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Innovative solutions for sustainable space heating: Integrating solar air heaters and low-cost retrofitting windows for hilly region of Kashmir

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ABSTRACT

The Kashmir valley experiences a moderate climate, characterized by cool springs and autumns, mild summers, and cold winters, necessitating heating for approximately 5–6 months annually. Due to unreliable power supply, traditional heating methods such as gas heaters, wood fires, or Kangri's are often relied upon, despite their adverse health and environmental impacts due to emissions of toxic gases. Therefore, there is a need of transition towards non-conventional energy sources. Solar air heaters emerge as a viable option, converting solar radiation into thermal heat which is then delivered to living or working spaces. In addition to minimizing energy requirements for space heating, strategies to reduce heat loss can further enhance energy efficiency. Developing low-cost retrofit window solutions to improve the thermal efficiency of existing windows proves instrumental in this regard. Retrofit windows, designed to fit into existing frames, improve insulation and reduce energy loss without requiring costly renovations. The primary aim of these retrofit windows is to optimize energy efficiency affordably, minimizing heat transfer and preventing air leaks, thereby reducing energy consumption and utility bills while enhancing indoor comfort by maintaining stable temperatures. The several tests were conducted on a thermally insulated test room of size 12×8*10 cubic feet room for solar air heaters under various atmospheric conditions gives a temperature increases of up to 10 °C within one hour under different parameters. Furthermore, retrofitting demonstrated a 45.69 % reduction in energy requirements at a very affordable cost.

1. Introduction

The formidable Karakoram Range to the north, the Pir-Panjal Range to the south and west, and the Zanskar Range to the east, all contribute to the valley's temperate climate. The valley typically has warm summers, chilly winters, and cool springs and autumns [1]. Owing to differences in altitude across its districts, the climate in mountainous regions is often colder than in lower flatlands. Generally speaking, summers are pleasant, dry, and have high humidity along with cold evenings. There are no very dry months and there is precipitation all year round. With a mean lowest temperature of 16 °C and a mean high temperature of 32 °C, July is the warmest month, while December through January are the coldest (mean minimum temperature of −15 °C and mean maximum temperature of 0 °C) [2]. The weather in the Kashmir Valley is erratic despite its temperate environment. The highest temperature ever recorded was 37.8 °C, while the lowest temperature ever recorded was −18 °C. After a period of little snowfall, a strong winter storm swept over the valley in January 2012, leaving it covered in several feet of snow and ice [3]. In Short Kashmir have the cold weather which prevails for almost 5,6 months. The average monthly minimum and maximum temperature along with precipitation of Jammu &Kashmir are shown in Fig. 1 [4]. If talking about the northern regions of India, these areas are prone to heavy snowfall and sub-zero temperatures in winters.

Night temperatures are below freezing point and there remains almost winters throughout the year. Therefore, for survival in these regions, there is a convenient use of heating appliances such as gas heaters, blowers, underfloor heating like (Hamam), wood burning fireplace, electric blankets. The need to use a lot of heating appliances, on regular basis to keep surrounding warm and prevent these cold conditions and thus use of conventional sources of energy is not really that much possible to prevent the people from harsh winter conditions in Kashmir [5]. Therefore, the people use Gas Bukhari or Fired woods or Kangri to warm but these methods not suitable for health & environment because They produce large amount of Poisons gas which affects health & environment. So, it's necessary that we turn towards the

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