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Energy savings comparison of two energy saving options

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***Abstract* —The energy consumption in building has sky rocketed during the past decade due to dramatic rise in population, improved standard of living, major time spent indoor and comfort necessities. The primary area of energy consumption in buildings is HVAC system approximately consumes 35-55 % of total building energy. In this paper energy saving prospective of VRF system and building insulation is investigated and paralleled. For this determination, a model office building situated in Jamshoro, Sindh, Pakistan is modelled and simulated in EnergyPlus software. The simulated results have shown that without applying insulation material zone temperature can reach up to 48 ^{O}C. The building was simulated with insulation material on interior and exterior surface of the wall separately to analyze its impact on interior temperature and zone cooling load. The results showed that applying insulation material on the outside surface of the wall is more effective. By using insulation material on the external wall the zone temperature and cooling load will reduce significantly. By installing VRF type air conditioner in place of conventional air conditioners we can save 40-45 % electricity. The most efficient system with a saving potential of about 66-69 % was polyurethane insulated building with VRF type air conditioner.**

***Index Terms* — Insulation, VRF.**

I. INTRODUCTION

Energy conservation is a progressively important subject for the residential segment. With the recent drive towards net zero energy buildings, numerous technologies are encouraged with emphasis on their superior energy efficiency. Energy consumption in buildings is increasing day by day due to rapid increase in population and urbanization. Almost 40 % of the total global energy is consumed in buildings and around 35% of this total energy is consumed by HVAC systems. Now a days HVAC system is an integral part of the building due to increase in comfort necessities. Energy Saving has become an important issue for domestic and commercial sector. Currently, many technologies with advanced energy performance are promoted to achieve net zero energy consumption in buildings. Now days one of the effective and smooth way of energy saving is through building insulation and VRF system. It is broadly used in residential, commercial and industrial sector. The variable refrigerant flow (VRF) and Insulated System are probably the supreme competitive technologies among all other technologies. Timeworn HVAC system use constant speed drive motor which runs on full load during operation and consumes maximum power during operation furthermore their controlling operation is also inefficient because it turns off the motor when desired temperature is achieved and turns on the motor when the temperature rises above the set point. This frequent on and off operation is more power consuming as the starting torque of motor is huge. Hence a novel technology was introduced which operates on variable speed drive which adjusts the rpm of the compressor as the temperature of the building approaches the set point temperature. According to numerous studies it has been proven that this system is effective in energy saving. Building insulation is also one of the method of conserving energy in the building it helps to maintain a desired temperature inside building around the year and also protects the building from excess heating during summer A well-insulated building is energy efficient and will require very less additional energy for cooling and heating. One of the significant approaches for improving energy efficiency of buildings and comprehending energy saving and emission reduction in the buildings is the energy-saving makeover of current residential buildings. Kumar D. [1] Introduced the concept of embodied energy, embodied carbon and summer overheating prospective for selecting optimal insulation material. A novel optimization structure is also proposed in this study which included four optimization criteria i.e. (comfort , functioning energy and carbon, embodied energy and carbon and life cycle cost). Almahdi Abdo-Allah [2] For comparing the consumption of hot water and electricity provided estimates with the measured data for a full year. Fabrizio Ascione [3] To discourse the energy design of building envelop suggested a multi-objective optimization approach. Implemented a generic algorithm to reduce primary energy utilization, global cost and hours of discomfort. Xi Chen [4] Proposed holistic scheme optimization approach for skyscraper office buildings with incorporated photovoltaic (PV) façade for exploring the influence of archetypes and confounding factors. Abdul-Rehman Al Qawasmi [5] Used wireless sensing and actuator network for inspecting the energy use and economic impressions of air-conditioners Proposed a novel numerical thermal model and tested it on α stirling engine. Yunyi Sun [6] Provided a comprehensive review of TIM for saving energy in buildings. Lin Duanmu et al [7] Used Hourly Cooling Load Factor Method (HCLFM) that can provide fast and fair estimate of building cooling load for a large-scale urban energy planning. Roba Saab [8] Investigated under various conditions

the performance of Variable Refrigerant Flow (VRF) system also Carried out parametric analysis on the VRF cycle model.

In this art work, a comparative thermal load estimation and energy evaluation of VRF system and insulated system is carried out. The 3-D drawing of the building is constructed in EnergyPlus software according to the accommodation, followed by estimation of thermal loads. The simulation results will show that which system is more energy efficient either VRF or thermal insulated system under lower cooling load. The findings offer insight of VRF system and insulated system to determine energy performance which could help to achieve low or zero net energy buildings.

Overall, we will analyze the VRF system Energy-Saving capabilities contingent on system outline, interior and external situations, when associated to the thermal insulated scheme.

II. METHODLOGY

In this paper a model office building is modelled in SketchUp software then the model is imported into energy plus software to simulated the model building. The model is simulated with and without applying insulation materials to analyze the effect of insulation on the cooling load and electricity consumption. The model is also simulated with conventional air conditioner and VRF type air conditioner to compare the energy saving potential of VRF type air conditioner with the various types of building insulation materials.

III. RESULTS AND DISCUSSION

In this section the results obtained from the simulation of the model building for peak zone temperature, peak cooling load, effect of applying insulation on exterior, interior and inside the cavity of the wall and electricity consumption by conventional and VRF type air conditioner are elucidated in detail. Table I shows the peak zone temperature with and without applying insulation material. Without applying insulation, the peak zone temperature can exceed 46 ^{O}C while using insulation material peak zone temperatures can be significantly decreased. The insulation material is applied on outside and inside surface of walls to analyze their effect separately it was shown in the results that applying insulation on the outside wall is more effective as it resulted in lower zone temperature as compared to insulation applied on the inside walls.

TABLE I: Peak Zone Temperature

Insulation Material	No Insulation	Cellulose	Expanded Polystyrene	Extruded Polystyrene	Polyurethane
Peak Zone temperature (^{O}C)	48.6	36.4	35.8	35.7	34.8

Table II shows the peak cooling load with and without applying insulation material. Without applying insulation, the peak zone cooling load 8523 W. The use of insulation on the external surface of the model building reduces the amount of solar radiation entering the inside of the zone hence reducing the peak cooling load of the zone. The polyurethane insulation proved as the most effective insulation material as it reduced the cooling load by about 72.9 %.

TABLE II: Peak Cooling load

Insulation Material	No Insulation	Cellulose	Expanded Polystyrene	Extruded Polystyrene	Polyurethane
Peak Cooling Load (W)	8523	2800	2611	2590	2310

Figure 1 shows the impact of applying insulation on outside inside and between the walls of the zone on the overheating hours. It shows that for cooler internal temperature the application of insulation on the external walls is better as compared to middle and insulated walls but for warmer internal temperature application of insulation on the interior walls will yield better results.

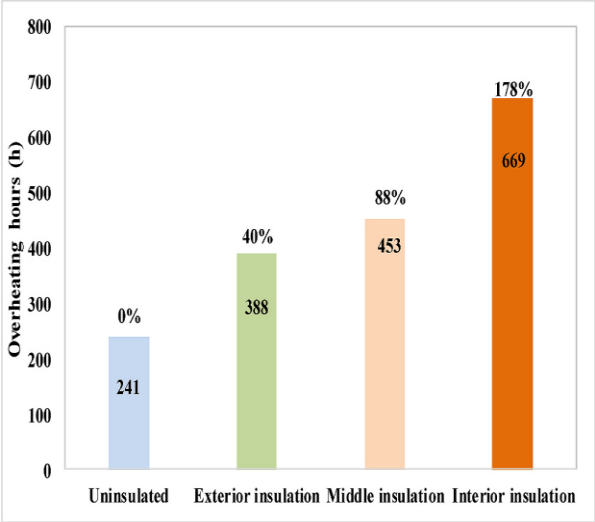

Fig. 1. Effect of applying insulation on overheating hours

Figure 2 shows the electrical energy consumed by the model building using conventional air conditioner without applying insulation and with applying different insulation material. It is clear from the results that applying insulation on the external walls can reduce the energy consumption almost by half. Uninsulated zone will consume 18366.86 KWh of energy annually while the polyurethane insulated zone will consume about 8350.02 KWh of energy annually saving about 54.54 % of energy.

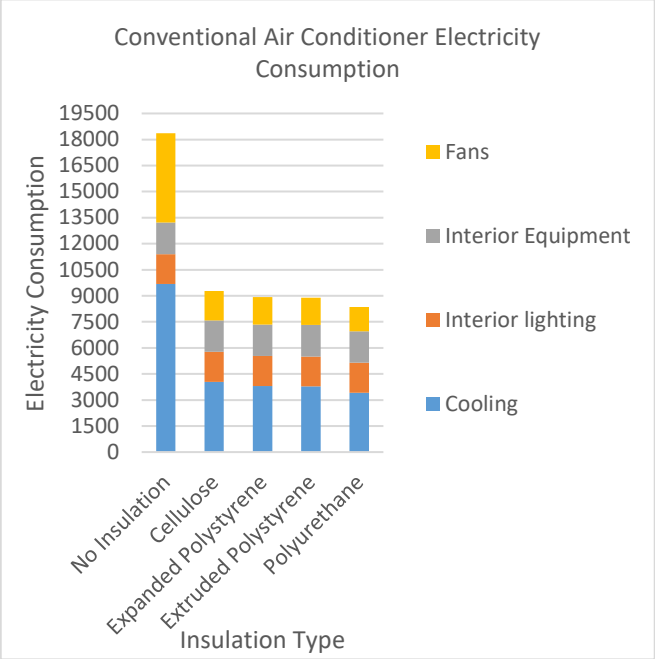

Fig. 2. Conventional air conditioner energy consumption with and without insulation

Figure 3 shows the electrical energy consumed by the model building using VRF type air conditioner without applying insulation and with applying different insulation material. It is clear from the results that applying insulation on the external walls can reduce the energy consumption almost by half. Uninsulated zone will consume 10353.92 KWh of energy annually while the polyurethane insulated zone will consume about 5718.81 KWh of energy annually saving about 44.76 % of energy.

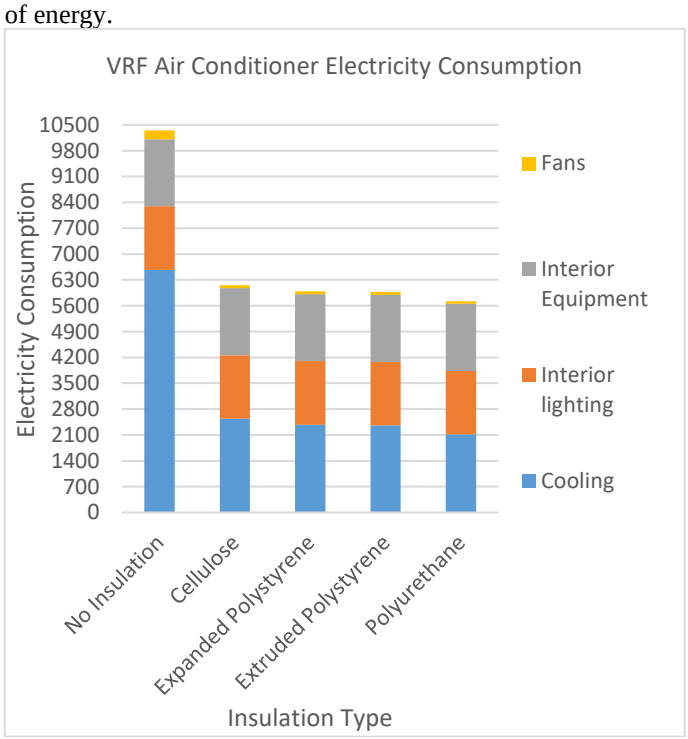

Fig. 3. VRF air conditioner energy consumption with and without insulation

IV. Conclusion

The main objective of this paper was to investigate the influence of replacing the conventional air conditioner with the efficient VRF type air conditioners and applying insulation on the electricity consumption of the model building situated in Jamshoro, Sindh, Pakistan. The simulated results showed that without applying insulation material zone temperature can reach up to 48 ^{O}C. By using insulation material on the external wall the zone temperature and cooling load will reduce significantly. By installing VRF type air conditioner in place of conventional air conditioners we can save 40-45 % electricity. According to simulated results the use of polyurethane insulation material is the best option as it has the highest saving potential as compared to other insulation material suited for cooler internal temperature.

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