

Solar Energy Potential and Integration in Alabama Residential Buildings: A Photovoltaic System Feasibility Study



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Abstract

This study investigates the integration of photovoltaic (PV) systems into Alabama's residential buildings using Autodesk Revit 2024 for solar analysis. It evaluates the efficiency, cost benefits, and payback periods of different PV panels in five Alabama cities, revealing energy and financial savings with payback periods between 11.6 and 14.1 years. The research also reviews Alabama's policy environment, highlighting net metering policy gaps, and suggests policy improvements and incentives for solar technology. The paper promotes sustainable energy in Alabama's residential sector, providing insights for homeowners, architects, urban planners, and policymakers.

Introduction

Importance of Solar Energy

- Clean.
- Energy consumption in Alabama's residential buildings and environmental impact.
- The potential of solar energy in Alabama.

Energy Consumption

- The potential, challenges, and future direction of solar PV system integration in Alabama, with a focus on residential building.

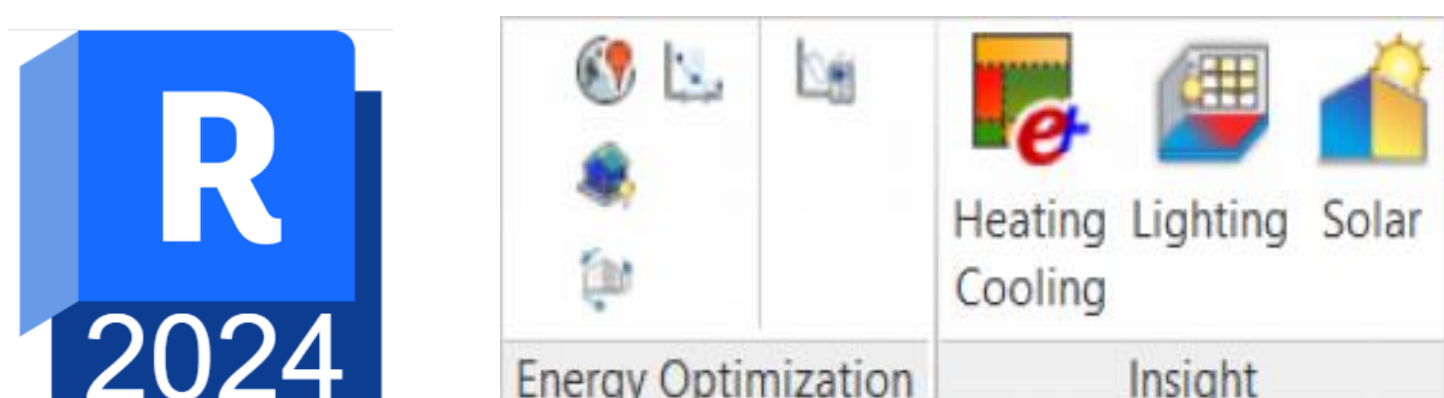
Potential of Solar Energy in AL

City	Sunny	Partly Sunny	Total Days With Sun
Birmingham	99	111	210
Huntsville	100	101	201
Mobile	102	116	218
Montgomery	107	107	214
Tuscaloosa	107	107	214

Table 1. Days of Sunshine Per Year in Alabama. Source: CurrentResults

- Climate Conditions
- Policy and Regulatory Framework
- Solar Panel Technology

Effective Assessment Tools



Revit 2024

Solar Plug-in

- PV panel types and placement.
- Sun path
- Solar radiation
- Climate variances

Evaluation and Understanding

- Solar energy deployment in AL.
- Advancements in solar panel technology.
- Dynamic nature of policies
- Decision making in solar investment.

Methods

DOE Prototypical Building Model

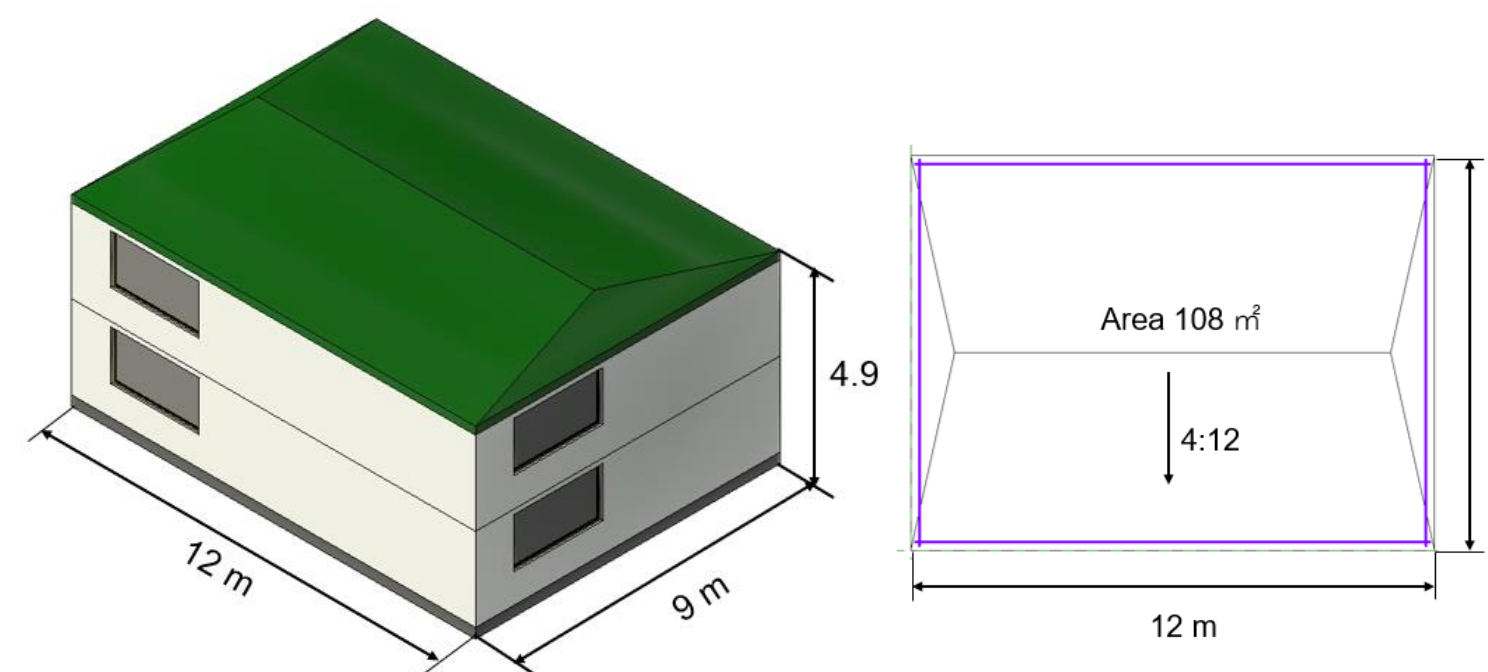


Fig 1. Single-family residential prototype building model

- Building dimension: 12 x 9 (L x W) in meters.
- Roof slope: 4:12

Selected Cities

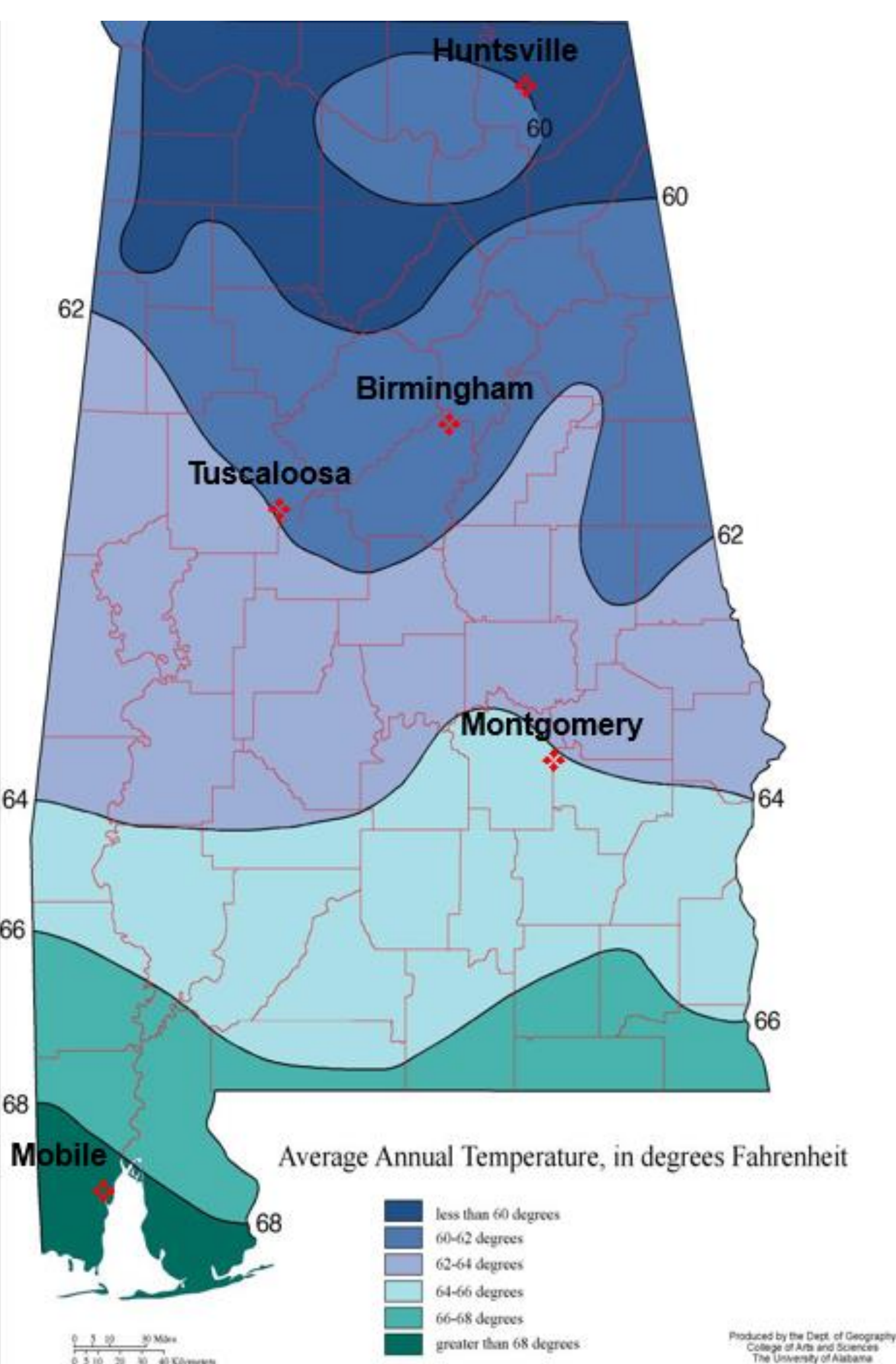


Fig 2. Alabama major cities temperature map. Source: Alabama Maps - Climate

Five major cities: **Huntsville, Birmingham, Montgomery, Mobile, and Tuscaloosa.**

Solar Analysis in Revit

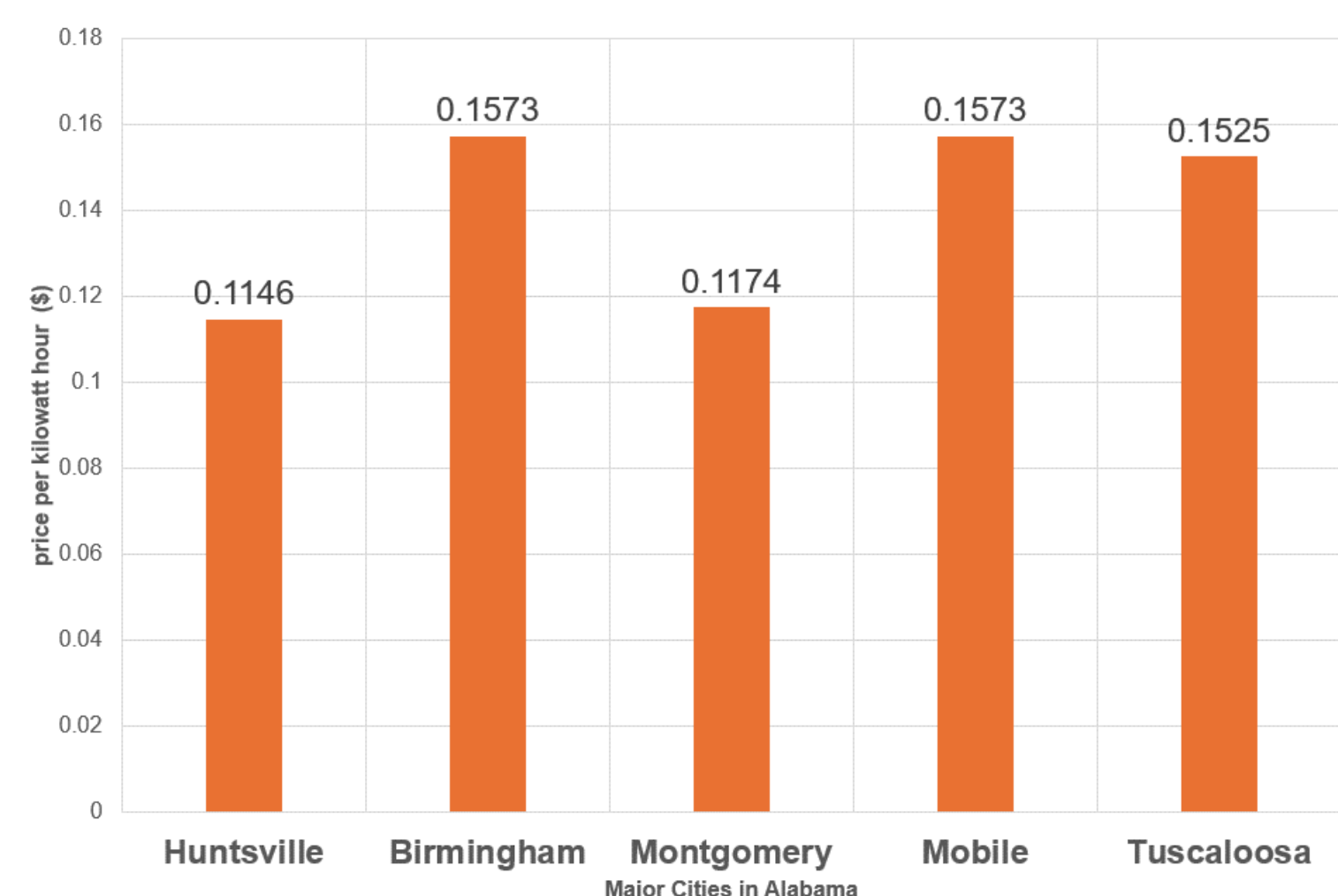


Fig 3. The average residential price per kilowatt hour

Analysis Result Settings

- The Study Type: "Solar Energy-Annual PV".
- Surfaces was "All Roof Exterior Surfaces".
- Date range from 01/01/2023 to 12/31/2023.
- Style in the results settings: "Solar Analysis Annual Insolation".
- Type: "Cumulative Insolation", "PV Energy", and "Payback Periods (years)"

Results

Solar Energy Potential

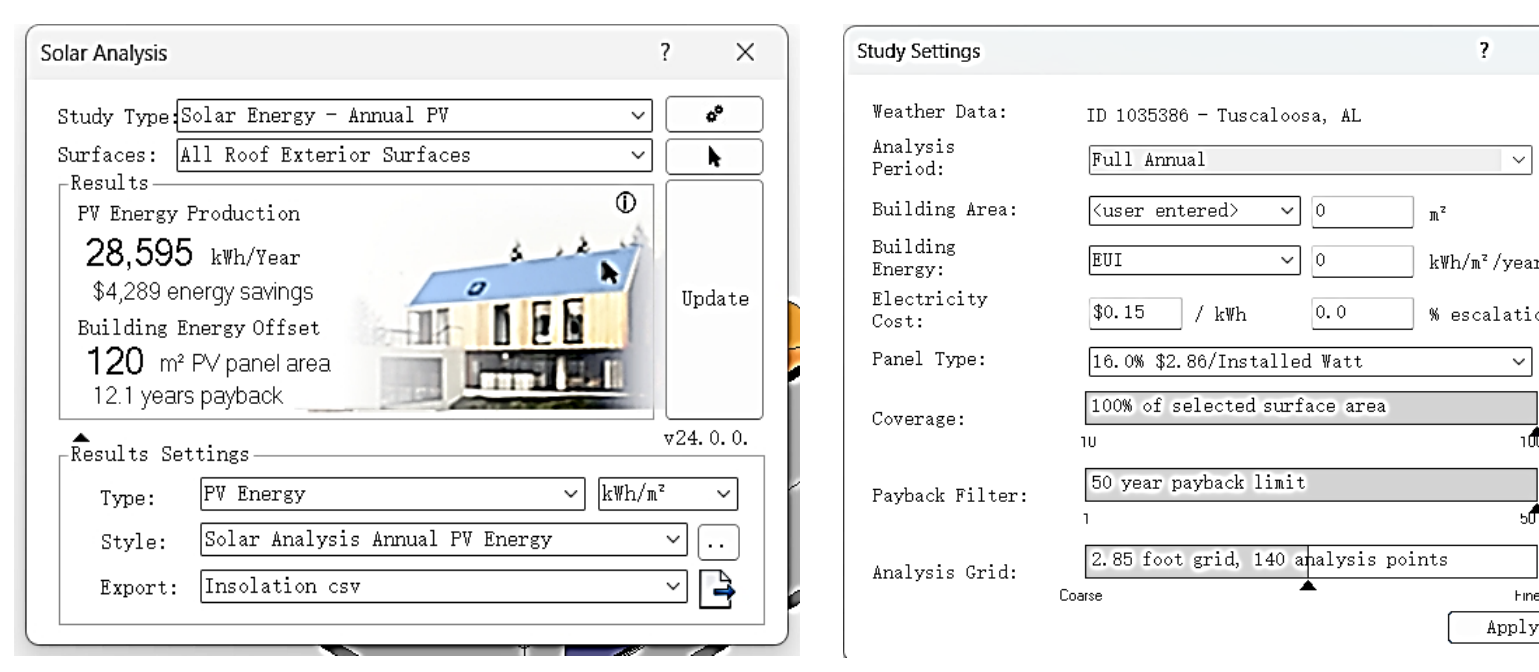


Fig 4. Solar Analysis Setting and Results interface

Fig 5. study settings interface

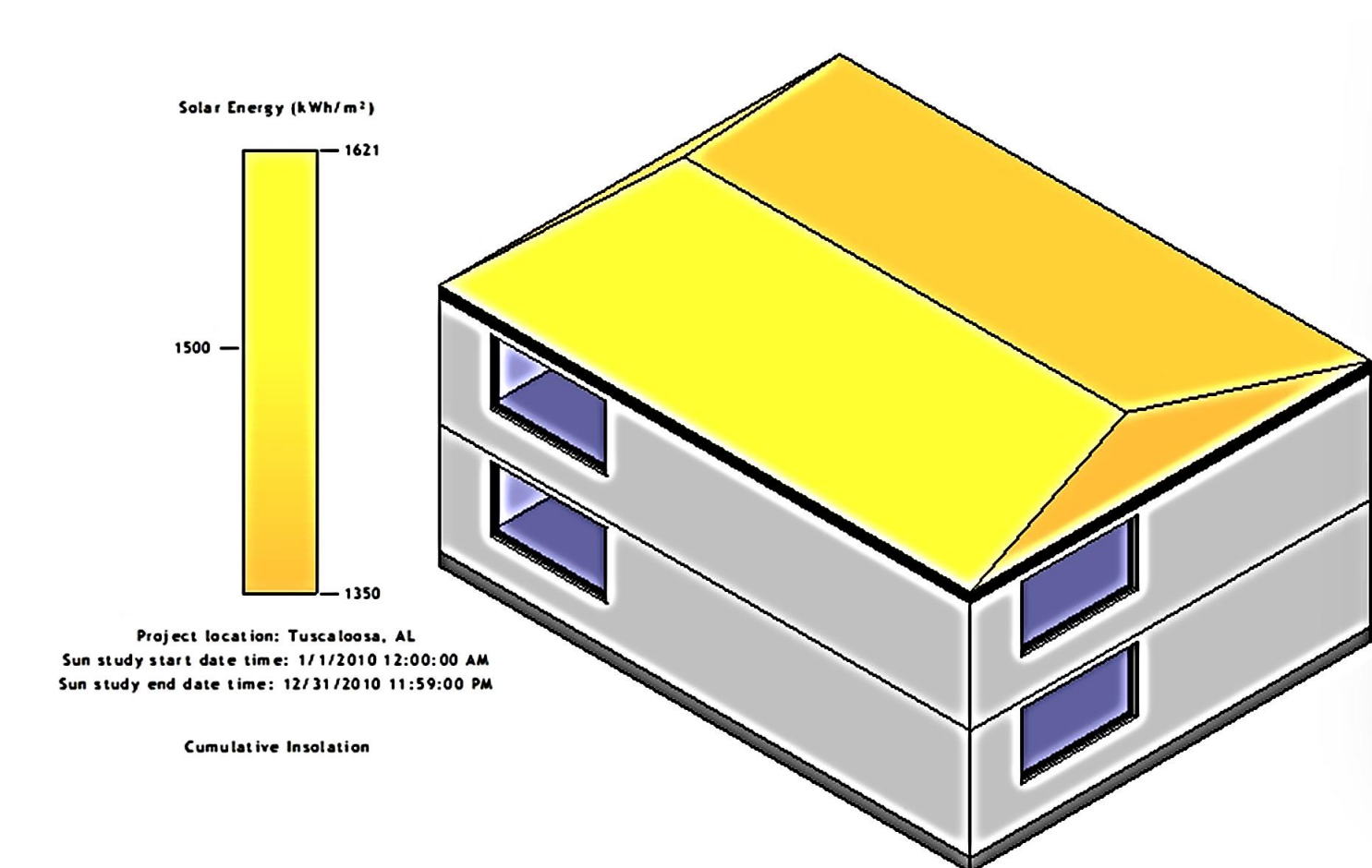


Fig 6. 3D view of the solar analysis results

Huntsville	Birmingham	Montgomery	Mobile	Tuscaloosa
153,898	177,691	180,638	179,891	179,197

Table 2. Annual cumulative Insolation for five cities (Unit: kWh)

PV Energy Production

The efficiency of PV panels:

- 16.0% \$2.86/Installed Watt, Type 1
- 18.6% \$3.06/Installed Watt, Type 2
- 20.4% \$3.47/Installed Watt, Type 3

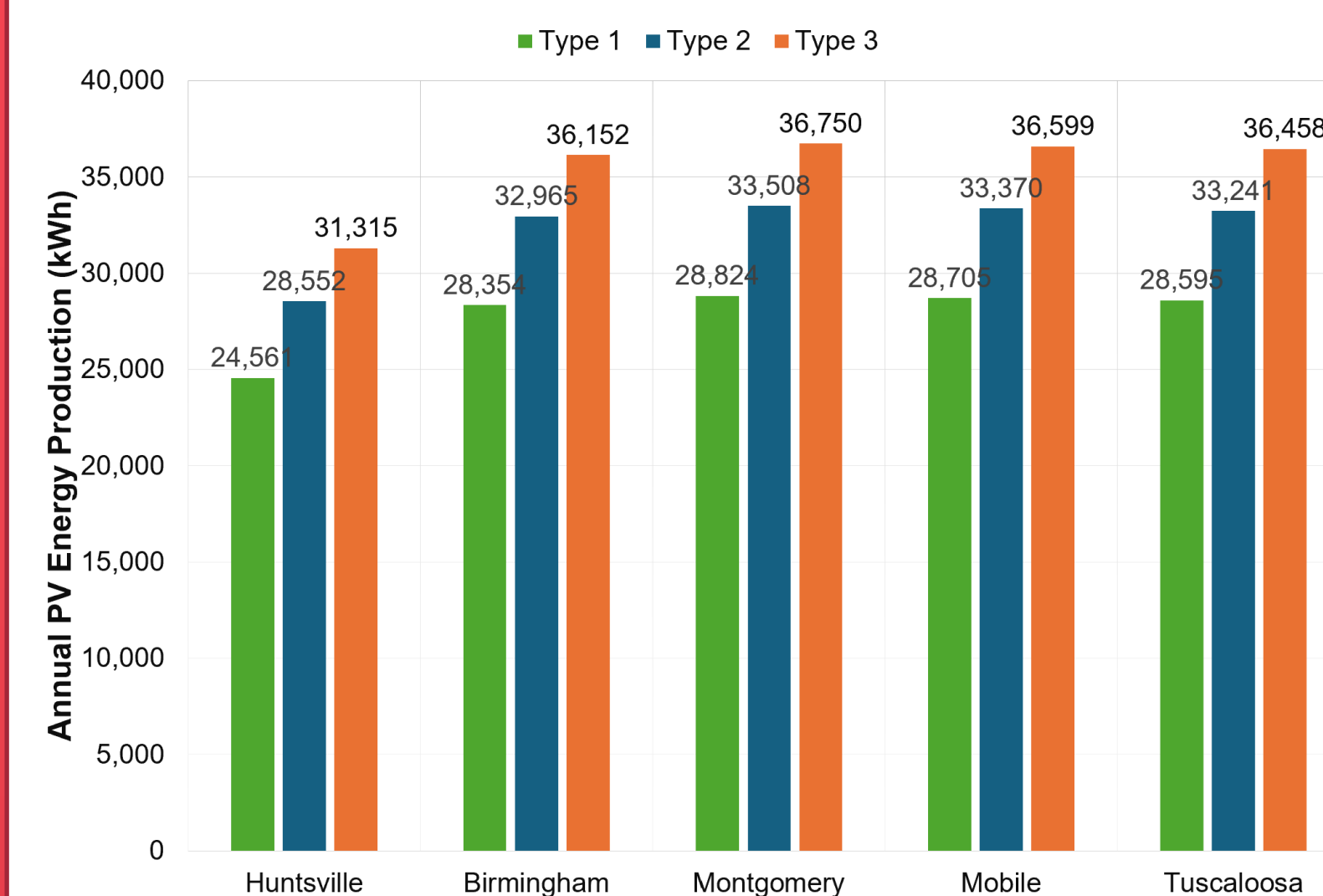


Fig 7. Annual PV energy production (Unit: kWh/y)

Energy Savings

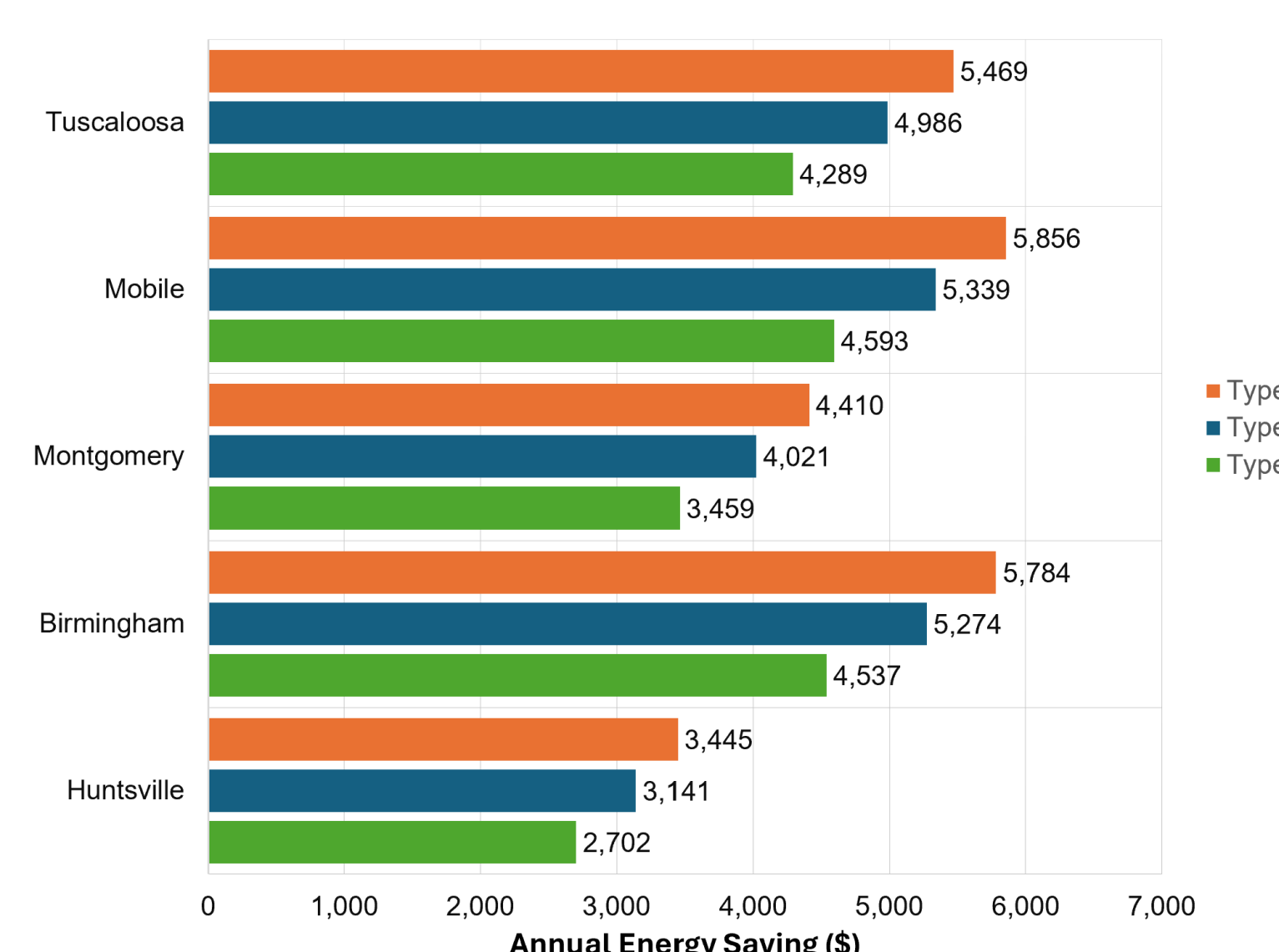


Fig 8. Annual energy savings (Unit: dollars \$)

Payback Periods

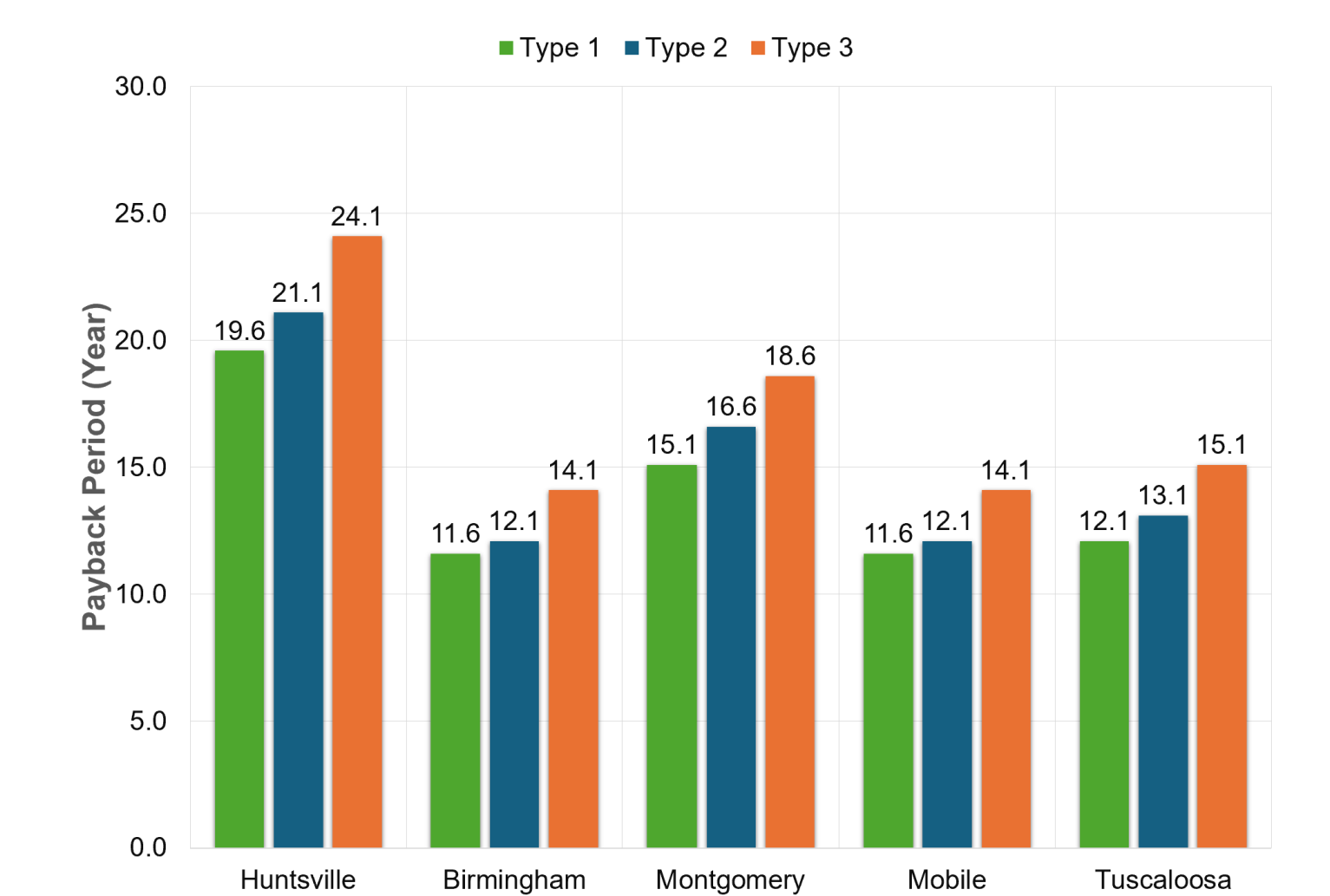


Fig 9. Payback Periods (Unit: Years)

Discussion

Key Results

- More sunshine hours and higher solar radiation make PV energy systems more efficient due to climatic conditions and geographical location.
- Higher efficiency panels with higher installation costs will save more money in the field.
- Higher solar energy production leads to greater electricity savings, reducing the payback period.
- The potential for energy independence and homeowner economics is huge.

Challenges

- AL's solar capacity growth largely through large projects.
- AL does not currently have any regulatory programs.
- Longer payback period for AL solar panels.

Future Research

- Strengthen polices and regulations: prioritize the development of supportive policy frameworks and regulatory
- Public awareness and education campaigns: Invest in awareness campaigns to encourage more people to install solar energy.
- Technology innovation and cost reduction: continue to advance solar technology and work to reduce installation costs.

Conclusions

Key Takeaways

- Solar PV system integration in major Alabama cities is evaluated through Revit software, considering geography, panel efficiency, and cost of electricity.
- Collaboration among stakeholders is critical to creating an environment conducive to solar energy adoption.
- Addressing the challenges facing states is critical; enhanced policy support, public awareness, and technological innovation are key to promoting the widespread use of solar energy.
- Alabama's goal of transitioning to a sustainable, cost-effective energy future is realized through a comprehensive effort.