Doctoral Dissertation
Doctoral Program in Architectural Heritage and Landscape
(37th Cycle)

Economic Enhancement of Architectural Heritage through Renewable Energy Communities (REC): Opportunities, Scenarios and Evaluation tools.

La Valorizzazione Economica del Patrimonio Architettonico attraverso le Comunità Energetiche Rinnovabili (CER): Opportunità, Scenari e Strumenti di Valutazione.

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Summary

In response to the challenges posed by climate change and the global energy transition, the conservation and enhancement of architectural heritage play a crucial role in promoting sustainability.
This research explores the complex relationships between architectural heritage enhancement and economic evaluation in the context of Renewable Energy Communities (RECs) development, examining the potential synergies and interactions throughout the entire lifecycle of historic assets.
The analysis focuses on the challenges and opportunities related to enhancing historic sites through renewable energy and protected landscapes, with particular attention to safeguarding architectural and historical value within a framework of sustainable innovation. The proposed methodological approach was developed to enhance the architectural and landscape heritage through the economic evaluation of energy empowerment interventions in the context of REC's development by supporting Public Administrations in decision-making processes finalized to identify preferable solutions.
The present research work applied this innovative methodological approach to the city of Sangano (in Northern Italy) in the enhancement process of a former Ammunition Depot (Ex Polveriera), a property of the Municipality of Sangano that holds significant historical value and could be included in the existing REC, initiated at the beginning of 2024.
The methodological approach is performed to two different applications. The first application was aimed at understanding if the public lighting of the site could be supported through the REC energy production (Base Scenarios). The second application, instead, was aimed to assess and to identify the preferable option for the public lighting of public spaces (Enhacement Scenarios) through a focused public lighting design. A comprehensive Life Cycle Cost Analysis (LCCA) was applied to evaluate both Base Scenarios and Enhancement Scenarios, comparing costs, benefits, and the whole life cycle of the project.
The Base Scenario demonstrated that REC energy production could support the maintenance costs referred to the site's public lighting; Enhancement Scenarios revealed the preferable lighting design for the Former Ammunition Depot. After the LCCA, a final scenario discussed with the Municiapality of

Sangano was proposed and it highlighted further economic and community benefits also thanks to a regional funding with increased positive externalities considering biodiversity conservation, and enhanced public access. In this regard, the potential benefits deriving from the REC have not been fully included in the current research, but they could significantly enhance the economic analysis, especially considering the public nature of the intervention.

By presenting a replicable model for small municipalities like Sangano, the study demonstrates that the economic evaluation of energy empowerment interventions on architectural and landscape heritage jointly with the potential of RECs can support processes of revitalizing fragile areas and enhancing community well-being, serving as a benchmark for sustainable and integrated solutions in energy and heritage redevelopment.

Moreover, this research underscores the role of lighting design not only as a tool for enhancing architectural and natural heritage but also for promoting biodiversity protection and fostering social and environmental regeneration. The project's outcomes emphasize the value of close collaboration between universities and public administrations, bridging innovative research with practical implementation.

Results show that although the initial costs of renewable plants are higher due to conservation constraints and technical challenges, these costs can be offset by long-term savings in energy and maintenance; in the analysed site, energy-efficient public lighting interventions proved to be pivotal in achieving these outcomes considering also the importance of lighting control systems. The economic evaluation of heritage energy empowerment in the context of RECs' development further highlights enhanced economic sustainability compared to standalone retrofit solutions, leveraging incentives related to energy production over the asset's lifecycle.

The conclusions emphasize the potential of energy efficiency interventions to contribute to sustainable energy goals, enhancing the resilience and longevity of historic and cultural sites in a low-carbon future while allowing the preservation of abandoned areas. This ensures the conservation and accessibility of heritage while addressing economic and environmental vulnerabilities, making such interventions particularly beneficial in fragile and under-resourced contexts.