

# NET ZERO SOLAR HOME IN PHOENIX, ARIZONA



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## ABSTRACT

This project presents a technical framework for achieving net zero electric energy status for a 2000 square foot residential dwelling in Phoenix, Arizona. By integrating a 40 square meter monocrystalline photovoltaic array with a 20 kilowatt hour lithium ion battery storage system, the design eliminates reliance on the utility grid during peak summer heat waves. The analysis focuses on the synergy between a high performance building envelope, utilizing 150 millimeters of spray polyurethane foam, and an optimized mechanical cooling cycle using R 454B refrigerant. Results demonstrate a positive annual energy balance and an 80 percent reduction in conductive heat gain compared to traditional framed construction.

## INTRODUCTION

The challenge of net zero engineering in arid climates is defined by extreme cooling loads where ambient temperatures frequently reach 48 degrees Celsius. This project investigates the integration of renewable generation and thermal management to maintain a comfortable indoor setpoint of 24 degrees Celsius.

- Preliminary Work: Analysis of Typical Meteorological Year 3 (TMY3) data to establish hourly irradiance and temperature profiles.
- Literature Review: Consultation of transport processes and convective heat transfer models to optimize refrigerant and airflow efficiency.
- Innovation: The unique contribution of this work is the localized matching of R 454B thermodynamic cycle performance with specific desert insulation requirements to ensure system stability under high thermal stress.

## SYSTEM DESCRIPTION AND DESIGN

The residence operates as a standalone electrical microgrid designed for high reliability and efficiency.

## KEY PERFORMANCE SPECIFICATIONS

- Photovoltaic Array:
  - 40 square meters | 20 percent efficiency | 0.80 performance ratio.
- Energy Storage:
  - 20 kWh total capacity | 19 kWh usable | Lithium Iron Phosphate chemistry
- Thermal Envelope:
  - 150 mm SPF insulation | U value of 0.15 W/m<sup>2</sup> \* K
- Mechanical Cooling:
  - R 454B vapor compression cycle | Optimized for 55 degree Celsius condenser temperatures.

## RESULTS BY THE NUMBERS

The following quantitative results validate the design philosophy under peak loading conditions:

- Peak Generation: The system produces over 6 kilowatts of power during solar noon in July.
- Heat Gain Mitigation: Conductive heat transfer (Q) is restricted to 500 Watts at 48 degrees Celsius, down from 2500 Watts in standard homes.
- Efficiency: The cooling system maintains a Coefficient of Performance (COP) above 3.2 during extreme heat events.
- Seasonal Surplus: A daily energy surplus of 13 kilowatt hours is achieved during the spring months.

## CONCLUSIONS

- Net zero status is technically and economically feasible in desert environments through high performance insulation.
- The 20 kilowatt hour battery bank is sufficient to manage the 13.8 kilowatt hour daily cooling load during the hottest summer nights.
- Shifting peak loads via thermal mass and high (R) value materials is essential for maintaining microgrid stability.