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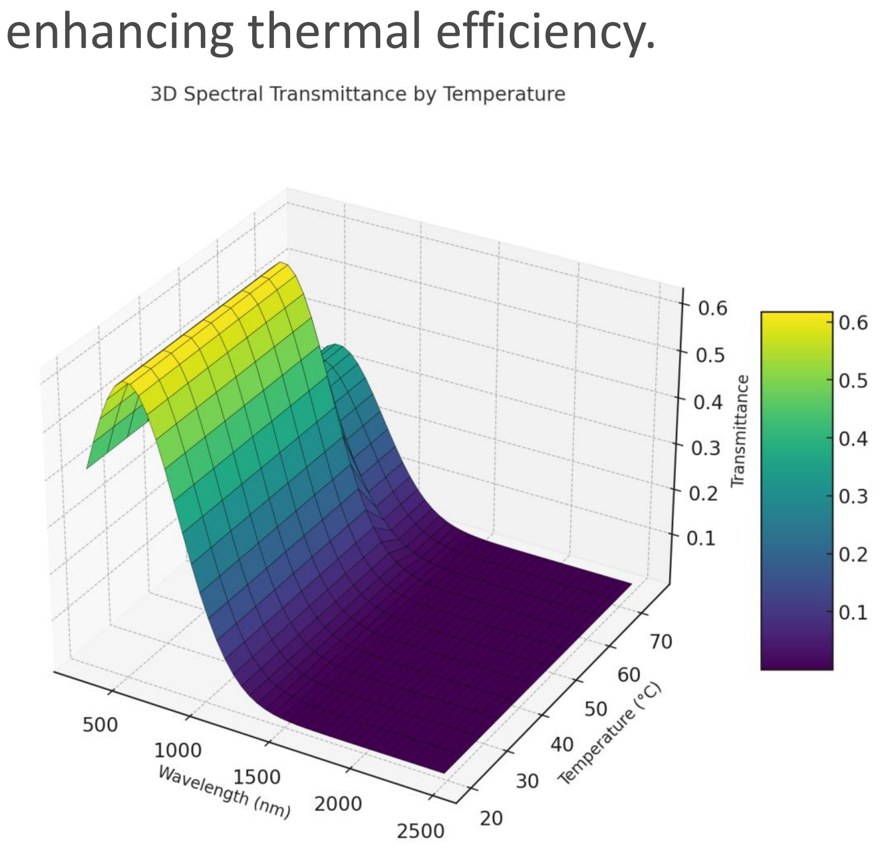
GLASS COATINGS AND OPTICAL INTERFACES: IMPROVING ENERGY EFFICIENCY AND DAYLIGHT IN ARCHITECTURAL STRUCTURES

Kachana Kasulu1, Anna Viktorovna Solovieva1

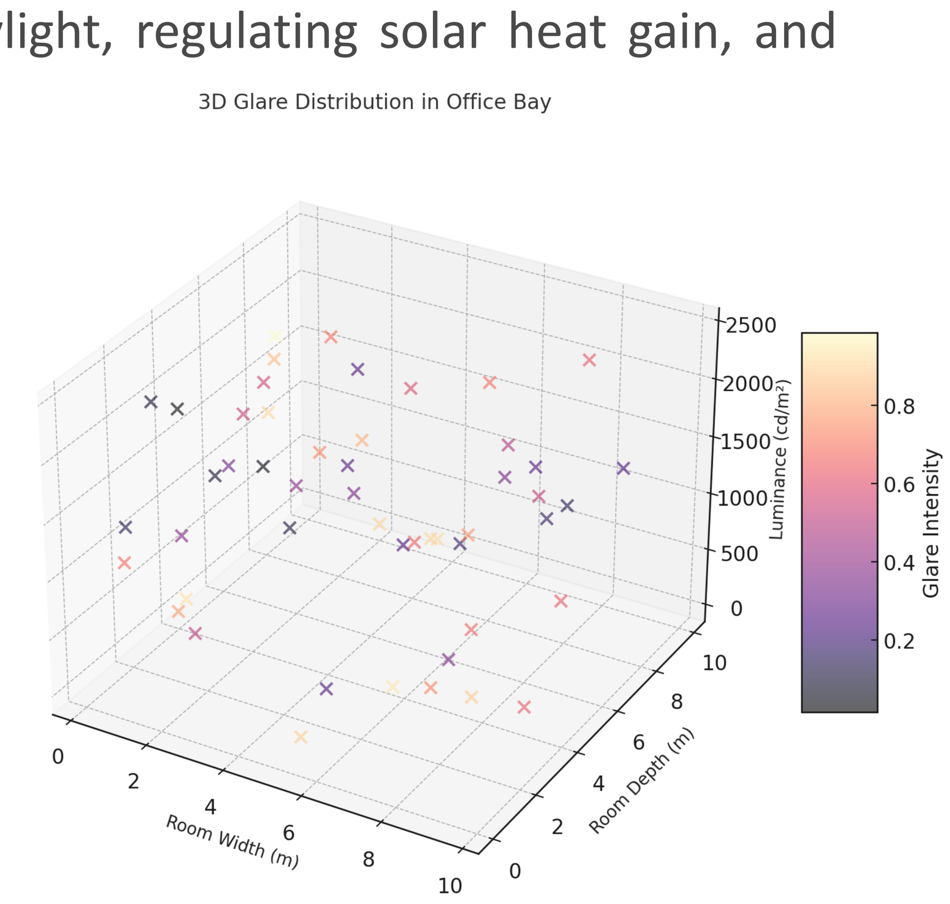
1People's Friendship University Of Russia

INTRODUCTION & AIM

Contemporary architectural approaches prioritise energy-efficient designs that focus on occupant comfort and sustainability. Glass facades and windows are integral to these efforts, providing ample natural light and maintaining visual coherence. However, uncontrolled solar radiation, glare, and poor insulation can undermine a building's thermal comfort and increase energy use. Recent advancements in thin-film coatings for architectural glass present innovative solutions for optimising daylight, regulating solar heat gain, and enhancing thermal efficiency.



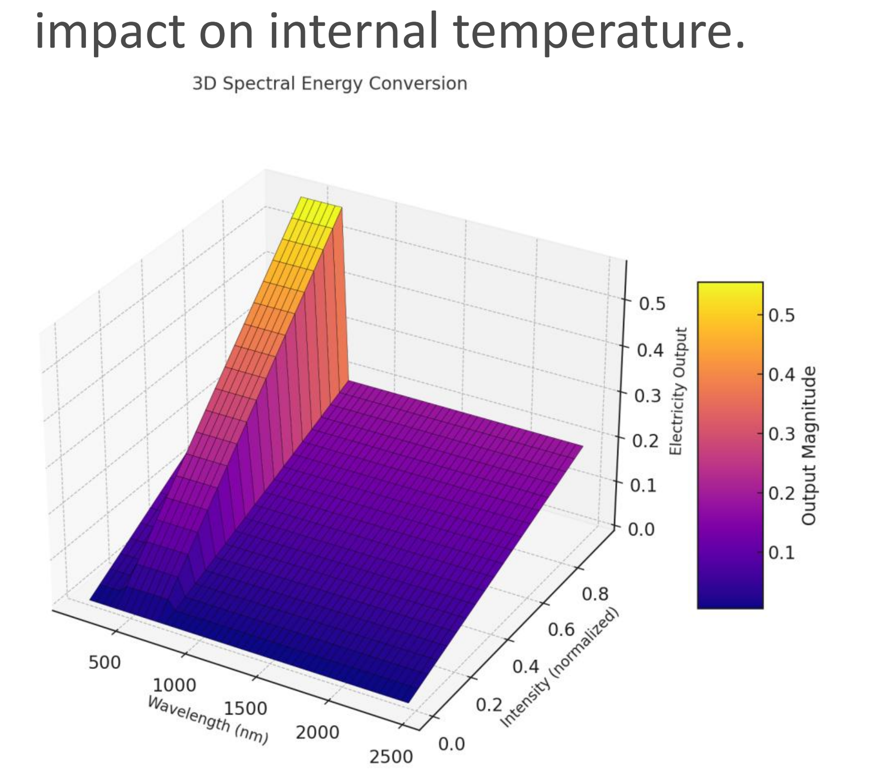
3D surface plot of spectral transmittance across wavelengths and temperature



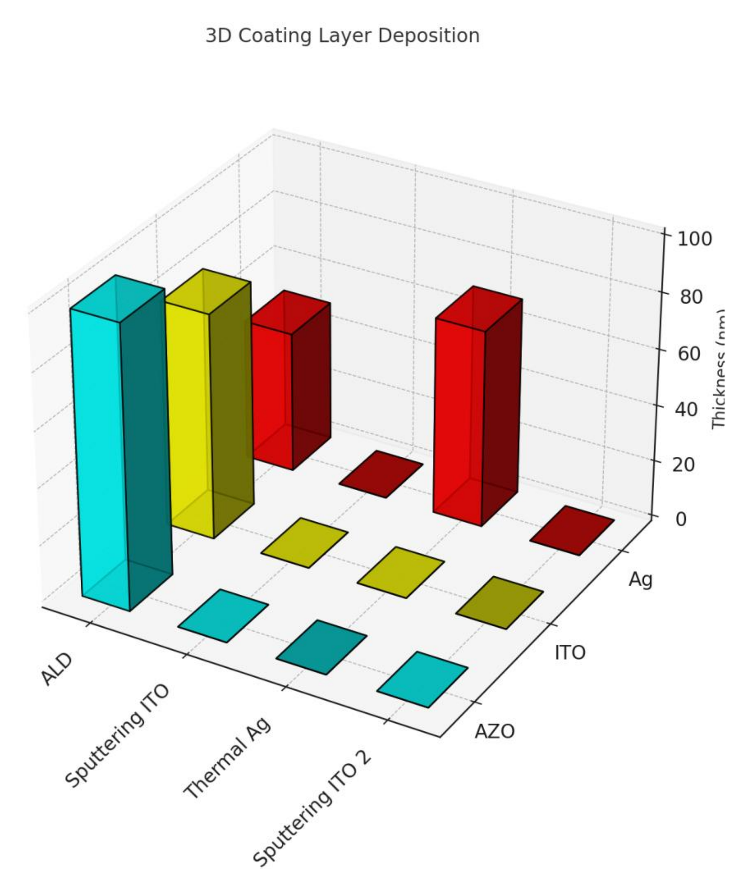
3D scatter for the life-cycle carbon assessment

METHOD

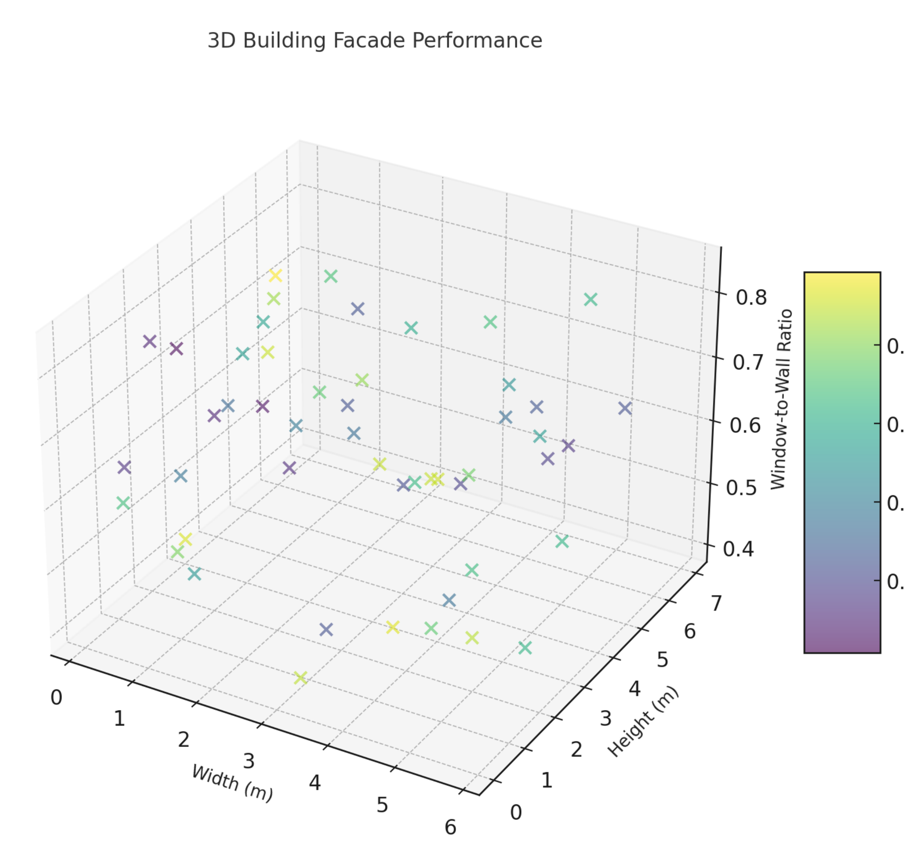
This study investigated various commercially available and prototype thin-film coatings intended for use on architectural glass. Different deposition techniques were examined, including magnetron sputtering and chemical vapour deposition (CVD). The samples underwent testing under controlled laboratory conditions to assess their optical transmission coefficients, reflection properties, and emissivity. Complementary testing in real-world room conditions further enhanced findings, facilitating a comprehensive evaluation of daylight effectiveness, glare reduction, and their associated impact on internal temperature.



3D surface plot for spectral energy conversion



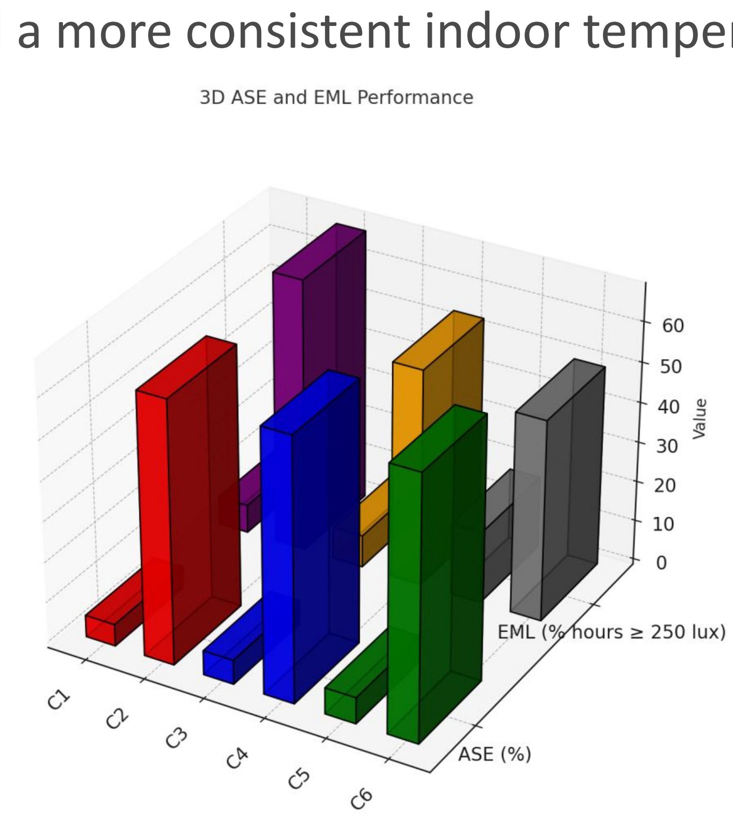
3D bar chart of coating layer deposition



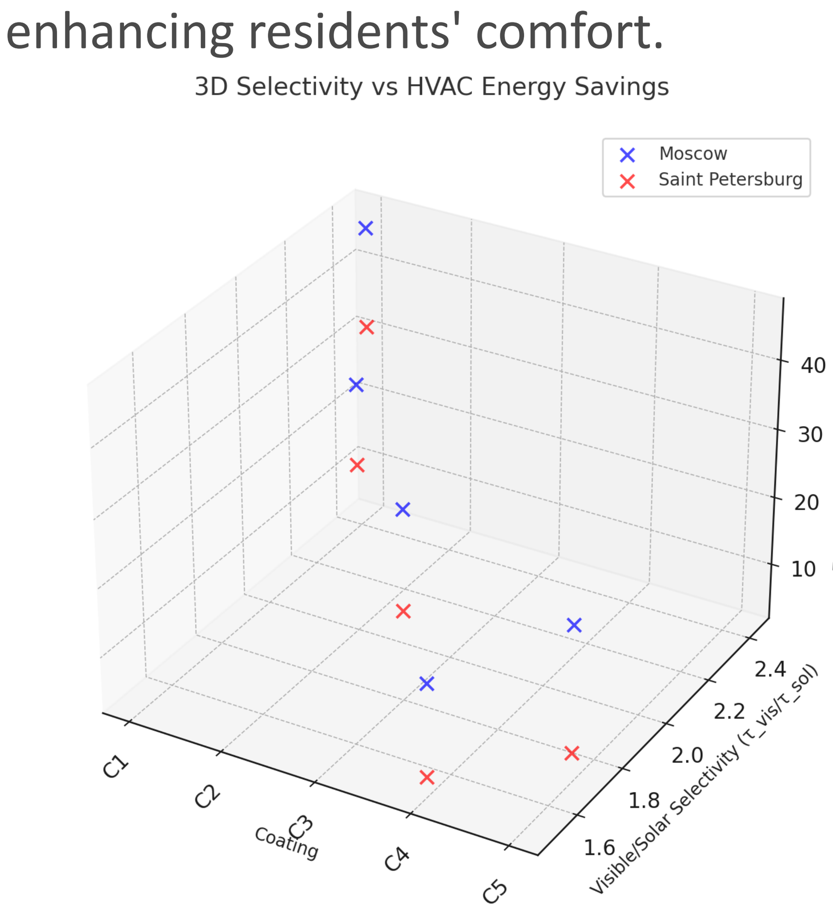
3D scatter of building façade performance is displayed inline, showing width, height, WWR, and transparency

RESULTS & DISCUSSION

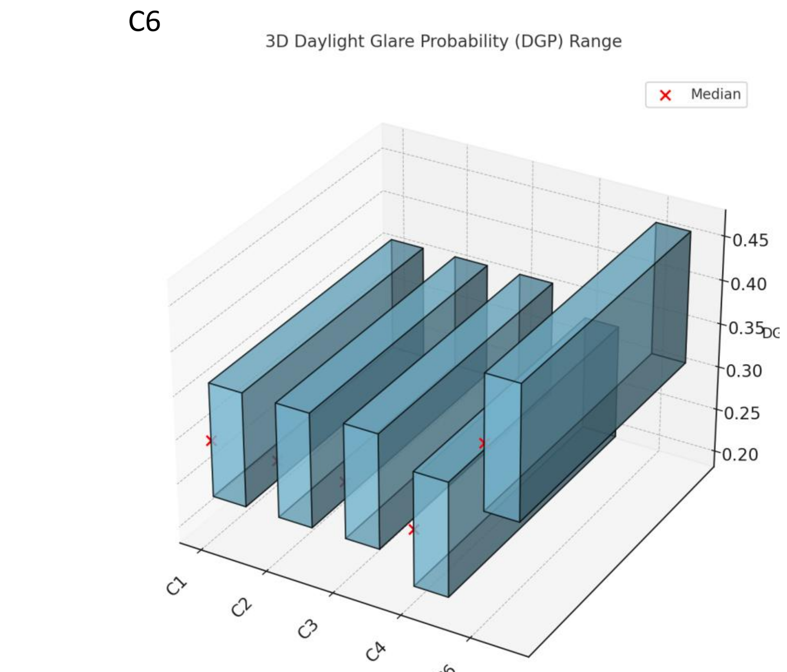
The data obtained indicate that multilayer thin-film coatings can substantially enhance solar radiation control by reducing the transmission of infrared radiation by up to 50% while maintaining an improved transmission coefficient for visible light. Additionally, low-emission coatings effectively diminish heat transfer through glass, resulting in an approximately 20% increase in insulation performance compared to conventional uncoated glazing. Measurements of the interior revealed a notable reduction in glare and a more consistent indoor temperature, enhancing residents' comfort.



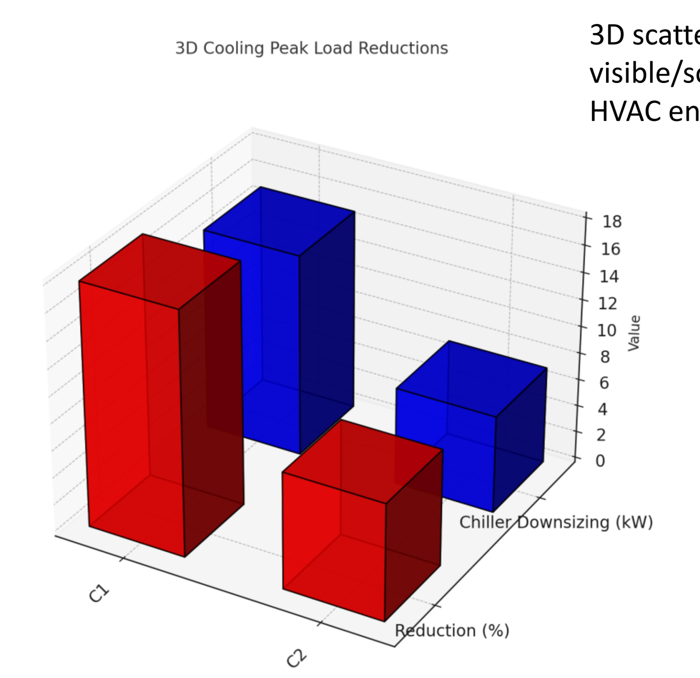
The 3D bar chart displaying ASE (%) and EML (% hours ≥ 250 lux) across coatings C1–C6



3D scatter plot correlating visible/solar selectivity with HVAC energy savings



D "box-plot" of DGP ranges (5th–95th percentile)



3D bar chart of cooling peak load reductions

CONCLUSION

The research shows that spectrally selective triple-silver low-e glazing delivered superior energy and glare reduction results when compared with thin-film alternatives even though it possessed higher embodied energy. The study identified significant relationships between τ_vis/τ_sol selectivity, emissivity, and HVAC savings which prove that precise optical engineering determines overall building effectiveness. The embodied–operational life-cycle analysis showed that high-performance coatings deliver carbon paybacks within five years which demonstrates they align with net-zero trajectories and evolving carbon-pricing systems. Architects seeking to achieve natural lighting benefits without sacrificing thermal and visual comfort will find thin-film coatings on glass to be a functional solution. The coatings promote sustainable development goals while creating healthier indoor spaces through solar radiation optimization and improved insulation performance alongside glare reduction. The evidence provides façade engineers with measurable standards to choose coatings that reduce HVAC requirements and simultaneously improves optical-interface models through the inclusion of occupant-centric metrics in dynamic performance predictions worldwide.

FUTURE WORK / REFERENCES

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