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Design and Development of a Hybrid Low-Emissivity and Thermoelectric Window Glazing Systems: A Systematic Review

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INTRODUCTION & AIM

Window glazing plays a critical role in modern building design by enabling natural daylighting and visual connectivity. However, conventional glazing systems represent one of the weakest thermal components in buildings, contributing to: High thermal transmittance Excessive solar heat gain in warm climates Significant conductive heat loss in cold environments These inefficiencies increase dependency on HVAC systems and reduce overall energy performance.

Aim of the Study:
To design and develop a **hybrid window glazing system** integrating:
Low-Emissivity (Low-E) coatings
Thermoelectric Generators (TEGs)
To simultaneously:
Reduce heat transfer
Generate electrical energy from temperature gradients

METHOD

- The proposed system consists of a double-glazed window integrated with:
- Low-E Coating:
  Reflects infrared radiation
  Minimizes thermal transmittance
- Thermoelectric Generators (TEGs):
  Embedded within the glazing structure
  Utilize temperature differences between indoor and outdoor environments
- Approach:
- System design and modeling
- Prototype fabrication
- Experimental validation under:
  - Solar radiation
  - Ambient environmental conditions

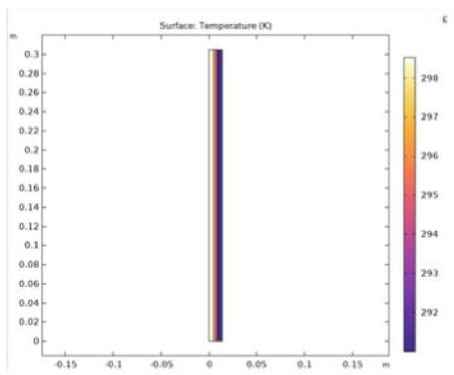
RESULTS & DISCUSSION

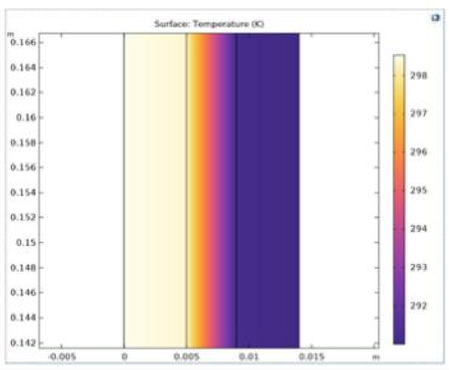
Experimental evaluation demonstrates:

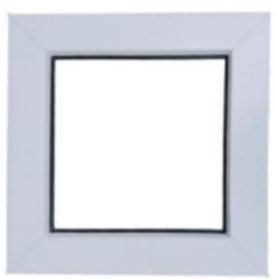
Thermal Performance:
~30% reduction in heat loss compared to conventional double glazing

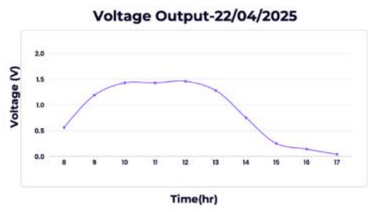
Energy Generation:
Peak power output: **2 W/m²**
Continuous low-grade energy harvesting capability

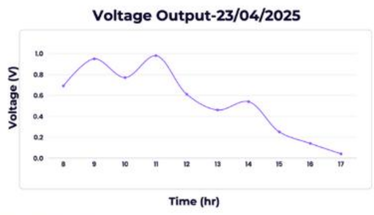
System Behavior:
Transition from passive insulation → **active energy-generating system**
Improved indoor thermal comfort
Reduced HVAC dependency
The integration shows strong potential for **energy-efficient building envelopes**.

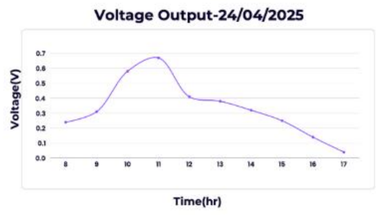


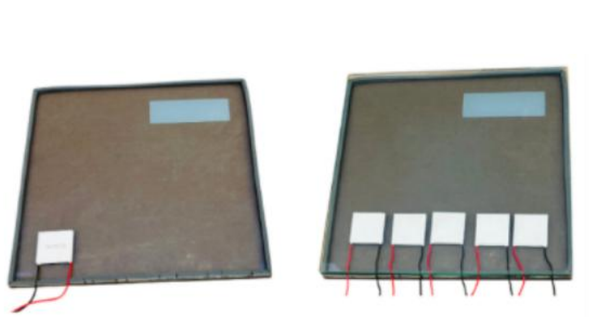


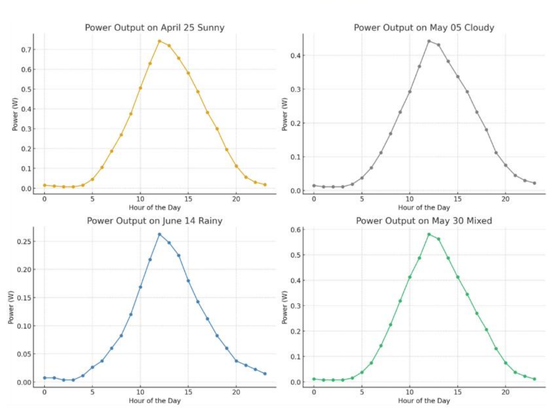












CONCLUSIONS

- The hybrid Low-E + TEG glazing system provides a **dual-functional solution**: Thermal insulation
- Micro-scale energy generation
- Enhances: Building energy efficiency
- Sustainability in architectural design
- Demonstrates feasibility for **next-generation smart windows**

FUTURE WORK/ REFERENCES/ACKNOWLEDGMENT

- **Future Work:**
  - Optimization of TEG placement and efficiency
  - Integration with smart building systems
- **Applications:**
  - Green buildings
  - Net-zero energy structures
  - Solar-integrated systems (e.g., solar ponds)

Keywords: Glazing Technology, Low-Emissivity (Low-E), Thermoelectric Generators (TEG)