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Strategy of solar energy integration in the built environment: case of residential rooftops in Laghouat, Central Southern Algeria

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Summary

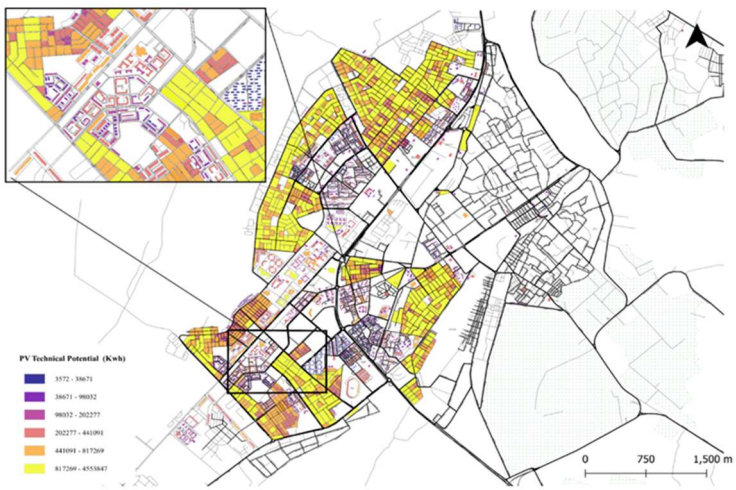
This thesis aims the integration of solar energy considerations into urban planning process in Algeria in order to improve the energy performance of existing buildings and guide future projects toward achieving the net zero energy (NZE) goal. Our focus is namely on the residential sector which is considered as the most energy-intensive sector in the country. The scientific relevance of this research is to develop a process which is adapted to the climatic zone, residential typologies and consumption profile in the southern cities of Algeria.

The proposed methodology combines engineering, statistical, and parametric analysis. Firstly, the engineering method refers to a number of solar simulations performed for 3D residential typologies to predict the annual solar radiation received after considering losses due to roof obstacles, shading from the surrounding environment, and the coverage ground ratio based on PV panels' performance under different tilts. Subsequently, the statistical method, established on a Geographic Information System (GIS), allows to determine the total area of residential roofs, the effective area suitable for PV installation, and offers an accurate estimation of the geographical and technical solar potential. Based on these findings, an aggregate layer is created to assess the energy balance and categorize the urban units as negative, positive or neutral, depending on the variation between solar PV potential and their electric consumption. Finally, based on innovative computational tools, the parametric analysis helps to find a compromise between optimizing the potential of solar energy in residential projects while limiting the negative impact of sun exposure on outdoor thermal comfort in such a hot climate.

Applied to the municipality of Laghouat, the results identify the "utilization factor" for each residential typology and demonstrate that the deployment of distributed rooftop PV systems on rooftops offers significant technical potential, which could cover up to 55% of the annual electricity needs. Furthermore, the statistical aggregation provides valuable insights into energy management and develops smart models of energy sharing that manages residential typologies based on their solar potential and allows to achieve net-zero energy (NZE) at the neighborhood level. The results of the parametric analysis, communicated in an interactive dashboard, suggest reliable indications and design scenarios for architects and urban planners to improve the solar potential and the level of outdoor thermal comfort of residential projects in this arid climatic zone.

Keywords

Energy planning, photovoltaic solar potential, Net-Zero Energy (NZE), residential building rooftops, solar simulation, GIS-statistical.



Map of the Technical PV potential (kwh) on residential rooftops in Laghouat municipality.