Assessing the Potential of Solar Energy Adoption in Urban Areas

Author: Alex R. Green
Institution: Horizon University
Date: April 12, 2025

Abstract
Urban areas consume significant energy, contributing to greenhouse gas emissions. Solar energy offers a sustainable solution, yet its adoption in cities remains uneven. This study evaluates the potential for solar energy adoption in mid-sized urban centers by analyzing technical feasibility, economic viability, and social acceptance. Using a mixed-methods approach, including GIS-based solar potential mapping and surveys of 500 residents in three cities, we find that rooftops can meet 25-40% of urban electricity demand. Economic analysis indicates payback periods of 5-8 years with current subsidies. However, public awareness and policy gaps hinder uptake. We recommend targeted education campaigns and streamlined permitting to accelerate solar adoption.

Keywords: solar energy, urban sustainability, renewable energy, adoption barriers, GIS analysis

---

1. Introduction
As global energy demand rises, urban areas account for over 70% of energy-related carbon emissions (IPCC, 2022). Renewable energy, particularly solar, is critical to decarbonizing cities. Solar photovoltaic (PV) systems are versatile, scalable, and increasingly cost-competitive, yet their integration into urban landscapes faces technical, economic, and social challenges. This paper investigates the potential for solar energy adoption in mid-sized urban centers (population 100,000–500,000), addressing three questions: (1) What is the technical potential of rooftop solar in urban settings? (2) How economically viable is solar adoption for residents? (3) What social factors influence public acceptance?

The study contributes to renewable energy literature by combining spatial analysis with socio-economic data, offering actionable insights for policymakers and urban planners. Section 2 outlines our methodology, followed by results, discussion, and conclusions.

---

2. Methodology
This study employs a mixed-methods approach to assess solar energy potential in three mid-sized U.S. cities: Boise, Idaho; Asheville, North Carolina; and Eugene, Oregon.

2.1. Technical Assessment
We used Geographic Information Systems (GIS) to estimate rooftop solar potential. LiDAR data provided high-resolution rooftop measurements, accounting for slope, orientation, and shading. Solar irradiance was modeled using National Renewable Energy Laboratory (NREL) datasets, assuming standard PV panel efficiency (20%). Total electricity generation potential was compared to city-level consumption data.

2.2. Economic Analysis
We calculated the levelized cost of electricity (LCOE) for rooftop solar systems, factoring in installation costs ($2.50/W), maintenance, and federal tax credits (26%). Payback periods were estimated using local electricity rates (10-15¢/kWh) and net metering policies.

2.3. Social Acceptance
Surveys were conducted with 500 residents across the three cities (n=167 per city), selected via stratified random sampling. Questions assessed awareness, willingness to adopt solar, and perceived barriers (e.g., cost, aesthetics). Responses were analyzed using logistic regression to identify predictors of adoption intent.

---

3. Results

3.1. Technical Potential
Rooftop solar can generate 25-40% of annual electricity demand in the studied cities. Boise showed the highest potential (40%) due to favorable solar irradiance and flat rooftop designs. Asheville and Eugene yielded 30% and 25%, respectively, limited by tree cover and building orientation.

3.2. Economic Viability
The LCOE for solar ranged from 8-12¢/kWh, competitive with grid electricity. Payback periods averaged 5 years in Boise, 6 in Asheville, and 8 in Eugene, influenced by state incentives. Sensitivity analysis showed that a 20% cost reduction could lower payback to 4 years across all cities.

3.3. Social Acceptance
Surveys revealed 65% of residents were aware of solar benefits, but only 30% considered adoption. Cost was the primary barrier (45%), followed by concerns about aesthetics (20%) and permitting complexity (15%). Higher income and education levels predicted greater adoption intent ($p<0.01$).

---

4. Discussion

The results highlight significant potential for urban solar adoption, consistent with prior studies (NREL, 2023). Technically, rooftops offer a viable resource, but shading and structural constraints require site-specific planning. Economically, solar is increasingly attractive, yet upfront costs deter lower-income households, suggesting a need for financing models like community solar. Socially, awareness gaps and bureaucratic hurdles align with findings from Smith et al. (2024), emphasizing education and policy reform.

Limitations include the study's focus on mid-sized cities, which may not reflect megacities or rural areas. Additionally, survey self-selection bias may overstate interest in solar. Future research should explore multi-family housing and grid integration challenges.

---

5. Conclusion

Solar energy holds transformative potential for urban sustainability, capable of meeting a substantial portion of electricity needs. However, realizing this potential requires addressing economic and social barriers. We recommend: (1) public awareness campaigns to highlight long-term savings, (2) streamlined permitting processes, and (3) subsidies targeting low-income households. By aligning technical feasibility with policy innovation, cities can lead the renewable energy transition.

References

- IPCC. (2022). *Climate Change 2022: Mitigation of Climate Change*. Cambridge University Press.
- NREL. (2023). *U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark*. National Renewable Energy Laboratory.
- Smith, J., et al. (2024). Barriers to Residential Solar Adoption. *Journal of Sustainable Energy*, 12(3), 45-60.