CASA VERDE

U.S. DEPARTMENT OF ENERGY Solar Decathlon

THE UNIVERSITY OF ARIZONA

Frijoles Verde | University of Arizona | Attached Housing | US Department of Energy Solar Decathlon® | 04.04.2023

MAKING LIVING SUSTAINABLE FOR ALL

PROJECT SUMMARY

As of 2020, only 0.2% of residences in the United States had achieved net-zero energy performance. Unfortunately, as long as cost remains a significant barrier to energy reduction solutions, this means that sustainable living will remain inaccessible to the most Americans.

This is especially a problem in South Tucson, a small community in the Sonoran Desert where 51% of the population lives below the poverty line. Many South Tucson residents – especially single parents and young adults – make less than $15k a year, and could benefit from a safe, sustainable living environment at an affordable price.

Casa Verde aims to meet this need through the creation of an **attached housing prototype that can be scaled to infill South Tucson neighborhoods**. Its rowhouse form allows multiple compact, 1-bedroom units to be arrayed, facing a shared neighborhood courtyard that cultivates community between new and old residents alike.

DESIGN STRATEGIES

These three key strategies help make net-zero building affordable while designing for South Tucson's hot, dry climate:

1. A **vernacular courtyard form** honors local building traditions, optimizes solar orientation, reduces wall surface area, utilizes vegetative cooling, and encourages community generation without sacrificing individual privacy.

2. **Wall prefabrication** in partnership with Habitat for Humanity sets up community engagement, reduces material usage, allows shared systems for increased efficiency and lower costs, and creates open floor plans for light and ventilation.

3. Passive and active **radiative surfaces** take advantage of the 30-degree temperature swing for cooling benefits, and improve energy efficiency, human comfort, and air quality relative to forced air systems.

These strategies make Casa Verde an affordable net-zero housing solution that can be implemented on sites throughout the Tucson area. By addressing socio-economic inequality in energy reduction efforts, it has the potential to **significantly increase the percentage of the population that is able to live sustainably**.

PROJECT DATA

Location: Tucson, AZ
Climate Zone: 2B
Lot Size: 1 acre
Building Size: 6,142 ft^2, 1 story
Occupancy: 31 (200 ft^2/person)
Construction Cost: $ 755,491.18
Energy Performance:
HERS score (before solar): 32
HERS score (with solar): 5
Average Utility Cost: $12.63/month
Total Carbon Emissions:
39,285 CO2e/ft^2/yr

TECHNICAL SPECIFICATIONS

R-Values:
Wall: R31 Windows: U.22 SHGC.21
Roof: R68
HVAC:
Energy Recovery Ventilator (ERV)
Heat Pump Reverse Action Chiller
Dehumidifier
Radiant Floor and Ceiling
On-Site PV: 15 kWH

PARTNERS

Habitat for Humanity - Tucson
Otterbein Engineering
Technicians for Sustainability
Culdesac
Chiltrix
Zola Windows
Nyle Water Heating Systems

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ARCHITECTURE

Casa Verde relies on traditional Tucson building forms and materials to evoke a desirable sense of place. Its pared-back form optimizes seasonal solar exposure and thermal boundary efficiency, while placing community at the center of the design with a neighborhood courtyard.

ENGINEERING

The structure is designed to implement Habitat for Humanity's wood frame prefabrication system. Paired units group ventilation, radiative cooling, and water systems along their shared wall. The simplified exterior form fully separates the building envelope from these building systems, creating efficient control layers. Combined with advanced wood stud construction, these moves prioritize ease of construction, low cost, and energy efficiency for increased scalability.

MARKET ANALYSIS

Cost-effective materials, such as wood-stud walls and cellulose insulation, combine with labor-efficient prefabrication methods to reduce construction costs. Lower maintenance and utility costs make Casa Verde less expensive than typical low-income housing in South Tucson over a 30-year span, while the neighborhood courtyard provides unmatched social benefits for single parents and young adults in need of community.

DURABILITY & RESILIENCE

The building envelope meets PHIUS prescriptive standards for ASHRAE Climate Zone 2B, decreasing energy dependance. An optimized building form with an effective thermal control layer is combined with the use of passive design strategies to make Casa Verde comfortable as much as 55% of the year, even in a power outage.

EMBODIED ENVIRONMENTAL IMPACT

An advanced wood frame structure is selected for its low carbon footprint and material usage, and is a well-known construction method among local contractors. Cellulose insulation is used for its similarly low carbon footprint. A recycled aluminum roof adds durability while keeping carbon costs low. Organization of units into pairs in a rowhouse layout significantly reduces material usage, especially within the building envelope.

INTEGRATED PERFORMANCE

The vernacular courtyard form minimizes exterior wall surface area to reduce cooling needs, and also provides optimal orientation for daylighting, solar exposure, and natural ventilation. Community-led prefabrication reduces material usage and increases scalability, while shared walls organize active systems and free alternating walls for phase change material implementation. Passive and active radiative surfaces create improved energy efficiency, human comfort, and better air quality.

OCCUPANT EXPERIENCE

Casa Verde provides a high quality of life for low-income residents with a streamlined layout that provides access to ample amenities without compromising individual agency. Accessible restrooms, ventilation systems, plumbing, and radiative cooling systems are organized along one wall to create open floor plans. Orientation toward a neighborhood courtyard generates a connection with the outdoors and the greater community.

COMFORT & ENVIRONMENTAL QUALITY

Radiative cooling systems and Phase Change Materials provide more effective passive and active temperature control methods than forced-air heating and cooling, and additionally improve air quality. Occupant-controlled daylighting and natural ventilation reduce reliance on active systems. Shared unit walls feature acoustic insulation to maintain privacy.

ENERGY PERFORMANCE

Casa Verde is designed to minimize internal and external heat gain to reduce the cooling need, and uses passive cooling strategies and high performance systems to create human comfort while improving energy performance. A solar array on the south-angled roof meets the remaining energy demand by harvesting ample solar radiation, cutting the HERS score from 32 to 5.