THERMOELECTRIC GENERATORS (TEGS) FOR BUILDING HEAT RECOVERY

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1. Introduction

Thermoelectric generators (TEGs) convert thermal energy into electrical energy by exploiting temperature differences across their surfaces [1]. In buildings, heat from boilers, radiators, or domestic hot water networks can be captured and partially transformed into electricity [2]. Although TEGs typically exhibit low conversion efficiencies (5–8%), their silent operation, lack of moving parts, and compatibility with small-scale applications make them attractive for building energy systems [3]. Performance can be notably improved by optimising temperature gradients and using advanced materials [4]. When combined with ORC systems or absorption chillers, TEGs can further contribute to energy autonomy and decreased grid dependence [2,4].

2. Scopus

This study aims to analyse the potential of TEGs for harnessing waste heat in buildings and to evaluate their energy and environmental benefits using real applications and documented case studies. Fig.1 illustrates the application of thermoelectric generators (TEGs) in buildings. Heat from boilers, radiators, and domestic hot water flows into TEG modules, which convert a portion of the thermal energy into electricity. The generated power is supplied to small loads such as lighting and pumps. Key performance metrics, including efficiency (5–8%) and electrical output (15–25 kW per module), are highlighted, along with improvements due to higher temperature differences (ΔT 50°C → 6%, ΔT 70°C → 8%) and integration with ORC systems (3–5% additional electricity, 10% HVAC load reduction). Arrows indicate energy flow, and labels clarify each component for clarity.

3. Methodology

The study combined experimental measurements, simulations, and case study analysis. TEG modules were monitored on boilers and ventilation ducts, recording temperature, voltage, and current under different temperature gradients [2,4]. Thermal simulations modeled heat transfer and predicted efficiency, while HVAC integration and airflow optimization were assessed to estimate energy savings. Real-world case studies validated the results and allowed calculation of CO_2 emission reductions from electricity generated via waste heat [1,2].

4. Results

In a 5,000 m² office building, TEGs installed on a natural gas boiler generated 15–25 kW of electrical power per module, covering up to 2% of the building's electricity demand [3]. Increasing the temperature difference from 50°C to 70°C boosted efficiency from 6% to 8% (Rowe, 2012). Combining TEGs with an ORC system in an industrial facility raised total electricity production by 3–5% and reduced HVAC thermal load by 10% [2]. TEG integration in ventilation networks reduced energy consumption by 10–15% while providing small-scale power for lighting or pump operation [4]. System performance improved significantly when cold-side heat dissipation and airflow conditions were optimized [3].

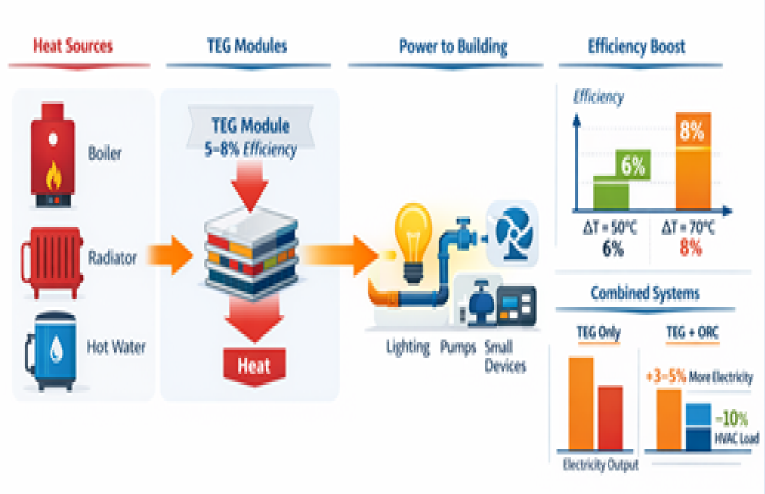

Fig. 1. TEG Applications in Buildings.

5. Conclusions

TEGs represent a promising technology for small-scale cogeneration and waste heat utilisation in buildings. When used in synergy with other recovery technologies, they contribute to enhanced energy efficiency, lower HVAC loads, and measurable reductions in CO_2 emissions.

References:

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