ENERGETICS

ENI Young Talent Award - Development and optimization of data-driven building integrated photovoltaic thermal radiative cooling (BIPVT-RC) systems

Funded By	ENI S.P.A. [P.iva/CF:00905811006]
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Context of the research activity	The goal of the research is to decabornize South Africa's (SA) building stock by transforming buildings from carbon-emitters to positive energy providers. In detail, the research proposal offers a model for building energy efficiency in SA using multi-objective numerical alongside data-driven modelling and experimental approach to determine feasible energy efficiency solutions. This will enable South Africa to attain its 2050’s carbon neutrality target. The position is reserved to candidates who have participated in the selection of the competition "Debut in Research: Young Talents from Africa" of the year 2024
	In South Africa (SA), building stocks account for 40% of the national energy consumption, exerting strain on the predominantly coal-dependent energy grid and resulting in frequent power outages. Achieving carbon neutrality through decreasing energy demand, increasing system energy efficiency and exploiting renewable energy sources, and at the same time optimizing indoor environmental quality is fundamental. In particular, most studies investigated such devices as photovoltaic-thermal (PVT) and radiative cooling (RC) systems in order to obtain a reduction in energy consumption and CO2 emissions. Integrating these separate systems as a single unit into buildings to optimize energy efficiency must be considered. Within this context, this research endeavors to bridge critical gaps in the field of sustainable building technologies by proposing an innovative model for Building Integrated Photovoltaic-Thermal Radiative Cooling (BIPVT-RC) systems. Grounded in the integration of photovoltaic-thermal and radiative cooling technologies, this research seeks to introduce a novel systems configuration that optimizes building energy efficiency by exploring local climate patterns and their intricate influence on BIPVT-RC system performance. Through a detailed investigation encompassing solar radiation, temperature variations, humidity levels, and wind patterns, the study aims to illuminate the nuanced relationship between climate dynamics and system efficacy. The novelty of this research lies in the development of advanced simulation models, enabling a comprehensive analysis of coupled energy

Objectives	and heat transfer processes within BIPVT-RC systems. By scrutinizing diverse operational scenarios and building configurations, the research endeavors to provide valuable insights into the complex dynamics of these integrated systems. Furthering the research objectives, the study involves the design and implementation of a real-world BIPVT-RC prototype affixed to a representative building. Sensor networks integrated into the prototype will capture performance data, facilitating validation and optimization of the developed system. The research will employ intelligent control strategies, leveraging predictive algorithms and machine learning techniques, to enhance energy generation and cooling efficiency while maintaining optimal indoor thermal comfort. These strategies contribute to the broader field of intelligent building systems. Anticipated outcomes include a comprehensive life cycle assessment and cost-benefit analysis, elucidating the environmental and economic viability of widespread BIPVT-RC system adoption in the studied South Africa's built environment. The expected findings are poised to inform sustainable building practices, influencing future policy and design considerations. The tangible prospects of this research extend beyond academic contributions to practical applications. The proposed BIPVT-RC system holds promise for widespread adoption, promising reduced energy costs, diminished environmental impact, and enhanced resilience to climate change. Conclusively, this research represents a concerted effort to innovate sustainable building technologies by integrating BIPVT and RC technologies. By addressing critical gaps in knowledge, the study aims to provide a robust framework for the sustainable development of building systems, with tangible benefits for energy efficiency, environmental impact, and indoor comfort.

Skills and competencies for the development of the activity	The candidate should present knowledge in terms of green buildings, energy efficiency, reference buildings (exploited for analyzing building stock consumption and emissions), and expertise in the use of dynamic simulation software and financial valuations (net present value, payback period).