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# Analysis of Green Technologies for Motorway Interchange

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***Abstract*—** Pakistan is in phase of increasing economic growth which is also giving people to raise their standard of living which is growing in building construction. This is further rising the demand of electricity which is a big challenge for Pakistan. The energy savings made at load sites are nowadays regarded as energy generation. Taking all this parameter into account, there is an urge for alternative way to minimize the energy consumption in order to overcome the electricity shortfall in Pakistan.

A detailed analysis has been conducted to lower the annual energy requirements of the test site. The optimization strategy mainly involves (i) energy audit, (ii) retrofitting technique .An important finding is that the payback period of all technique is less than seven years. The results indicate that when 3 inch polystyrene insulation is internally employed along with the energy efficient appliances, an electricity saving up to 22% with a payback period of 4.96 years can be achieved.

***Keywords*—** Green technologies, Retrofitting, Energy Efficiency, LEB.

## I. INTRODUCTION

Building is consuming one third of the total world of energy consumption [1] and the building construction is on rise and which is associated with energy consumption. Energy is basic need of life. Pakistan at the time of dependence only got 60 MW. At early Pakistan made some remarkable growth but it doesn't continue in positive manner [2] Energy sector of Pakistan is facing a severe shortfall form last decade. Rapid urbanization led to shortfall problems plus theft, loses and low energy mechanism took out major portion leaving shortfall up to 5000 MW during summer [3]. In 2009 the electricity shortage led to loss of 3.9 billion dollar which is 2.5% of Pakistan GDP [4].

Pakistan has great potential in field of renewable energy which can generate huge amount of energy.[5]. And also when we talk about on consumption side residential and commercial buildings use huge amount of energy

Due to crises of energy in Pakistan there is intense need to design new building in such a way that it consume less energy or the existing building should be retrofitted to such a design that it consumes less energy which can help to reduce the shortfall. Pakistan has neglected the green building topic which can lead to save huge amount of energy. Commercial and residential consumes a lot of power and has ability to save energy just by following basic steps like selecting right design of building and choosing right electrical appliances. Building design which can save energy can cost 15-20% extra in Pakistan[6]. Various estimate shows that by using energy efficient product can save 30% of energy consumption. Enercon estimated shows that by using efficient appliances can save in utility bills up to 50% while building design can save 15% of utility bills[6].

The difference between supply and demand of energy in Pakistan causes shortfall of electricity, this gap between demand and supply causes load shedding in urban and rural areas. The supply from generating station is 15,700MW while the requirement of energy is 20,223 MW per day, the country is facing approximately 5000 MW of energy per day[7]. Due to this gap of electricity in supply and demand, load shedding occurs for about 15 hours in rural areas, while 8-10 hour load shedding in urban areas, which is badly affecting all spheres of life [8]. To overcome load shedding there is intense need to increase the generation of energy, while on demand side the consumption should optimized. the demand of energy increases every year and hence the associated cost also increases, there is a need to minimize the existing energy consumption in an efficient way, so that the end consumer will fulfill their energy requirements at minimum price.

In this paper analysis has been done on motorway interchange of an existing building. Different type of insulation has been used while also energy efficient equipments are also been used

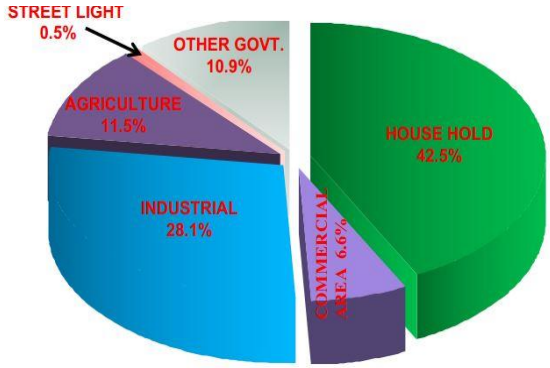



Figure 1. Consumption of electricity in various sectors of Pakistan [3]

## II. GREEN BUILDINGS

Green buildings are those buildings which consume less energy as compare to conventional buildings. It can be achieved by using certain passive techniques like selection of site for buildings, windows position, using of materials, green roofing, shading etc[9]. While net zero energy building are those buildings which can generate all of its energy on site by renewable resources with no or zero emission of carbon dioxide. Retrofitting is a technique used to convert a existing building into energy efficient one. Retrofitting is cost effective as compare to build a new one. The goal of retrofitting to lower down the energy requirement for space heating without affecting the human comfort [10].

## III. SYSTEM COMPONENTS

### A. *Insulation Material*

The use of insulation in the building can significantly minimize the consumption of energy. Initially the building was examined for two different types of insulation i.e. for Polystyrene and Polyurethane. Results were in favor of polystyrene. thermally insulated model consist different size and different arrangement that has applied on the walls. the different location i.e. insulation on the outer surface of wall termed as external insulation, insulation on the inner wall known as internal insulation and combination on both external and internal known as mixed insulation.

### B. *Energy Efficient Appliances*

By incorporating the energy efficient appliances, the energy consumption can be definitely low down as compared to the conventional appliances, so in this model the energy efficient appliances were considered and reduction in the energy consumption was noticed.

In this model the tube lights are to be replaced with energy saver bulbs or LED, conventional AC with inverter type etc.

### C. *Combination of Insulation Material And Energy Efficient Appliances*

In this technique as the name suggests combination of insulation that is Polystyrene and energy efficient appliances was proposed. A significant reduction in consumption of electricity was observed.

## IV. SYSTEM CONFIGURATIONS

The residential building was analyzed for different energy efficient strategies in the form of different scenarios. All these scenarios are discussed below.

### A. *Scenario-I Insulation Using Polystyrene*

When pentane is added to Polystyrene grains and evaporated from which white, rigid and closed-cell foam is formed having thermal conductivity from 0.031 to 0.037 W/ mK, .In this model polystyrene is used against the 8 inch brick having 0.25 inch mortar on both sides. Insulation is used for wall and roofs.

- Cement mortar 0.25 inch
- Common brick
- Polystyrene 3 inch
- Cement mortar 0.25 inch

### B. *Using Energy Efficient Appliances*

The appliances which are for conventional use consumed considerable amount of energy so for reducing consumption of electricity, energy efficient appliances are used in this model. For instance tube light which has consumption of 60 watt can be replaced by energy saver light which has consumption of only 25 watt. Likewise desktop computer replaced by laptop. And air conditioner is replaced by dc invertors air conditioner.

### C. *Scenario-III Insulation using 1-inch Internal Polystyrene with EEA*

In this scenario insulation of Polystyrene of 1inch applied on wall and roof internally and also energy efficient appliances is used. The construction material is given as

- Cement mortar 0.25 inch
- Common Brick
- Polystyrene 1 inch
- Cement mortar 0.25 inch

### D. *Scenario-IV Insulation using 1.5 inch internal polystyrene with EEA*

In this scenario Polystyrene of one and half inch is applied on the roof and walls internally and energy efficient appliances is also used. The construction material is given below.

- Cement mortar 0.25 inch
- Common brick
- Polystyrene 1.50 inch
- Cement mortar 0.25 inch

### E. *Scenario-V Insulation using 3 inch internal polystyrene with EEA*

In this scenario Polystyrene of 3 inch is used internally on the walls and roofs. And also energy efficient appliances are considered. The construction material for this case is given below.

- Cement mortar 0.25 inch
- Common brick
- Polystyrene 3 inch
- Cement mortar 0.25 inch

*F. Scenario-VI Insulation using 3 inch polystyrene external with EEA*

In this scenario insulation of three-inch Polystyrene is used externally on the walls and roofs with the use of energy efficient appliances. The construction materials are given below.

- Cement mortar 0.25 inch
- Polystyrene 3 inch
- Common brick
- Cement mortar0.25

*G. Scenario-VII Mixed Insulation with EEA*

When insulation is used on both side internally and externally known as mixed insulation. In this scenario insulation of polystyrene is applied internally and externally and also energy efficient appliances are considered. The construction materials are given as.

- Cement mortar 0.25 inch
- Polystyrene 0.25 inch
- Common brick
- Polystyrene 0.25 inch
- Cement mortar

## V. RESULTS

Results are discussed briefly in this section which is obtained as analysis and simulation were done for different cases. Which are given below.

*A. Scenario-I Insulation using Polystyrene*

When Polystyrene is applied on roof and walls the total energy consumption is reduced from 68,801 kWh to 59878 kWh. The comparison graph between baseline and insulation of Polystyrene is given below.

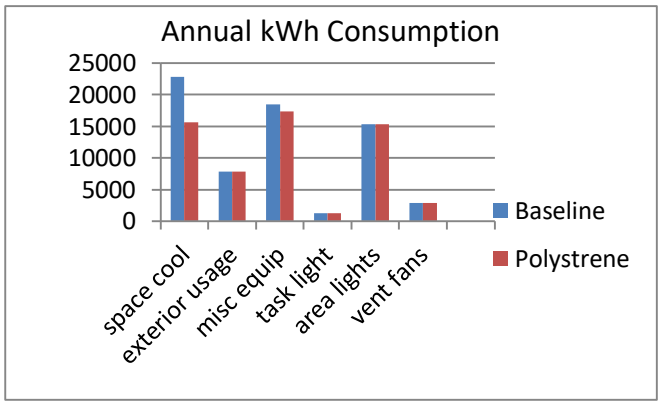



Figure 2. Comparison between Baseline and Scenario-I

*B. Using Energy Efficient Appliances(EEA)*

When conventional appliances is replaced by energy efficient appliances. The consumption of total energy is reduced to 57774 kWh per annum. Which is 17% of the total energy .the graph is given below.

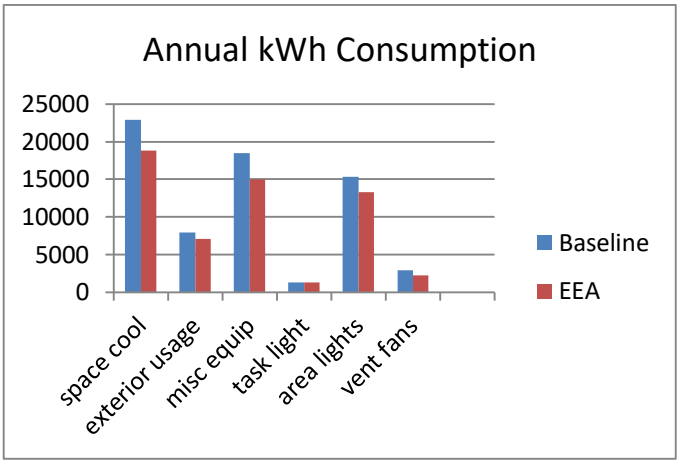



Figure 3. Comparison between Baseline and Scenario-II

*C. Scenario-III Insulation using 1-inch internal Polystyrene with EEA*

When 1 inch Polystyrene is used internally the total load in this case is lower down to 56,078 when insulation of Polystyrene is used in thickness of 1inch almost 19% of the saving. In this case mixture of insulation is used with energy efficient loads so the saving in loads will occur.

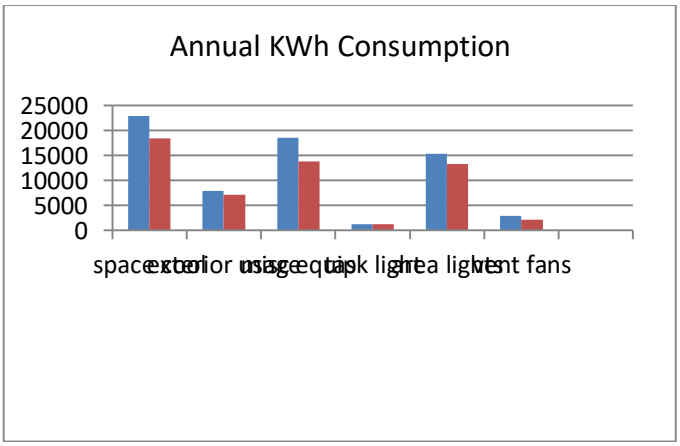



Figure 2. Comparison between Baseline and Scenario-III

*D. Scenario-IV Insulation using 1.5 inch internal Polystyrene with EEA*

When the diameter of insulation is increased from 1 to 1.5 inch of Polystyrene. Which show that consuming energy becomes lower in every sector. The total saving in kWh is given 13215 kWh of the unit almost 20% of the total.

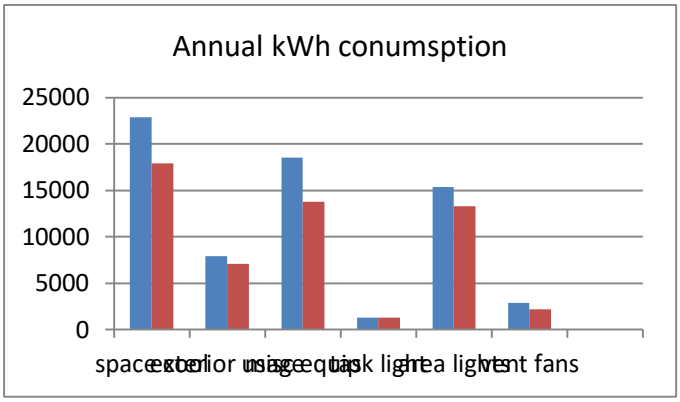



Figure 5. Comparison between Baseline and Scenario-IV

### *E. Scenario-V Insulation using 3 inch internal polystyrene with EEA*

In this case insulation of Polystyrene is increased from 1.5 to 3 inch along with energy efficient appliances. The total saving in this case is 15389 kWh per annum which is almost 23% of the total.

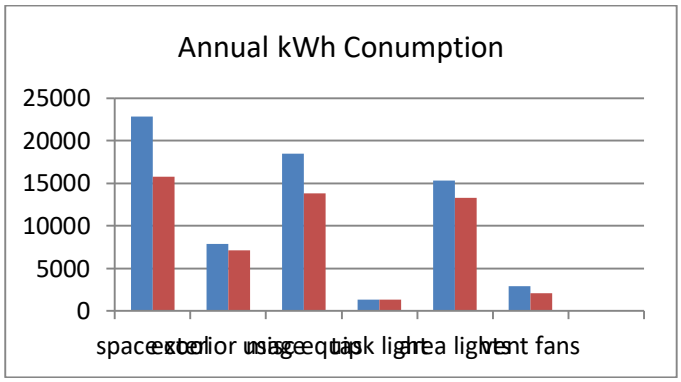



Figure 6. Comparison between Baseline and Scenario-V

### *F. Scenario-VI Insulation using 3 inch Polystyrene external with EEA*

When 3 inch Polystyrene is taken externally along with energy efficient appliances the result shows that it lower down space cooling from22877 kWh to 14304 kWh per year. The total saving in this case is 17115kWh per annum which is almost 25% of the total power.

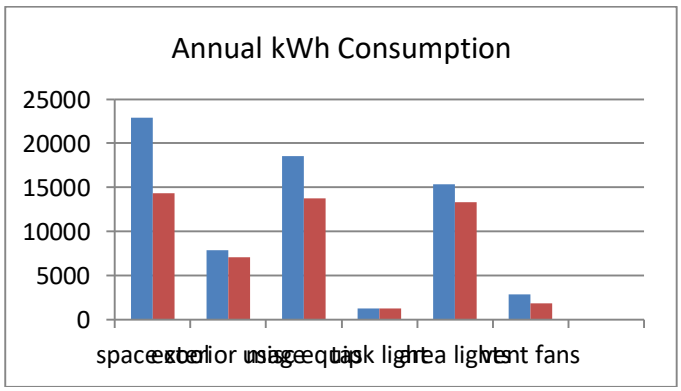



Figure 7. Comparison between Baseline and Scenario-VI

### *G. Scenario-VII Mixed Insulation with EEA*

When insulation of Polystyrene is used internally and externally with energy efficient appliances space cooling loads is lower down to 22877 to 11384kWh unit. The total saving in this case is 20573 which are almost 30% of the saving in a year.

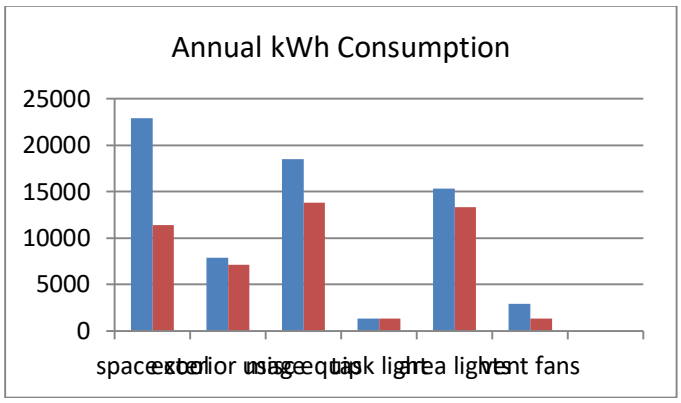
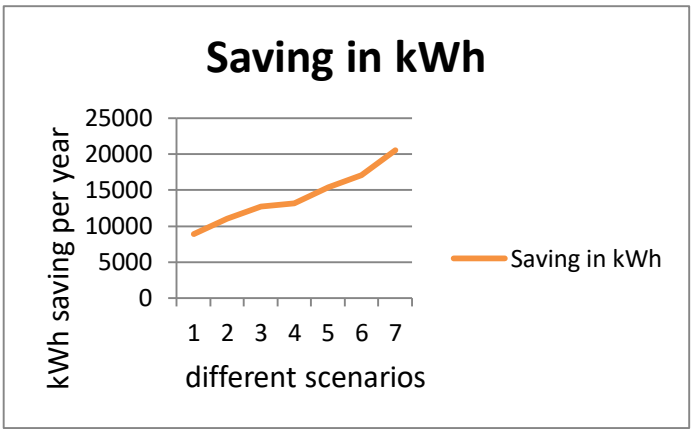



Figure 8. Comparison between Baseline and Scenario-VII

## VI. COMPARISON

The comparative graphs of all scenarios are given below by line graph. The vertical showing per year kWh saving while in horizontal different scenarios is given.




## CONCLUSION

Pakistan is facing energy crises like other developing countries. Pakistan has strong growth of economy and demand of energy is rising but despite of this Pakistan has not given full attention to install new capacity for generation. So Pakistan is facing shortfall from past decade. To tackle this problem on distribution site people awareness is required to build such type of building which uses less amount of energy as compared to conventional building numerous potential is available in this regard. The strategies described in the above section are analyzed individually on the basis on insulation of polystyrene and also with energy efficient appliances and it is also analyzed mixture of both to lower down the use of electricity consumption with baseline model. The result shows that the insulation model taken lower down the kWh consumption to some extent but energy efficient equipments help to save kWh units in greater amount as the equipments used in building are not energy

efficient. The economical and easy way to lower down electricity consumption are the use of energy efficient appliances. And the payback will not be more than five years in this case and also lower down electricity consumption by 20-30% of kWh units.

In this research motorway interchanges has been taken and different technique has been applied to show how much energy can be saved. As there exists a lot of interchanges and new motorway are underway and will be completed. If we follow the way mentioned can save a lot of energy. The best technique is insulation of 3 inch polystyrene with energy efficient appliances as the pay back is period is 4.96 years. while other scenario Polystyrene external and mixed insulation with energy efficient appliances is not only costly but payback period of those model are above five years. And the second most important thing is that the appliances we are using are not as efficient. Switching to energy efficient appliances can have huge impact in our daily life in saving of energy.

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