
INTEGRATED CIVIL AND ELECTRICAL ENGINEERING STRATEGIES FOR ENERGY-EFFICIENT RESIDENTIAL BUILDINGS IN COLD/MIXED CLIMATES: A CASE STUDY OF SRINAGAR, INDIA**Misba Gul¹ and Sami Jan Lolu^{2*}**¹Assistant Professor, Department of Civil Engineering, Islamic University of Science and Technology, Awantipora, 192122, J&K, India²Assistant Professor, Department of Electrical Engineering, Islamic University of Science and Technology, Awantipora, 192122, J&K, India²sammymanzoor@gmail.com**ABSTRACT**

Buildings contribute nearly 40% of global energy use and associated greenhouse-gas emissions, making energy-efficient design a critical priority. Traditional approaches to improving building performance often address either the civil/architectural envelope or the electrical/services systems in isolation, leading to sub-optimal results. This study proposes an integrated civil–electrical engineering framework for residential building design, combining passive envelope enhancements with active system optimization. Using Srinagar, Jammu & Kashmir—a cold/mixed climate region of India—as the case context, a simulation-based methodology was developed to evaluate four design scenarios: (A) baseline, (B) civil improvements only, (C) electrical/services improvements only, and (D) integrated civil + electrical improvements. Dynamic energy simulations using EnergyPlus v9.6 quantified annual energy use, peak demand, heating/cooling loads, renewable contribution, and thermal comfort. Results show that envelope improvements alone reduce annual energy use by 30.8%, while electrical upgrades achieve 37.8% savings. The integrated design yields a 55.7% reduction in total energy consumption, a 39% reduction in peak demand, and a 75% improvement in thermal comfort relative to baseline conditions, with a simple payback period of approximately five years. These findings highlight strong synergies between passive and active design strategies and underscore the need for early-stage interdisciplinary collaboration. The proposed framework offers practical insights for sustainable residential design in cold-climate regions and contributes to advancing integrated building energy-performance practices.

Keywords: *Integrated building design, Energy-efficient buildings, Passive and active strategies. Building envelope, HVAC systems*

1. INTRODUCTION

Buildings currently constitute one of the largest contributors to global energy consumption and greenhouse-gas emissions. According to recent estimates, the construction and operation of buildings account for roughly 30 %–40 % of global energy use. As societies increasingly strive to meet climate-change mitigation targets and reduce operational costs, the adoption of energy-efficient building design has become a critical endeavour. Traditional approaches to improving building energy-performance have often focussed on either the structural or architectural envelope side (for example, improving insulation, glazing, orientation, thermal mass) or on the services side (such as HVAC systems, lighting controls, renewable-energy integration). For instance, civil-engineering oriented studies emphasise the role of the building envelope in reducing energy use through passive strategies. On the electrical/ services side, smart control-systems, sensors, automation, and integration of renewables are gaining prominence. However, despite these advances, there remains a gap in truly integrated, multidisciplinary design where civil (structural/architectural) engineering and electrical engineering are co-designed from the early phases of building planning. In many projects, the envelope and passive design are optimised without full consideration of how electrical and control systems will respond to the resulting load profiles or, conversely, the services systems are selected without sufficient adaptation to the passive design. Such siloed approaches can lead to sub-optimal outcomes: even a highly insulated building may still consume significant energy if the lighting, HVAC