HBKU Thematic Research Grant 3rd Cycle– Project Highlight

Project Title: Cool and clean: Smart Radiative-Cooling and Self-Cleaning Paints for Greener, Longer-lasting Buildings

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Executive Summary (limit to 200 words)

Smart Radiative-Cooling and Self-Cleaning Paints for a Sustainable Future. Rising surface temperatures, particularly in arid regions like Qatar, have intensified the demand for air conditioning and other energy-intensive cooling systems that rely heavily on fossil-fuel-based electricity. This dependence accelerates pollution and climate change, underscoring the urgent need for energy-free, sustainable cooling technologies.

Our research introduces an innovative solution: durable, self-cleaning radiative cooling paints that passively reduce surface temperatures by reflecting solar radiation and efficiently emitting heat into outer space, without consuming energy. Formulated from advanced polymeric composites, these paints achieve solar reflectance and thermal emissivity above 90% in ultra-thin layers.

A key innovation lies in using recovered barium sulfate ($BaSO_4$), sourced from Qatar's desalination brine, as the primary pigment, reducing reliance on virgin materials and advancing circular-economy principles. The paints' superhydrophobic micro/nano structures provide over 80% dust-removal efficiency, ensuring sustained optical clarity and minimal maintenance.

Easily applicable by brush or spray, these coatings offer scalable solutions for buildings and urban infrastructure, delivering energy savings of 25–35% while enhancing durability and air quality. This project represents a step toward greener, cooler, and more resilient cities built on innovation and sustainability.

Expected Outcome (limit to 100 words)

A. Expected invention disclosures (Potential Patent)

- Self-cleaning radiative cooling paint incorporating recovered barium sulfate pigment from Qatar desalination brine.
- Dual-functional polymeric coating with enhanced solar reflectivity and IR emissivity for passive cooling applications.
- Superhydrophobic nano-textured paint for dust-repellent and energy-free thermal regulation in arid environments.

B. Prototype development

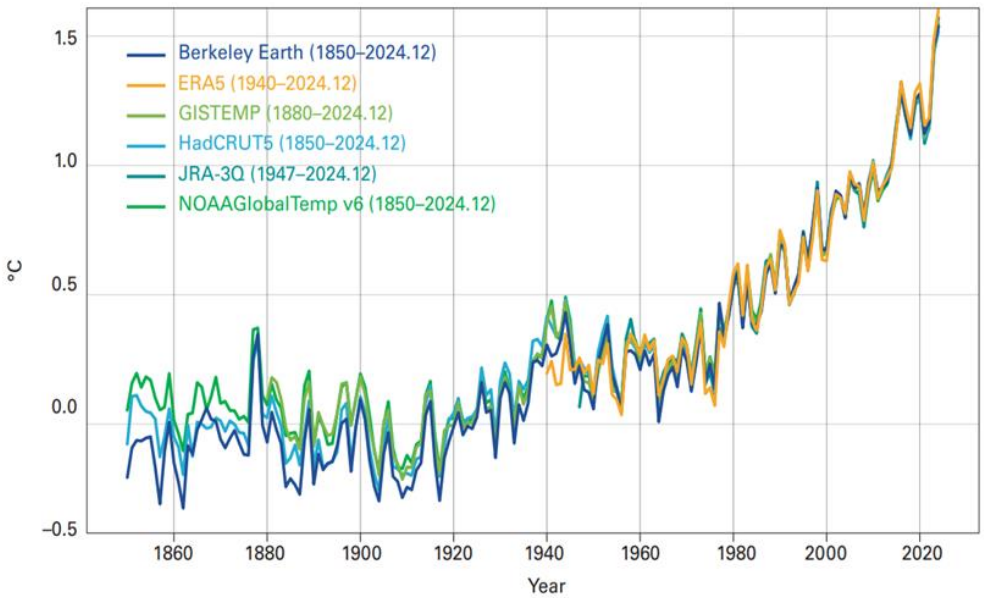
1. A functional paint formulation based on PVDF-HFP/PMMA composites with recovered $BaSO_4$ pigment and nano-textured surface for self-cleaning.
2. A modular coating panel integrating multi-layered hybrid films (radiative + photocatalytic + hydrophobic layers) to enable self-cleaning and long-term durability.
3. A software tool coupling COMSOL Multiphysics**,** EnergyPlus, and AI/ML algorithms to model cooling performance and optimize coating design.

C. Feasibility study

- Techno-economic assessment showing reduction in building cooling loads.
- Environmental impact analysis highlighting CO_2 savings.
- Life-cycle cost comparison versus conventional coatings.
- Validation of industrial scalability and commercial potential.

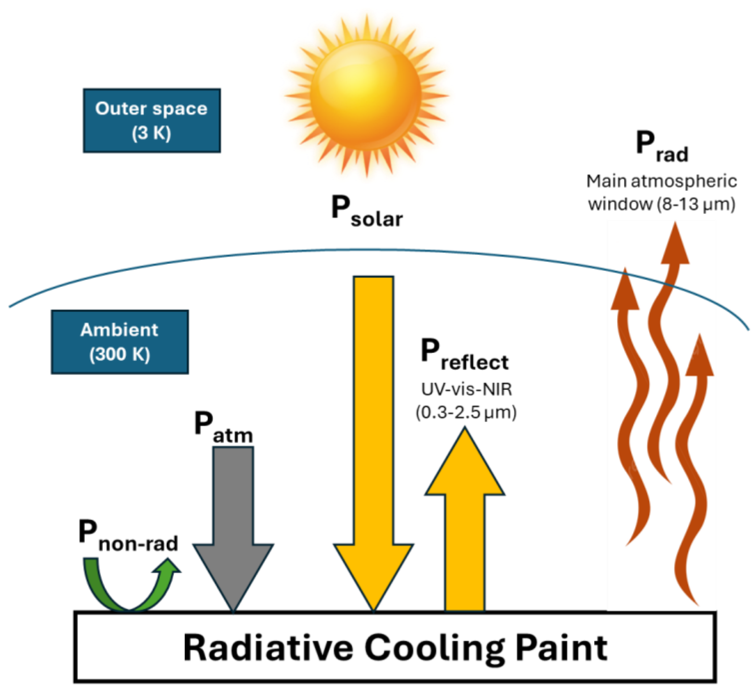
Collaborating HBKU entities: QEERI & CSE.

Photos:

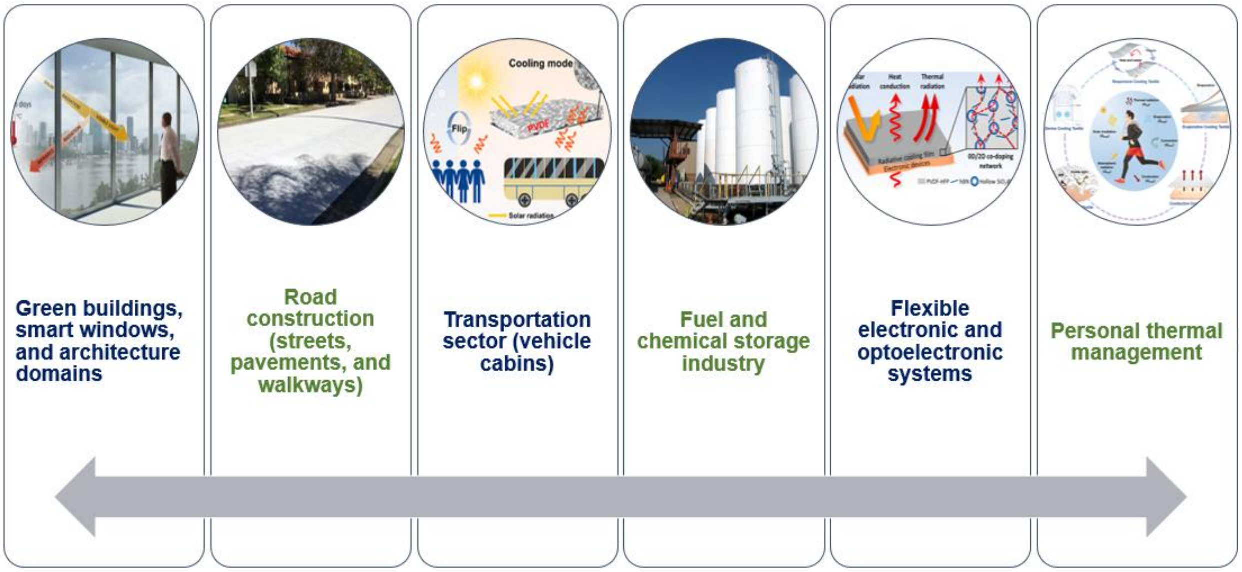


Source: World Meteorological Organization (WMO), 2025

The annual average global near-surface temperature in 2024 was approximately 1.55 °C above the average temperatures recorded from 1850 to 1900. This leads to a heavy dependence on actual air conditioning systems, which account for approximately 20% of global electricity consumption in buildings.



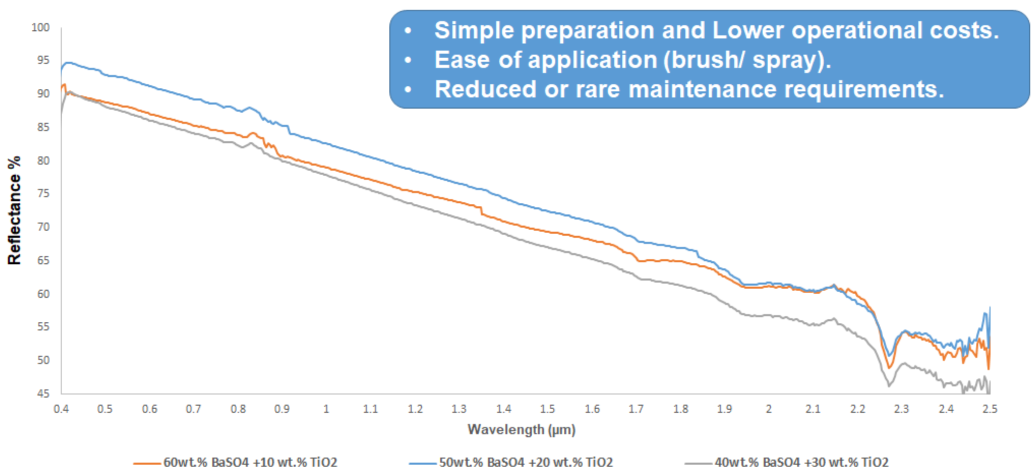
Schematic showing the mechanism of radiative cooling.



Large spectrum of application of the radiative cooling coatings.

Methodology

Polymeric binders : Poly(vinylidene fluoride-co-hexafluoropropylene), PVDF-HFP pellets	Pigment: Barium sulfate ($BaSO_4$)	Secondary filler: Titanium dioxide (TiO_2)	Thickness ~ tens of µm



Developed methodology applied for this research project along with preliminary results.