efficiency that can significantly contribute to the conservation of energy. Study is a quantitative analysis that is based on secondary data sources collected from concerned departments (e.g. ENERCON). Research also examines the government's proposed conservation strategies and buildings code of Pakistan. The findings of the present research reveal that energy smart buildings have significant potential for conservation and efficiency of energy. Moreover, we can save lot of money by adopting energy conservation technologies in buildings.

Key Words: Energy Smart Buildings, ENERCON, UN-HABITAT, Thermal Performance

1. Background

Energy is the basic ingredient for economic growth and there is strong correlation between energy and economic growth in present context (Lorde et. al, 2010). Globally demand for energy is escalating with the passage of time due to increased population and consumption (OECD, 2011). In order to meet the increased energy demand and ensure its sustainable supply, different energy options are being considered. Pakistan is also facing the severe energy crisis since last decade (Javaid et. al, 2011; Masood et. al, 2012). This energy crisis has seriously hampered the economic growth and development progress.

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 is approximately 2.5 percent of the gross domestic product (GDP). Intensive efforts are being invested by concerned departments and agencies to reduce the current shortfall. In present situation potential of energy conservation cannot be neglected as it is also one important area that can yield significant results. There are a number of options or potential areas which can be worked out to achieve the energy conservation and efficiency.

In the backdrop of energy conservation and efficiency, present study focuses the energy efficient or energy smart buildings. These buildings have relatively reduced energy demand and better efficiency that can significantly contribute to the conservation of energy. Around the world countries have adopted energy conservation policies in buildings, for instance Dutch government aims at 50% reduction in energy use in the existing housing stock by 2020 (Hoppe et. al, 2011). Similarly performance goal for buildings in the European Union is a reduction in energy consumption of 20% by 2020 (European Commission, 2011).

The European Commission also estimated that the energy saving potential for residential and commercial buildings that is up to 30% (European Commission, 2006). In this regard Energy smart buildings can save 30% 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

Mainly the data for present study has been collected from National Energy Conservation Centre (ENERCON). ENERCON is a government organization that deals with almost all main energy conservation related issues at domestic as well as commercial level. It also formulates and devises the strategies and guidelines for conservation of energy in Pakistan. Specifically, data and information used in present analysis was collected from the website of the ENERCON that includes; Building Code of Pakistan, UN-HABITAT guidelines on energy efficient housing (formulated by UN-HABITAT in partnership with the Ministry of the Environment, ENERCON, and the Capital Development Authority Islamabad), and few other sources.

2.2 Methodology

Study is a policy paper which highlights the importance, scope, and potential of energy smart buildings in terms of energy saving and monetary gains. Present research followed the quantitative analysis approach to examine the energy smart buildings with reference to their energy efficiency and conservation potential. Specifically study is based on descriptive analysis method which is suitable given the nature of the study and its objectives. Descriptive analysis mainly includes the tables and graphs which present data and information in such a way that different phenomena related to energy smart buildings can easily be observed and analyzed.

3. Energy Conservation and Efficiency Systems

According to the building energy code of Pakistan, a building can be classified by a number of energy systems. Following (Table: 1) presents the main energy systems of a building and each one of them have the potential for energy conservation and efficiency. This conservation and efficiency can be achieved by many ways such as altering the designs and structures of the system or introducing the new technologies which are more energy efficient or consume less amount of energy. Unfortunately construction industry in Pakistan is still following the old traditional designs and structures which are highly energy inefficient.

Table: 1 Buildings Energy System

Building envelope (type, geometry and location)
Lighting
Heating, Ventilation and Air Conditioning
Mechanical and electrical systems
Service water heating

Source: ENERCON, 2013.

This energy inefficiency is found in almost all systems ranging from building envelope to lighting, mechanical, and electrical systems. It puts burden on national grid, in terms of extra supply, and on consumer in terms of electricity bills to greater extent. Following the energy building code of Pakistan for new buildings and UN-HABITAT guidelines to improve the thermal performance of rooftops of traditional buildings can yield the energy conservation and other benefits as well.

4. Potential Conservation Areas

A number of potential areas of energy efficiency and conservation are presented in Table: 2 along with their energy efficiency and conservation potential. The estimates on energy conservation potential have been produced by ENERCON after identification of a number of potential areas. In this regard first prospective area in buildings is building envelope which has 40% energy conservation potential. Building envelope consists of building type, geometry, location, walls and roof specifications, and windows. It means that almost 40% 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.

It is worthwhile to mention that modification in buildings structure in light of standard building energy code can also yield the energy conservation though that may be lesser than those which are construed according to the standard building energy code. Next potential area of energy conservation and efficiency in buildings is lighting. Overall energy conservation potential of lighting is about 29% that means there is still lot of room for improvement and technological advancement in this area. Majority of the people still use the energy inefficient lights at domestic as well commercial level which put a burden on energy demand as well as electricity bills.

Next area of energy saving potential is Air Conditioner (AC) usage that has 18% energy conservation potential. This means that use of inefficient AC is also putting burden on household energy demand which can be reduced by adopting the technologies recommended for energy efficient buildings. In this regard standard building energy code can play role in reduced demand for AC as well. Heaters are also a source of energy inefficiency and losses which can be improved by adopting energy conservation technologies to reduce the demand of energy. Potential for energy conservation of heaters is approximately 17% that can be unleashed by choosing appropriate technologies. Similarly fans' energy conservation potential is 5% and computers' energy conservation potential is 2%.

All these aforementioned potential areas of energy conservation can contribute 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 presented data on energy saving potential of energy smart buildings in terms of building envelope, lighting, and air conditioning gives an overview of the cumulated potential of these three areas. This cumulated potential is used for calibration and extrapolation of energy conservation potential. And for this purpose sensitivity analysis approach is used to assess the monetary saving from energy conservation. Overall saving of aforementioned three potential energy conservation areas is 29% that means roughly 29% of the energy consumption can be reduced and saved. Consequently, same percentage of the energy cost or price paid in terms of electricity bills can also be saved. Following is the sensitivity analysis of the monetary saving as a result of energy saving in energy smart buildings.

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

Above Table: 3 depict the simple calibration on energy saving potential and their monetary benefits in energy smart buildings. This calibration is the extrapolation of the cumulated energy conservation finding and subsequent monetary savings. In Table: 3 first column presents different hypothetical amounts of electricity bills of various dwelling units which are having 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.

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, one may draw the conclusion from this sensitivity analysis that energy smart buildings do not only save the energy to manage the demand but also yields domestic saving in terms of reduced electricity bills.

6. Improvement of Thermal Performance of Rooftops

In building envelope rooftop is one important area that can play crucial role in energy conservation by maintaining the temperature inside the buildings. There are different energy efficiency measures to improve the thermal performance of rooftops. UN-HABITAT in collaboration with Capital Development Authority (CDA), and ENERCON tested and applied different techniques to improve the thermal performance of roofs on experimental basis in Islamabad City. The application of different solutions to improve thermal performance of roofs is divided in to three categories; insulative techniques, reflective surface techniques, and radiant barrier techniques. Following are the explanations of aforementioned techniques along with their examples.

(a) Insulative Techniques

Insulative techniques which are applied on rooftops are effective in maintaining heating and cooling in both summer and winter. According to the UN-HABITAT calculations most of the technologies are have a life of more than 10 years. 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 on roofs; Stabilized mud (cement stabilization), Mud with High density Styrofoam (thermo pole), Brick tiles with stabilized mud, Polystyrene (Jumbolon) with plain concrete screed, Concrete wizard insulating tiles, Sachal CLC (cellular light weight concrete) tiles, Smart concrete tiles (aerated concrete with thermo pole used as sandwich between concrete layers), Munawar AC Tiles (Terrazzo mixed with white apoxy with thermo pole sheet), Fired clay extruded hollow tiles, and Green netting.

(b) Reflective Techniques

By adopting these techniques sun radiations are reflected it reduces the absorption of heat into the rooftops. According to technical guidelines reflection depends upon the color of the slab; the lighter the color (white), the more it will reflect (UN-HABITAT 2010). Following are some of the reflective techniques applied to reduce the heat of rooftops; Lime wash, White Enamel paint, Weather shield white paint, OCEVA-MOL chemical, Aerosol Heat reflective paint. 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 the condition of weather and various other factors.

(c) Radiant Barrier Techniques (False Ceiling)

Radiant barrier techniques reflect the direct sun radiations. When the rooftops become hot, they radiate 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. Following are the radiant barriers; Gypsum board false ceiling, Gypsum board with aluminum foil on the back, Paper board false ceiling, Thermo pole false ceiling. These techniques are durable if proper care is taken. These techniques can be used as a decorative finish as well. These solutions are more appropriate if the room height is adequate.

7. Improved Thermal Performance and Temperature

Data on temperature changes due to the use of the technologies was collected and analyzed which revealed that there is significant difference in terms of thermal performance due to reduced temperature after the application of these solutions. Following tables presents the temperatures in control and treated scenarios. Control is the condition of temperature before the application of the solutions (where insulation technologies were not applied) and treated is after the application of different solutions (where insulation technologies were applied). The first highlighted row is of control condition that presents the normal temperature of the house before the treatment of thermal performance.

Table: 4 Thermal Performances and Temperature

	Without Solution	**Temperature**
Control	Normal Temperature (Inside)	36.2
	Solution	
Treated	Stabilized mud	35.3
	Mud with thermo pole	33.6
	Brick tiles with stabilized mud	33.1
	Extruded Polystyrene (Jumbolon)	32.2
	Concrete wizard tiles	34.7
	Sachal CLC tiles	34.0
	Smart concrete tiles	33.7
	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 treatment of the roofs 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.

8. Cost Estimates

While examining the potential insulation techniques on experimental basis for improved thermal performance of the rooftops, per unit cost of the material have also been reckoned. Table: 4 unveil the initial costs of the material used in each insulation technique. All the presented solutions are effective for rooftops insulation to reduce the inner temperature of the buildings. These insulation technologies play pivotal role in making buildings energy efficient or energy smart. However, some of them have 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, type of building etc.

Table: 5 Cost Estimates of Different Solutions

Solution	Initial cost Rate/ Sft (PKR)
Stabilized mud	32
Mud with thermo pole	52
Brick tiles with stabilized 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

In present context, apparently least cost or most economical insulation technique is Paper board false ceiling which is Rs. 22 per square foot. It is economical due to its material that is relatively less expensive. Paints insulation is the most expensive solution (i.e. Rs. 80 per square foot) in above presented options for insulation to enhance the thermal performance. It is worthwhile to mention that the presented costs were estimated by UN-HABITAT in 2010 and certainly the estimates are not reflecting the present costs due to inflation and increased material costs. Due to technical information constraint the relative effectiveness of each technology could not ascertained. Though apparently most potential option is Paper board false ceiling because of its least cost and highest reduction in temperature but relative life of the technology is still unknown.

9. Benefits

Energy efficiency and conservation is unquestionably a crucial business for domestic as well as commercial consumers. And it is the unique attribute of energy smart buildings which lessen the burden of energy supply. Whether it is energy efficiency, conservation, or improved thermal performance in energy smart buildings, there are a number of direct and indirect benefits of such measures. Following are some of the direct and indirect benefits of energy smart buildings in terms of energy efficiency and conservation. The direct benefits of energy smart buildings include; the reduced energy consumption due to their innate potential for conservation, and reduced energy supply due to their saving potential which consequently helps in managing the energy demand. Beside this energy smart buildings save lot of money which are paid in terms of electricity bills in traditional buildings.

Beside aforementioned direct benefits there are some indirect benefits of the energy smart buildings as well. For instance energy smart buildings use to have less carbon footprint due to reduced energy consumption. Due to low carbon emissions, these have reduced pollution. Lastly energy smart buildings are environment friendly in terms of reduced pollution. Moreover, they are climate compatible in terms of reduced carbon footprint and reduced exposure to extreme heat.

10. Missing Link in National Housing Policy

National Housing Policy 2001 is the main housing policy document of government of Pakistan. This housing policy provides detailed and comprehensive strategies and guidelines on different aspect of various types of housing. However, this detailed document has not been revised since its formulation in 2001. Due to which the present issues are either neglected or could not receive ample attention of the policy makers. Specifically, there is no policy guidelines and recommendations on energy conservation and saving in newly constructed housing schemes.

Though ENERCON has produced some guiding material but Ministry of Housing and Works Pakistan has no such separate strategy for energy efficient housing. Nonetheless in present context of energy crisis in Pakistan, there should be greater emphasis on energy efficient housing and it must be reflected in the national housing policy of Pakistan. Present study will present the policy recommendations which can be the useful policy inputs to produce the guidelines for energy efficient housing.

11. Conclusion and Policy Implications

We may conclude the following from preceding research study on energy smart buildings. There are standard policy guidelines for energy efficient housing in Pakistan in the form of building energy code which can be adopted in construction of houses. Beside that UN-HABITAT has developed the guidelines in collaboration with Capital Development Authority and ENERCON to improve the thermal performance of already constructed houses. It includes a number of insulation technologies which have the potential to reduce inside temperature of the buildings by 2 to 4 C^0. Energy smart buildings are not only helpful in energy conservation but also yield monetary saving in terms of reduced electricity bills. Lastly energy smart buildings play important role in reducing the carbon footprint and subsequent problems of carbon emissions of energy consumption in buildings. Following are some of the policy implication spawning from present study;

- Since there are standard guidelines formulated by government on energy smart building, their implementation should be ensured. In this regard awareness can play vital role because there is lack information about such guidelines.

- Government should set the targets and prepare the plan of action for each year to unleash the potential of energy conservation in buildings.
- Media should be used to promote energy smart buildings as it can play a crucial role in sensitizing people about their responsibilities on energy conservation in buildings.
- Monetary reward of energy conservation in terms of reduced electricity bills should be demonstrated to attract people for conservation of energy.
- There should be some strict criteria of the monitoring of energy consumption in the domestic as well as commercial buildings to implement the guidelines on energy smart buildings.
- Energy smart 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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