U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

SOLAR TEXAS

Texas A&M University

Solar Texas

Architecture Jury

March 28, 2023

Architecture Jury Project Highlights

The highlighted components of the *Solar Texas* design include:

- To break the cycle of poverty for the target audience
- To reduce the region's dependence on nonrenewable natural resources
- To leverage knowledge from the region's vernacular architecture by aligning passive strategies with integrative and active design solutions
- To balance natural and artificial light with adaptive and controllable system design approaches
- To integrate leading-edge research that improves the built environment
- To develop new opportunities for academic and industry partnerships

The *Solar Texas* team proposes the following contest-by-contest approach for addressing the Build Challenge goals:

Response: The project's architecture aims to combine increasing social aspects, integrate sustainable technologies, and increase living space to integrate work connectivity. With the growing risk of climate change, the team has been focussing on a strategy of passive survivability for residents. The project will encourage a direct relationship to the site from the overall Texas vernacular utilizing long horizontal brick (king brick) to the usage of passive sustainability using Architectural and advanced systems to accommodate the overall site conditions. The team has explored a range of single-story building typologies. A common goal is to use spaces that are liveable and functional effectively. Although the proposed organization of the house necessarily aligns with the axis of the Habitat for Humanity site we were given, the team has responded to the need to maximize the use of solar energy on the site through the orientation of our proposed photovoltaic system. The interior layout optimizes conditioned spaces and uses programmatic buffers to order the flow of the house. Doing so minimizes the need for air conditioning despite setting in a climate Zone 2A site as shown in Figure 1. The spaces have been designed to be easy to maintain. The kitchen serves as the heart of the home that connects to a unifying dining room and living room area, enabling adaptability for small meals and large dining while serving as a centralized community space for the target market to share their daily experiences. The bedrooms include seasonal storage and work areas for studying and paying bills. The large bathroom will serve as a FEMA-compliant safe room as protection in the event of tornadic activity while maintaining its core functionality. The additional bathroom area will provide functional, simple, yet elegant solutions that maximize daylighting for the master bedroom. The project also takes its cues from the surrounding natural context. The proposed larger-scale project will develop a *Solar Texas* community with centralized functions and walking trails. The development and the project site will utilize Low-Impact Development (LID) concepts to maximize opportunities for Habitat for Humanity families while bringing solar and sustainability-oriented architecture to Brazos County, TX. As the project aligns with AIA's 2030 Challenge, *Solar Texas* will aim for carbon neutrality and financial attainability for our demographic target market.

Building Orientation

The building is rotated ∠34-degrees from the True North (north-south) axis. In this design, the solar panels are oriented toward the south. The roof design maximizes the number of PV panels while enabling soft, northerly light inflow into the house's primary public spaces (living room, kitchen, and dining room). Therefore, the design has a scheme that generates enough power to achieve net-zero energy while enabling controlled light to enter the house. The family room and kitchen face southwest, so they can utilize the warmth of the southern sun. Since the bedrooms face southeast, the size of their window openings has been optimized to protect the building from the eastern sun. The building is accessible from the northern part of the site. A shed is also provided beside the building since it is required for all Habitat for Humanity Houses.

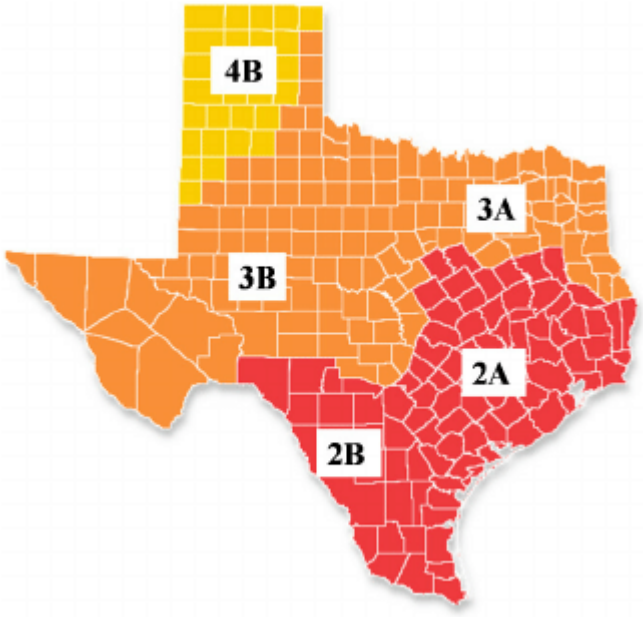


Figure 1: ASHRAE Climate Zones in Texas Building Program
Mukhopadhyay, J., Baltazar, J. C., Kim, H., & Haberl, J. (2011). Comparison of ASHRAE Standard 90.1, 189.1 and IECC Codes for Large Office Building in Texas), Energy Systems Laboratory, Texas A&M University.

Energy Performance:
Through the use of the Life Cycle Assessment, Solar Texas was able to monitor the reduction of the environmental impact of this home. As shown in Figure 2, Solar Texas has worked digitally to reduce the EC amount. This tool highlights the energy use and the correlated environmental impact affiliated with each phase of the building's life. The technique identifies and quantifies the environmental loads concerned with the dwelling. On the left is a basic home that habitat for humanity builds. Conversely, on the right is Solar Texas's proposed home. The drastic difference can be seen when comparing these two homes.

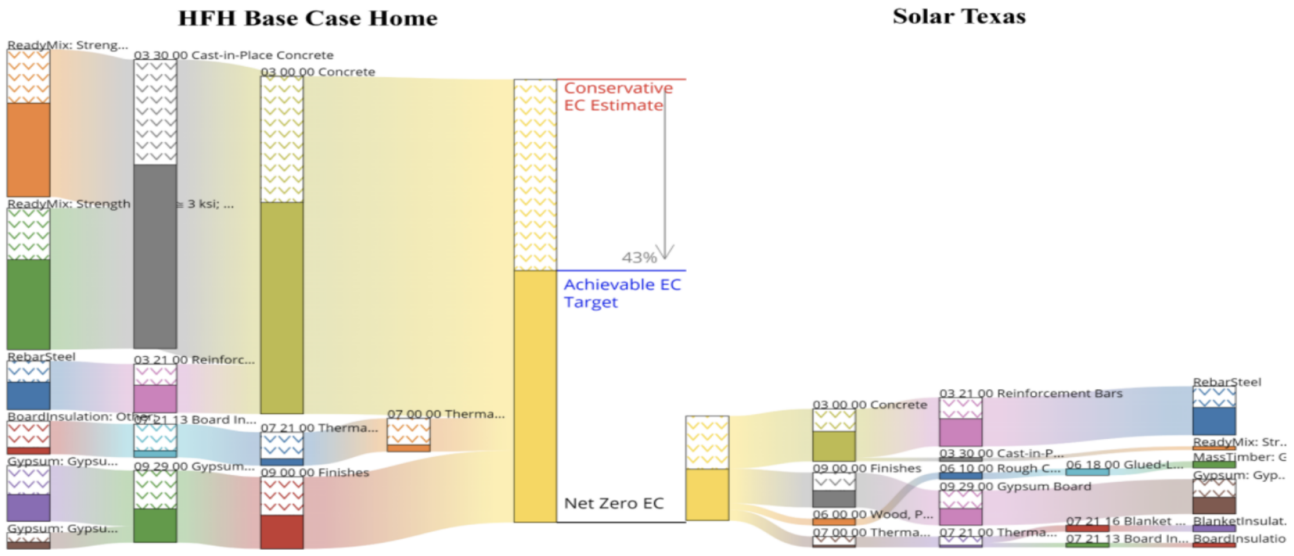


Figure 2: Life Cycle Assessment

Impact Evaluation

Solar Texas exceeds its net-zero energy status with a HERS score of -37 in accordance with reducing the home's environmental impact. Through several design strategies, Solar Texas has reduced energy consumption and implemented ways to self-produce enough energy to function on its own. This "net zero" target promotes the depletion of greenhouse gas emissions by balancing the amount of these harmful gasses in the atmosphere. This, in turn, will reduce the home's carbon footprint which is the ultimate goal in responding to climate change.

Energy Performance:
By implementing environmentally sustainable features, this proposed home is able to have an annual energy impact of "net zero." Through reducing energy consumption, Solar Texas was able to decrease the electrical load on the home significantly. Some design features that allowed this home to decrease the load so significantly include: building orientation, window type, window-to-wall ratio, roof and wall insulation, reducing HVAC loads, use of energy-efficient utilities, and infiltration rate. In order to reduce the energy consumption of the buildings, the home is also proposed to provide substantial amounts of clean energy that allow this dwelling to be deemed net zero energy. Solar Texas's home is able to produce a significant amount of solar energy using PV and BIPV solar photovoltaic panels. The average home in the United States typically consumes around 10,000 kWh per year from the grid. Per Figure 1, the Sefaira default CO_{2e} values per kWh is 1.213 pounds for the region in which our proposed home is located. Thus, a typical home emits around 12,130 CO_{2e} per year. However, Solar Texas's proposed home is achieving net zero energy consumption. Thus, through this net zero milestone, this home is saving about 12 thousand pounds of CO_{2e} per year compared to the average home.

Achieving LEED Standards

LEED v4.1 Residential: Single Family
Project Checklist

Project Name: Solar Decathlon Texas
Date: 03/27/2023

Y	?	N			
			Credit	Integrative Process	2

10	0	0	**Location and Transportation**		10
Y			Prereq	Floodplain Avoidance	Required
			PERFORMANCE PATH		
10			Credit	LEED for Neighborhood Development Location	10
			PRESCRIPTIVE PATH		
			Credit	Site Selection	6
			Credit	Compact Development	1
			Credit	Community Resources	1
			Credit	Access to Transit	2

5	0	0	**Sustainable Sites**		5
Y			Prereq	Construction Activity Pollution Prevention	Required
1			Credit	Heat Island Reduction	1
2			Credit	Rainwater Management	2
2			Credit	Non-Toxic Pest Control	2

11	0	0	**Water Efficiency**		15
Y			Prereq	Water Use	Required
Y			Prereq	Water Metering	Required
			PERFORMANCE PATH		
			Credit	Total Water Use	15
			PRESCRIPTIVE PATH		
8			Credit	Indoor Water Use	11
3			Credit	Outdoor Water Use	4

39	0	0	**Energy and Atmosphere**		40
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Energy Metering	Required
Y			Prereq	Education of the Homeowner, Tenant, or Building Manager	Required
36			Credit	Annual Energy Use	36
1			Credit	Efficient Hot Water Distribution System	2
1			Credit	HVAC Start-Up Credentialing	1
1			Credit	Refrigerant Management	1

11	0	0	**Materials and Resources**		12
Y			Prereq	Certified Tropical Wood	Required
Y			Prereq	Durability Management	Required
3			Credit	Durability Management Verification	3
4			Credit	Environmentally Preferable Products	5
2			Credit	Construction Waste Management	2
2			Credit	Material Efficient Framing	2

14	0	0	**Indoor Environmental Quality**		16
Y			Prereq	Ventilation	Required
Y			Prereq	Combustion Venting	Required
Y			Prereq	Garage Pollutant Protection	Required
Y			Prereq	Radon-Resistant Construction	Required
Y			Prereq	Air FIltering	Required
Y			Prereq	Compartmentalization	Required
3			Credit	Enhanced Ventilation	3
3			Credit	Contaminant Control	3
6			Credit	Balancing of Heating and Cooling Distribution Systems	6
2			Credit	Low Emitting Products	4

3	0	0	**Innovation**		6
Y			Prereq	Preliminary Rating	Required
2			Credit	Innovation	5
1			Credit	LEED AP Homes	1

0	0	0	**Regional Priority**		4
0			Credit	Regional Priority: Specific Credit	1
0			Credit	Regional Priority: Specific Credit	1
0			Credit	Regional Priority: Specific Credit	1
0			Credit	Regional Priority: Specific Credit	1

93	0	0	**TOTALS**	Possible Points:	110

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

Figure 3: LEED for Homes: Aiming for platinum

LEED for Homes

The Solar Texas team has sought to further challenge itself by earning a LEED Platinum rating. According to LEED v4.1, a platinum rating requires evidence that between 80 to 110 points are justifiable based on fulfilling specific LEED categories. Figure 3 represents a tabulation we believe we will achieve once the home is constructed based on our design and calculations. We calculate that our residence can earn at least 93 points, sufficient for a LEED Platinum certification. The following summarizes how we will achieve this rating.

Location and Transportation (LT):
Prerequisite: Floodplain Avoidance The site is not in a flood hazard area.

LEED for Neighborhood Development Location (10/10). We will address these points using performance-based justification.

Sustainable Sites (SS):

Prerequisite: Construction activity pollution prevention The construction site will ensure the protection of the stockpile and topsoil by storing cleared vegetation, allowing it to decompose and later be repurposed as usable topsoil. The runoff will be controlled with silt fencing.

Heat island reduction (1/1) Option #1 is used to meet the goal. The heat island effect will be avoided by ensuring that at least 50% of roof and sunroof hardscapes (not including common roads that serve multiple buildings) on the site meet this requirement. The structures of the energy generation systems, such as solar thermal collectors, photovoltaics, and wind turbines, are expected to contribute to the reduction of the heat island.

Rainwater management (2/2) To manage rainwater, we will use option #2 (Basic Landscape Design). The turf will not be used in heavily shaded areas, nor in areas with a slope of 25% or greater. No invasive plant species will be introduced to the landscape, and mulch/soil amendments will be added after the viability of soil is verified. In addition, all compact soil will be tilled at least 6 inches and the land will be given a graded 5% slope to drain water away from the structural foundation.

Non Toxic pest control (2/2) We will minimize pest problems and risk of exposure to pesticides by (i) designing discharge points for rain gutters, air conditioning condensation lines, steam vent lines, and any other moisture source (such that discharge is at least 24 inches from the foundation) and (ii) sealing all external cracks, joints, penetrations, edges, and entry points with appropriate caulking. Rodent and corrosion-proof screens (e.g., copper, or stainless-steel mesh) will be installed on all openings greater than ¼ inch, except where code prohibits their installation.

Water Efficiency (WE):

Prerequisite: Water use. We will address these points using prescriptive-based justification.

Prerequisite: Water Metering
Indoor Water Use (8/11) Solar Texas plans to install WaterSense labeled high-efficiency dual flush toilets, faucets, and shower heads. In addition, the implementation of Global Waste Solution (GWS) smart valves is expected to reduce water usage by up to 30%. To further optimize water usage, the water heater will be centrally located, minimizing the travel time and distance to the delivery points, which will help to minimize water wastage when hot water is desired at different points.

Outdoor Water Use (3/4) The building features a butterfly roof that enables the capture of rainwater in the centrally located drain in between the two slopes facing each other. The collected water will be collected in a rainwater harvesting cistern and used primarily for watering plants, reducing the use of potable water (or other natural surface or subsurface water resources) for landscape irrigation and thus reducing outdoor water consumption.

Energy and Atmosphere (EA):

Prerequisite: Minimum energy performance By achieving a HERS score of -37 (Figure 4) and obtaining ENERGY STAR (Figure 5) for Homes, Solar Texas will successfully minimize energy performance. The project has met the ENERGY STAR v3.1 (after Rev. 09) standards and the SAF and ENERGY STAR HERS Index Target requirements. Additionally, ENERGY STAR-qualified appliances have been acquired and will be installed, including a refrigerator, dishwasher, and clothes washer. Finally, all duct runs will be fully ducted insulated and within the thermal envelope, ensuring optimal energy efficiency.

Prerequisite: Energy metering Solar Texas will install whole-house electricity to monitor energy use over time.

Prerequisite: Education of Homeowner, Tenant, or Building Manager We will provide an operations and maintenance manual and binder to Habitat for Humanity for their residents, who will be responsible for the maintenance of the home. HfH will then use this information for training the families during their transitionary stay on the operation and maintenance of LEED features and equipment.

Annual energy use (36/36) The building will undergo regular upgrades such as proper insulation, sealing leaks, and installing energy-efficient appliances and high-efficiency heating and cooling systems. For instance, the building will utilize a mini-split with a zoning system verified by the US Department of Energy to save up to 30% on electricity consumption. Source Advisors and Ekotrope software evaluated the building's HERS score and adjusted it with a Size Adjustment Factor (SAF) of 1.00, resulting in a HERS Index (SAF Adjusted) of -37. The building achieved 36 points for meeting the HERS Index Rating and being below the ENERGY STAR HERS Index Target (SAF Adjusted).

Efficient Hot Water Distribution System (1/2) To comply with this requirement, we will design and install an energy-efficient hot water distribution system that meets the maximum pipe length requirements (Path 1) or maximum pipe volume limits (Path 2) while ensuring that all heat-traced piping is insulated. We may use multiple water heaters and multiple distribution systems to comply with this credit. The circulating pump will not operate continuously and will be demand-activated by a momentary contact switch, motion sensor, flow switch, door switch, or voice command. Additionally, controls will allow the pump to operate until the water temperature in the return pipe rises not more than 10ºF (6 ºC) above the initial temperature of the water in the pipe. The controls will also limit the water temperature to a maximum of 105ºF (40 ºC) and the pump operation to not more than 5 minutes per activation in the event that both means of shutting off the pump have failed. Lastly, the circulating hot water systems will have an automatic or readily accessible manual switch to turn off the hot water circulating pump when not in use.

HVAC start-up credentialing (1/1) The heating systems shall be installed by a licensed HVAC contractor that has completed the ENERGY STAR for Homes, version 3, HVAC system quality installation contractor checklist, or equivalent as defined by USGBC. Solar Texas will ensure that the credentialed technician will commission all heating, cooling, and ventilation systems.

Refrigerant Management (1/1) A cooling system will be employed that contains a refrigerant called R-454b with a global warming potential (GWP) of less than 50.

Materials and Resources (MR):

Prerequisite: Certified tropical wood All wood in the building will be non-tropical, reused, reclaimed, or certified by the Forest Stewardship Council or USGBC-approved equivalent. For example, cabinets in the kitchen and bathroom will be manufactured by Kent Moore Custom Cabinets. This company uses waterborne finishing materials, environmentally approved construction materials, non-tropical wood, reduced waste, and recycled materials.

Prerequisite: Durability management The durability requirement will include the water management system and interior moisture control measures. The water management system will meet the Energy Star for Homes (version 3, water management system builder requirements). The interior moisture control measures will be in the kitchen, bathroom, laundry room, and spa area. It will be placed in the entryway within 3 feet of the exterior door accessible from the ground. A water heater tank will be installed in or over the living space with a drain and drain pan, and a clothes washer and dryer will be placed in the living space. The dryer will directly vent to the outdoors. There will also be a plumbing system for the building and irrigation.

Durability management verification (3/3) There are three options for durability management verification. Option one is a water management system, option two is the overhangs (provided for all exterior doors), and option three is the plumbing condensation control (cold water piping will not be installed in unconditioned spaces.

Environmentally Preferable Products (4/5) Multiple aspects of the building will be environmentally preferred products. The floor covering, drywall (interior finish), and framing will all be environmentally preferred. The flooring in the kitchen, living area, and bedroom will be exposed sealed concrete. The floor in the bathroom area will be tile. The drywall will be a gypsum wallboard that features an innovative, noncombustible gypsum core encased in a 100% recycled blue face paper that controls water absorption, provides a strong plaster bond, and resists plaster sliding or slipping under the trowel. FSC-certified wood studs #2 grades will be used for the framing. McCoy's, a local building supplier that promotes green building supplies and positive environmental stewardship throughout the forestry sector, supplied the products to the team.

Construction Waste Management (2/2) To minimize waste, Solar Texas plans to weigh trucks upon entry to Twin Oaks Waste and Landfill located at 2690 SH 30 Anderson, TX 77830. Our approach aligns with the mission of Habitat for Humanity to optimize material ordering and maximize the use of discarded materials through controlled collection and centralized storage for reuse. By implementing these measures, we aim to reduce the total amount of waste material generated during construction.

Material Efficient Framing (2/2) Two ways to efficiently frame the building are to space the roof rafters and to space the interior wall studs. The roof rafters will be 16 inches apart, and the wall studs will be greater than 16 inches.

Indoor Environmental Quality (EQ):

Prerequisite: Ventilation The ventilation of the building meets the requirements. It features combustion venting (there is use of electrical appliances) and radon-resistant construction. As the project does not have a garage, there is no need for pollutant protection.

Enhanced ventilation (3/3) The equipment to be used satisfies the requirements of enhanced ventilation.

Contaminant control (3/3) Three actions will be taken to ensure contamination control. Walk off mats will be placed at the entrances to the home, a pre-occupancy flush will be conducted before the occupants move in, and an exhaust fan will be placed in the laundry or utility room of the house.

Balancing of heating and cooling distribution systems (6/6) Quiet heating and cooling systems will be installed, as well as dehumidification equipment able to maintain humidity at or below 60%. The heating and cooling system fan airflow will be tested to confirm it is within the requirements. For pressure balancing, each bedroom will demonstrate a pressure difference of no more than 3 Pa compared to the main body of the house. Lastly, multi-stage equipment will be used. A variable stage space heating and cooling system (with more than 2 speeds) will be installed.

Low emitting products 2/4) Products used as mentioned in the product listing will be low-emitting products. For example, we will use open cell foam insulation rather than closed-cell foam insulation due to the reduced volatile organic compound outgassing of the former.

Innovation (IN):

Prerequisite: Preliminary Rating Products used as mentioned in the product listing will be low-emitting products.
Innovation (2/5) This project is eligible for Platinum-Certification and has seven points of innovation. Firstly, it includes a FEMA-compliant safe room with a thickened slab and optimized private bedrooms. Secondly, the building features a butterfly roof for rainwater harvesting, which can be used for non-potable purposes. Thirdly, the building has high-performance windows and a sloped roof to provide natural light and promote healthy circadian rhythms. Fourthly, the embedded design allows for complete disassembly for repurposing. Fifthly, the whole building design approach considers materials' strength, durability, and embodied energy. Sixthly, the house has a continuous public sector with all water access centrally located. Lastly, the Solar Texas team is developing new shading tools to improve performance.

LEED AP Homes (1/1)
Regional Priority (RP): The following points are not currently designed into the project (and therefore, points are not included in our LEED Platinum calculation), but are certainly possible for the future.

Water efficient landscaping (0/1) For lower water bills in the future, the building could be focused on limiting or eliminating the use of potable water (or other natural surface or subsurface water resources) available on or near the project site for landscape irrigation.

Water use reduction (0/1) It is conceivably possible to reduce the water from the municipal water supply and use natural water as much as possible. This will increase water efficiency and reduce the use of municipal water supply.

Optimize energy performance (0/1) This project can be designed for minimal consumption of artificial lights and maximum usage of natural resources. This would also efficiently create load reduction and HVAC systems for the project.

Enhanced commissioning (0/1) Enhanced and monitoring-based commissioning could be used to assess the performance of energy and water consumption systems. This project could engage envelope commissioning.

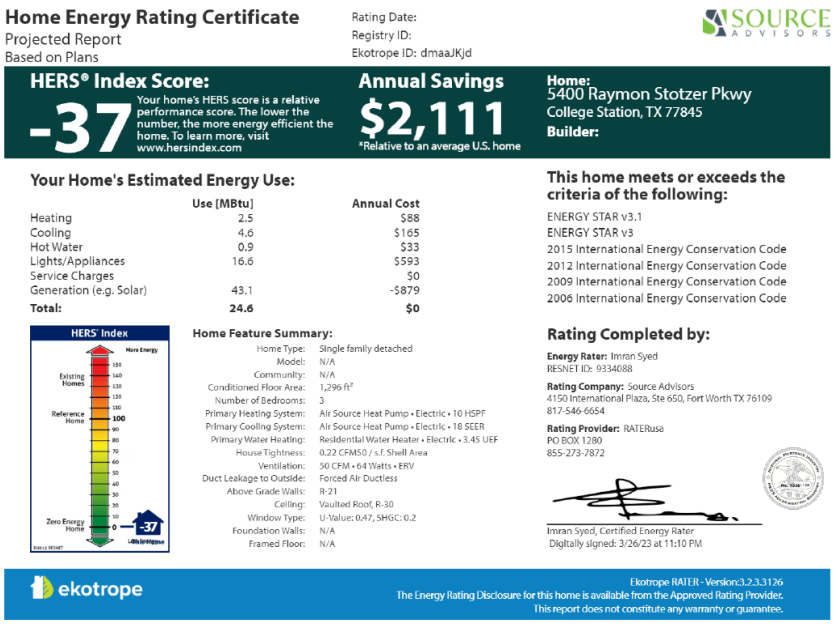
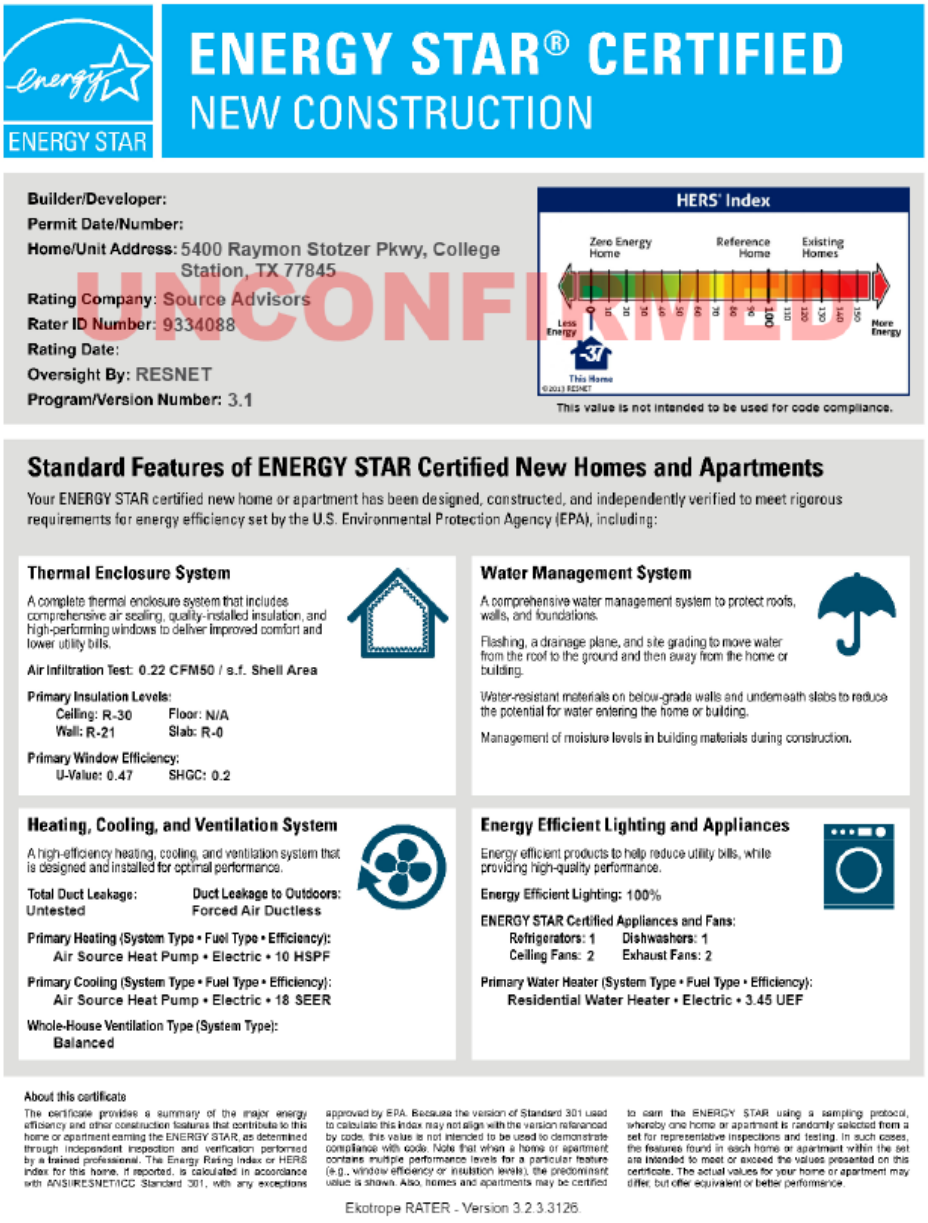


Figure 4. HERS rating of -37 of Texas Solar home design by independent certification.



ENERGY STAR® CERTIFIED
NEW CONSTRUCTION

Builder/Developer:
Permit Date/Number:
Home/Unit Address: 5400 Raymon Stotzer Pkwy, College Station, TX 77845
Rating Company: Source Advisors
Rater ID Number: 9334088
Rating Date:
Oversight By: RESNET
Program/Version Number: 3.1

HERS® Index
Zero Energy Home
Reference Home
Existing Homes
Less Energy
More Energy
This Home
This value is not intended to be used for code compliance.

Standard Features of ENERGY STAR Certified New Homes and Apartments

Your ENERGY STAR certified new home or apartment has been designed, constructed, and independently verified to meet rigorous requirements for energy efficiency set by the U.S. Environmental Protection Agency (EPA), including:

Thermal Enclosure System
A complete thermal enclosure system that includes comprehensive air sealing, quality-installed insulation, and high-performing windows to deliver improved comfort and lower utility bills.
Air Infiltration Test: 0.22 CFM50 / s.f. Shell Area
Primary Insulation Levels:
Ceiling: R-30 Floor: N/A
Wall: R-21 Slab: R-0
Primary Window Efficiency:
U-Value: 0.47 SHGC: 0.2

Water Management System
A comprehensive water management system to protect roofs, walls, and foundations.
Flashing, a drainage plane, and site grading to move water from the roof to the ground and then away from the home or building.
Water-resistant materials on below-grade walls and underneath slabs to reduce the potential for water entering the home or building.
Management of moisture levels in building materials during construction.

Heating, Cooling, and Ventilation System
A high-efficiency heating, cooling, and ventilation system that is designed and installed for optimal performance.
Total Duct Leakage: Untested
Duct Leakage to Outdoors: Forced Air Ductless
Primary Heating (System Type • Fuel Type • Efficiency):
Air Source Heat Pump • Electric • 10 HSPF
Primary Cooling (System Type • Fuel Type • Efficiency):
Air Source Heat Pump • Electric • 18 SEER
Whole-House Ventilation Type (System Type):
Balanced

Energy Efficient Lighting and Appliances
Energy efficient products to help reduce utility bills, while providing high-quality performance.
Energy Efficient Lighting: 100%
ENERGY STAR Certified Appliances and Fans:
Refrigerators: 1 Dishwashers: 1
Ceiling Fans: 2 Exhaust Fans: 2
Primary Water Heater (System Type • Fuel Type • Efficiency):
Residential Water Heater • Electric • 3.45 UEF

About this certificate

The certificate provides a summary of the major energy efficiency and other construction features that contribute to this home or apartment earning the ENERGY STAR, as determined through independent inspection and verification performed by a trained professional. The Energy Rating Index or HERS index for this home, if reported, is calculated in accordance with ANSI/RESNET/ICC Standard 301, with any exceptions approved by EPA. Because the version of Standard 301 used to calculate this index may not align with the version referenced by code, this value is not intended to be used to demonstrate compliance with code. Note that when a home or apartment contains multiple performance levels for a particular feature (e.g., window efficiency or insulation levels), the predominant value is shown. Also, homes and apartments may be certified to earn the ENERGY STAR using a sampling protocol, whereby one home or apartment is randomly selected from a set for representative inspections and testing. In such cases, the features found in each home or apartment within the set are intended to meet or exceed the values presented on this certificate. The actual values for your home or apartment may differ, but offer equivalent or better performance.

Ekotrope RATER - Version 3.2.3.3126

Figure 5. Impact of Energy Star appliances specified