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Design Portfolio for The Tri-Cities Homestead 2.0: A Second Look at a DOE Solar Decathlon Net Zero Home Design

Talia Dreicer
Western Washington University

THE TRI-CITIES HOMESTEAD 2.0

A Second Look at a DOE Solar Decathlon Net Zero Home Design

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Advised by Dr. Imran Sheikh

Introduction

The Tri-Cities Homestead 2.0 is a re-evaluation of a 2021 Department of Energy Solar Decathlon Challenge (SDC) project entitled The Tri-Cities Homestead. The Solar Decathlon Design Challenge is a 10 contest, collegiate competition where interdisciplinary teams design efficient homes powered by renewable energy. Teams submit an initial project proposal which is used to select 10 finalists per division. These finalist teams have the opportunity to present live in front of a panel of judges at the competition event. First, second, and third place honors are awarded within each division and the first-place teams are then asked to present again, competing for the title of challenge Grand Winner.

The original Tri-Cities Homestead was designed by a team of seven Western Washington University students with a variety of educational backgrounds, all passionate about energy efficient home design. The design was selected as a Division Finalist in the Suburban Single-Family Division after the initial project proposal. The team worked to complete the project, writing a Design Narrative, and recording a presentation for the division judges to review before the live event. In April 2021, four team members presented live over Zoom for a panel of judges at the Competition Event, describing the house design and answering questions posed by the judges. Unfortunately, the design did not place in this final event, but the team learned and grew significantly throughout the process.

Serving as the team lead for the SDC team gave me a significant appreciation for the challenges of organizing a team in a short period of time. Despite many challenges, we came up with a design which we were proud of and felt comfortable presenting to the judges. The road to this final product was not smooth and much of our submitted material was imperfect, resulting in specific questions and constructive criticism from the judges. After completing and reviewing the project and answering questions from the judges during the live presentation, I noticed some significant errors and issues with the original design. I felt that the basis of the house was solid but that the design at a whole could use some improvements in the overall effectiveness of design strategies and accuracy of energy and costing analysis.

I decided to take a second look at the original Tri-Cities Homestead design with the goal of reflecting on the original design, correcting inaccuracies, and working to create a more energy efficient and cost-effective home design. With a solid understanding of where the original project had gone astray, based on judges' feedback and personal critiques, I also approached the Tri-Cities Homestead 2.0 design as an opportunity to do design characteristic comparisons. By analyzing design characteristics and identify the measures that created the greatest efficiency increases for the lowest cost, I planned to create a more robust and realistic building design.

To complete the goals of this project, I completely redid the analysis elements of the original Solar Decathlon Challenge as well as the 2D and 3D renderings. Significantly more detail was added to all analysis and additional comparisons of design elements separate the 2.0 design version from the 1.0 version. Elements of the floorplan, building envelope, HVAC system, and solar system were redesigned and adjusted. Some of the base design components remained the same, particularly the location and sustainable material choices, and the work of the original team greatly influence the final Tri-Cities Homestead 2.0 design.

Various software programs were used to complete the analysis for this project: Ekotrope (a RESNET accredited RATER software used for energy analysis), RSMeans (construction costing estimation software), and SketchUP and AutoCAD (2D and 3D renderings). The results from this analysis software were used to make design decisions and the software will be referred to throughout this portfolio.

As a redesign of a different project, this paper will address the changes that were made to design elements, the logic behind those decisions, and the comparative analysis of design elements methodology and results. There is also an appendix which contains all analysis software outputs, renderings, and additional resources and information.

Property Location and Design Constraints

The property location and design constraints of the Tri-Cities Homestead 2.0 remained the same from the original design. The reasoning for our location choice and design constraints for our target market are described below:

When designing the original house for the Solar Decathlon Challenge (SDC), we were given few constraints. As a team of students from a Washington university, we were interested in keeping the home within the state but wanted to find a location with lower property costs and more solar potential than our university town of Bellingham, WA. For these reasons, we looked toward the southeast portion of the state, settling on the city of Kennewick, WA. Kennewick is located close to the confluence of the Yakima, Snake, and Colombia Rivers, approximately equidistant from Seattle and Portland. It is one of three cities that make up the Tri-Cities and features a population of around 81,000 people as of 2019.

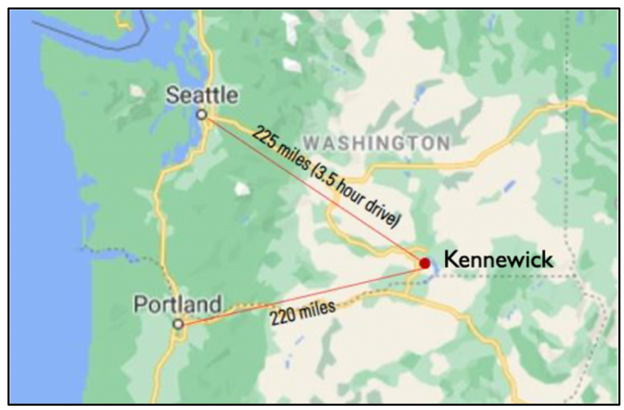

Figure 1: Location of Kennewick, WA relative to Seattle, WA and Portland, OR

The climate in Kennewick, WA is semi-arid with four distinct seasons. Summer are hot and dry with highs are in the 90’s and winter are cold and can have snow with lows are in the mid 20’s. The average high for the area is 66°F and the average low is 44°F. We chose a city with harsher winters but more sunny days than we usually get in WWU’s mild Bellingham, WA, to challenge ourselves with the solar and heating components. Kennewick experiences annual precipitation of around 8 inches and averages around 191 days of sunshine[1]. It is also important to note that Kennewick is in IECC climate zone 5B[2] and, according to the Energy Star Portfolio Manager Heating Degree Days calculator, Kennewick has an average of 4841 HHD65 and 1030 CDD65 (based on 2015-2020 data).

[1] (“Weather Averages Kennewick, Washington” n.d.)
[2] (“IECC Climate Zone Map | Building America Solution Center” n.d.)

Through exploration of online real-estate companies, we found a fantastic, empty parcel of land in the heart of Kennewick. Designing the home with a young family in mind, we sought to find a property with easy access to local amenities and schools, outdoor spaces, and an existing or growing neighborhood. The plot we chose is roughly triangularly shaped, located at the end of a Cul-de-sac, with one long side of the property against neighboring backyards and the other along a medium sized street. Lawrence Scott Park is just around the corner, featuring large open grassy space, tennis courts, a basketball court, and baseball fields. The property is nicely situated near a local shopping center and multiple local schools.

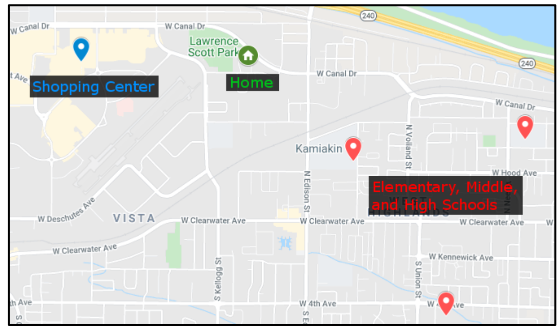

Figure 2: Location of chosen property relative to local schools, shopping center, and park.

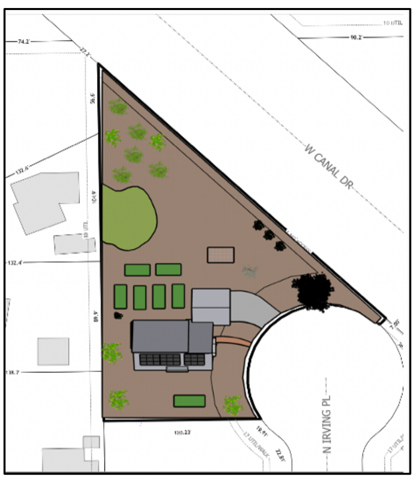

Figure 3: Site plan for the Tri-Cities Homestead 2.0.

In designing the house, we took into consideration local and state building codes. One of the biggest code-based challenges we ran into was ensuring the setbacks on the house and garage were adequate as code dictates that the house must have a minimum setback of 15’ and the garage must have a setback of 25’. These considerations and considerations of solar gains on the south side of the house helped to dictate its positioning on the chosen lot. Factors such as the roads and surrounding properties also influenced the positioning.

House Design

Architectural Overview

Many of the architectural details of the original and the 2.0 design are very similar. Both designs feature a long east-west axis and rectangular shape that optimizes passive and active solar gains. Extensive windows on the south side of the house provide both light and passive heating for the house in the winter. A sunspace along the south wall of the house brings the outdoor environment inside and serves as additional passive heating for the home.

Both designs feature a three-bedroom, two bath, split story design with the master suite located upstairs and the two remaining bedrooms and bath located downstairs. Both designs also featured an open concept living/dining/kitchen area with vaulted ceilings and an attached, unheated two car garage. The remaining elements of the internal floorplan did experience significant adjustments in the 2.0 version of the home. The original home had a long, heated breezeway between the main house and unheated garage. In the 2.0 version of the home, this breezeway was removed due to it being unnecessary heated space and was a significant heat and energy suck in the given climate.

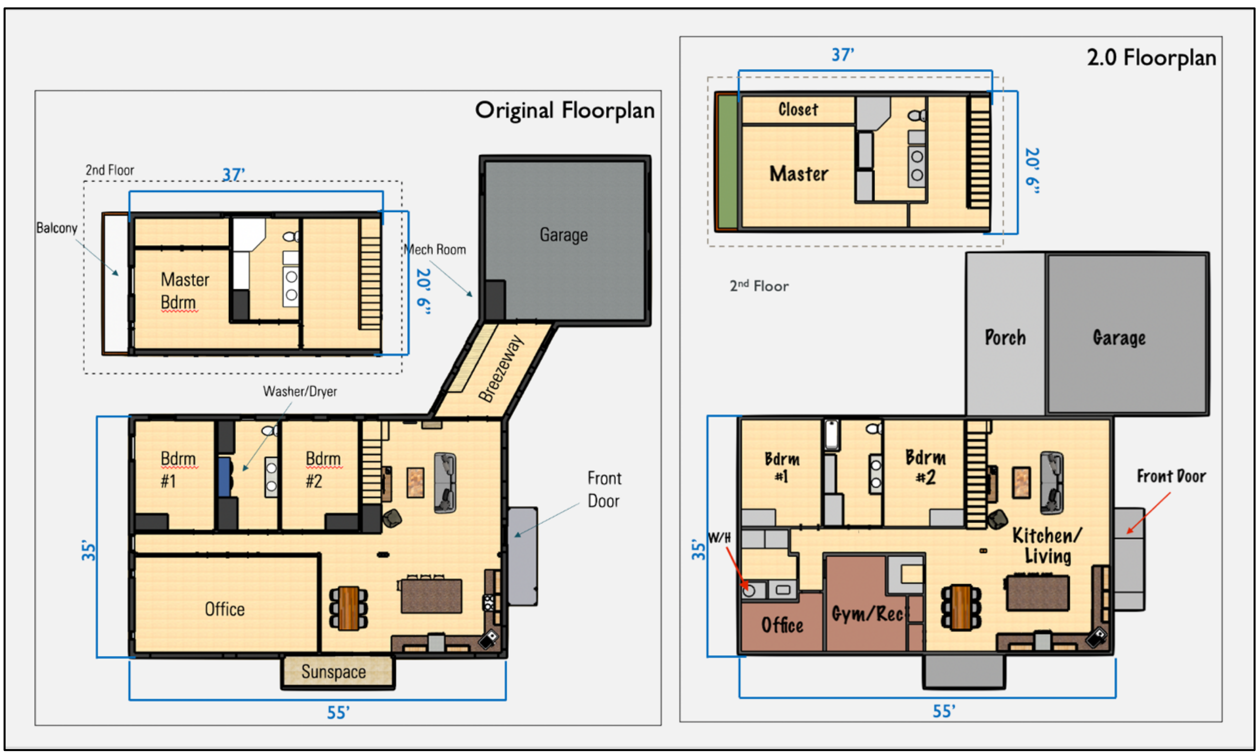

Figure 4: Side-by-side comparison of original floorplan and 2.0 Version floorplan.

The original design featured a large office space that could be divided in two for maximum utility. In the 2.0 version, the office space split into two smaller rooms (office and gym/recreation room) and a mud room/laundry room. This new design is much more functional as the mechanical closet was moved into the heated space (now located in the mud/laundry room) and the washer and dryer were moved from the downstairs bathroom to the mud/laundry room. By placing the mechanical closet in the heated space, and locating the washer and dryer in the same room, there was a significant reduction in the distance that hot water had to be piped throughout the house. The redesigned floorplan also allowed for the addition of more storage space in the form of two closets and a pantry.

The removal of the breezeway and a slight adjustment to the size of the sunspace resulted in an overall difference in the square footage of the two designs. The original house had 2,872 square feet of heated space and the 2.0 version of the house has 2,665 square feet of heated space.

Engineering Overview

Most of the engineering elements remained the same between the two homes. Both homes used the same framing and roofing materials and internal structural supports. The most significant difference between the two designs lay in the lack of accurate costing for the engineering elements in the original design.

The slab construction for both designs is similar, featuring a fully insulated 4 inch thick slab on grade, with 24 inch x 6 inch deep stem walls and 8 inch x 18 inch concrete footers. Under the slab and inside the footer walls, there is extruded polystyrene (XPS) foam board insulation. The thickness of this insulation does vary between the houses with the original house having 2 inches (R-10) and the 2.0 design comparing 2 inches (R-10) and 4 inches (R-20) of insulation[3]. Both designs also include a section of thicker concrete below the east-west running peak of the roof where there is a significant load on the wall and slab. This thicker slab area provides extra structural support to the wall and beams that support the intersection point of the roof.

Both designs used structurally insulated panels (SIPs) for the building envelope. SIP panels use a sandwich style insulation system with a foam core insulating material between two OSB plywood panels. The SIPs used in both designs used a graphite polystyrene (GPS) core. SIPs

[3] R-Values from HomeDepot.com

have a number advantages that made them worthwhile for use in these home designs. By using an integrated insulation system, and prefabricated panels that include window and door openings, SIPs provide a very tight seal for the home. With the addition of sealing any seams with foam insulation and SIP tape, infiltration into the house is extremely low. Not only are SIPs great for insulation and a tightly sealed house, but they also are structural walls, meaning they can support the roof and elements of the home without additional supporting. Another advantage of SIPs is the reduction in labor costs due to reduced framing time for a SIPs house compared to a traditional house. Since SIPs are prefabricated, the walls for a house can go up within days rather than over a few weeks time which is standard for a framed home. Although both the original and 2.0 design featured SIP exterior walls and roof, the thickness and thus R-value (insulation factor) of the walls differed in the two designs. The original design featured 8.25 inch thick, R-38 SIPs for both the walls and roof. The 2.0 design considered SIPs that ranged in thickness and R-values, comparing 6.5 inch (R-29), 8.25 inch (R-38) and 10.25 inch (R-48) wall and roof configurations.[4]

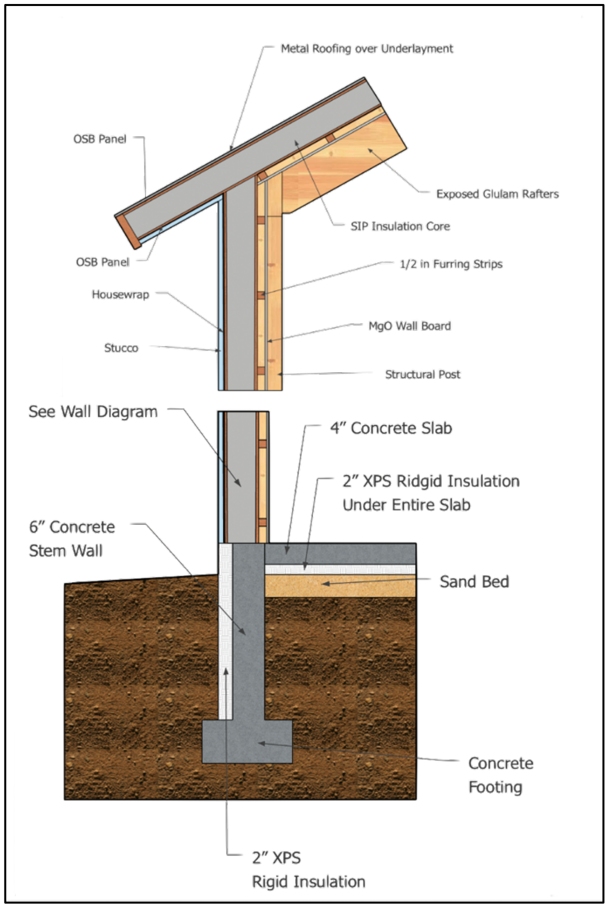

Figure 5: Detailed slab, wall, and roof assembly drawing.

Both houses feature the same external layer for their roofs and walls. Three coat stucco creates the most exterior surface on the wall assembly and metal roofing creates the most exterior surface on the roof assembly. Both the stucco and metal roofing sit on top of moisture barriers, an underlayment for the roof and Tyvek housewrap for the walls.

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[4] ("Premier SIPS Testing, Code Reports & Building Standards" n.d.)

The original and 2.0 designs both feature exposed north-south running beams that support the SIP roofs. They also feature additional exposed glulam beam and structural posts that helped support the middle SIP wall that runs east-west under the center roofline of the house. Structural beams and posts were also used in to construct the front porch off the front door and back porch of the 2.0 design which is located off the west side of the garage.

The internal wall framing, and garage framing was similar between the two designs. Both designs used locally sourced lumber and labor for the internal wall and garage framing and both designs used hemp insulation. The hemp insulation was chosen because it is a biobased, hypoallergenic material with a low carbon footprint, thermal resistance of R-3.7 per in, and is non-toxic, non-abrasive and easy to install. It also has significant flame-retardant properties. The specific details of the hemp insulation were not calculated correctly or considered in the original design. In contrast to this, correct costing was accounted for and specific hemp insulation products were carefully chosen in the 2.0 version. The interior was used 2 inch HempWool insulation with a R-7 value and the garage walls used 5.5 inch HempWool insulation with a R-20 value[5].

Windows and Lighting

The window designs for both houses were very similar in location of windows but there were significant changes to the number and type of windows that were used in each design. The original design featured many more windows than the 2.0 version does and the windows that were used in the energy modeling were not carefully selected. The 2.0 version removed a number of windows from the west and north sides of the house but kept the arrangement and number of windows the same on the south side.

The metrics that are important for energy analysis of windows were selected based on averages and the windows in the original design were not costed correctly. In the 2.0 design, the windows were carefully selected and the U-Values (insulation factor) and Solar Heat Gain

[5] ("HempWool" n.d.)

Coefficient (SHGC), a measure of how much solar radiation travels through a window and subsequentially heats the inside space, were considered and adjusted based on window location. The original design used only double pane windows while the 2.0 version of the design considered both double and triple pane windows. The original design did not consider changes in U-value or SHGC based on operability of windows and did not accurately cost all the windows in the design. The 2.0 design took operability into account and costed all windows as accurately as possible, basing all values on real vinyl windows.

	South	North	East	West
SGHC	high	low	low	low
U	low	low	low	low
Low E	either	yes	yes	yes

Figure 6: Window SGHC and U-Value considerations for 2.0

In consideration of passive solar gains through the south facing windows, both designs calculated the roof overhang length. By calculating the optimal overhang length, the designs optimize solar gains in the winter but reduce heat gains from the sun in the summer by shading the windows as much as possible. In conducting these calculations, the location of the house, height from top of wall to top of window, and time of year are important. For both designs, the optimal roof overhang was 3 feet 4 inches.

Light fixtures in both designs are 100% LED. Many of the lighting fixtures imagined for this house would include sliding dimers and any outdoor lights on the garage would include motion activation to reduce energy usage overnight. The large number of windows, particularly the clear story windows, combined with light colored walls provide significant daylighting, reducing the need for electric lighting within the home. These features existed in both designs.

Water Heating

The water heating system experienced a total redesign between the original and 2.0 versions. The original house water heating system was a combination of a solar thermal system and two tankless water heaters. While significantly more efficient than a traditional water heating system, which typically uses a natural gas tanked water heater, this water heating setup was not optimally efficient.

The 2.0 version updated the water heating system to be as efficient as possible, using a SanCO2 Heat Pump Water Heater instead of the previous system. This heat pump water heater is high efficient, with statistics of 80% savings over electric resistance water heaters and over 40% savings over other heat pump water heaters. The unit is also great for use in a house powered by solar as it has a relatively low power draw (>2000W)[6]. The system used in the 2.0 version of the Tri-Cities Homestead features a 119 gallon tank and 10 year warranty. An additional consideration in the 2.0 version that was not part of the original houses water heating system was the addition of a mini tank electric water heater in the kitchen. By adding this mini tank, a hot water line would not need to be run to the kitchen (the farthest point from the water heater) and could potentially reduce energy demands. The effectiveness of this heater was analyzed as part of the comparative studies conducted for this capstone project.

Heating, Ventilation, and Air Conditioning

The general ideas behind the HVAC system remained the same between the two design but the specific components were more carefully considered in the 2.0 version and some small changes were made. Both versions also featured smart thermostats in combination with their heating and cooling systems to increase efficiency.

In both versions of this house design, natural ventilation was considered. Operable windows were placed in all bathrooms to help ventilate moist spaces. Multiple windows on the side of the downstairs and many of the clearstory windows are operable to create a natural ventilation loop from downstairs to upstairs, helping to remove hot and dirty air from the house. This airflow system existed in both designs as well as a heat recovery ventilator (HRV). The HRV unit in the 2.0 design, like many of the other elements in the house, was much more carefully designed than the original house, where the specifications used in the energy modeling were arbitrarily selected. In the 2.0 version, a Zehnder ComfoAir 200 HRV was selected based on its size and efficiency. With a ventilation rate of up to 118 cubic feet per

[6] (ECO2 Systems, n.d.)

minute and a 90% energy recovery percentage[7], the 2.0 version HRV provides adequate clean air for the home throughout the day and night. An HRV unit is necessary because the other elements of the home design create such a tight seal that there is little airflow into the house. The HRV unit brings in clean air and removes old, stale air from the house while also conducting a heat transfer of the two airflows, helping bring in fresh air but not dramatically reduce or increase the temperature inside the home.

The heating and cooling setup of the two designs, like the ventilation system, is very similar but based on more accurate metrics. Not only are the efficiencies and sizing of the heating and cooling system more accurate in the 2.0 version, but the type of heating for the radiant hydronic floors is slightly different. While both homes featured radiant hydronic floors for heating much of the downstairs, the hot water for the original system was produced using the solar thermal system while the 2.0 version is heated using the SanCO2 heat pump water heater. Both designs also feature mini split ductless heat pump, but the sizing and costing of the 2.0 version was more accurate and the 2.0 version conducted a comparison of different sizing combinations for the heat pump and radiant systems.

Solar Setup

The solar setup of the original Tri-Cities Homestead had some significant issues that were addressed in the redesign for the Tri-Cities Homestead 2.0. The original house design featured a 7.9kW photo voltaic system using Panasonic HIT Solar Panel 330W 96 Cell BOW and a 13.5 kWh Tesla Powerwall battery. One of the key differences between the original system and the 2.0 version was the overall sizing. The 2.0 system is significantly larger, in order to account for an electric vehicle, an element the original team did not consider adding. The PV setup of the original house was size precisely to make the house net zero and resulted in a Home Energy Rating System Index (HERS) of 0 for the original house. This HERS rating indicates that the house produced enough electricity from its PV system to offset its electricity demand.

[7] (“CA200-Specifications-2019.08.30.Pdf” n.d.)

The solar system of the 2.0 design was sized to cover the electric needs of the house and account for the electric demand for an electric vehicle. The additional demands of the electric vehicle were estimated to be around 3,000 kWh of load per year. With this additional load in mind, the system was sized using an estimated 33kWh per day of electric consumption. With this in mind, a 10.4 kW system was sized for the house and, using PV Watts and the Enphase solar system tool, a solar system consisting of 31 IQ7+ AC Solar Panels (with microinverters) and a 16.8 kWh capacity Enphase battery system were selected for the house. This battery system should be able to provide the home with power for essential functions for up to 12 hours in the event of a blackout from the grid and no solar availability.

Comparative Analysis

- Created base house design and did baseline Ekotrope analysis
  - Adjusted one factor at a time and ran analysis
- Points of Comparison
  - Number of Windowpanes: 2 vs 3 pane
  - Wall Insulation: R-29 vs R-38
  - Roof Insulation: R-38 vs R-48
  - Slab Insulation: R-10 vs R-20
  - Water Heating: 100% heat pump vs incl. mini tank
  - Space Heating: 2 mini splits vs 5 mini splits
- Base home:
  - 2 pane windows, R-29 SIP walls, R-38 SIP Roof
  - R-10 slab insulation, 100% Heat pump water
  - 80% radiant/ 20% mini split heating (2 units)

	2 or 3	6.5 or 8.25	8.25 or 10.25	2 or 4	Hot Water System		Heating System	
	# window Panes	Wall SIP Thickness (2599 sqft)	Roof SIP Thickness (2690.71 sqft)	Slab Insulation	% Mini Tank	% Heat Pump	% Radiant	% Mini Split
BASE	2	6.5	8.25	2	0% mini	100% HP	80% radiant	20% mini
Windows	3	6.5	8.25	2	0% mini	100% HP	80% radiant	20% mini
Walls	2	8.25	8.25	2	0% mini	100% HP	80% radiant	20% mini
Roof	2	6.5	10.25	2	0% mini	100% HP	80% radiant	20% mini
Slab	2	6.5	8.25	4	0% mini	100% HP	80% radiant	20% mini
H20 Heating	2	6.5	8.25	2	25% mini	75% HP	80% radiant	20% mini
Space Heating	2	6.5	8.25	2	0% mini	100% HP	61% radiant	39% mini

- Focused on changes in HERS, heating/cooling loads, and resulting energy bill changes in heating, cooling, and water heating
- Calculated differences of each change against baseline efficiency metrics to compare effect of each change
- Most focused on changes in HERS and total energy bill differences

	HERS Rating	Heating Load	Cooling Load	Heating Costs	Cooling Costs	Water Heating Costs	Change HERS	Change Heating Load	Change Cooling Load	Change Heating Costs	Change Cooling Costs	Change Water Heating Costs	Total $$ Savings
BASE	-21	17	17	$ 122	$ 39	$ 45	0	0	0	0	0	0	0
Windows	-22	16	15	$ 113	$ 37	$ 45	-1	-1	-2	-9	-2	0	11
Walls	-23	16	17	$ 110	$ 39	$ 45	-2	-1	0	-12	0	0	12
Roof	-22	16	17	$ 114	$ 38	$ 45	-1	-1	0	-8	-1	0	9
Slab	-22	16	17	$ 107	$ 40	$ 45	-1	-1	0	-15	1	0	14
H20 Heating	-20	17	17	$ 122	$ 39	$ 72	1	0	0	0	0	27	-27
Heating	-21	17	17	$ 126	$ 40	$ 45	0	0	0	4	1	0	-5

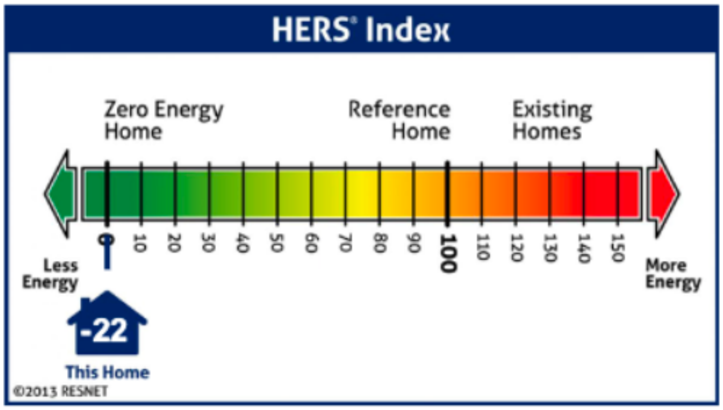
Results

- Calculated cost differences for each adjustment
  - Compared to total savings (simple payback period)
  - Calculated value of each adjustment as dollar value per degree change in HERS rating

	Change HERS	Total $$ Savings	Cost Difference	Simple Payback Period (Yrs)	$/HERS
BASE	0	0			
Windows	-1	11	$ 1,953.39	178	$ (1,953.39)
Walls	-2	12	$ 3,430.68	286	$ (1,715.34)
Roof	-1	9	$ 2,260.20	251	$ (2,260.20)
Slab	-1	14	$ 11,441.84	817	$ (11,441.84)
H20 Heating	1	-27	$ (200.00)	7	$ (200.00)
Space Heating	0	-5	-1	0	#DIV/0!

- Used findings to design best and worst combination and educate design for final house design
  - Worst Design: 2 pane windows, low end R-values, 20% mini tank water heating, 5 mini split units
  - Best Design: 3 pane windows, high end R-values, 100% heat pump water heater, 2 mini split units
  - Final Design: 3 pane windows, R-29 SIP walls, R-38 SIP roof, R-20 slab insulation, 100% heat pump water heater, 2 mini split units

	HERS Rating	Heating Load	Cooling Load	Heating Costs	Cooling Costs	Water Heating Costs	**Cost Difference**
WORST COMBO	-20	17	17	$ 120	$ 40	$ 71	$ 200.00
BEST COMBO	-23	13	15	$ 79	$ 37	$ 45	$ 18,885.11
Final Design	-22	15	15	$ 98	$ 38	$ 45	$ 13,395.23



	HERS with Solar	HERS without Solar	Annual Energy Use (Mbtu)
Worst Design	-20	38	33.8
Best Design	-23	34	30.5
Final Design	-22	35	31.4
Original House	0	52	43.6

Costing Analysis

The area of Kennewick, Washington is a fast-growing, yet relatively affordable area in the Columbia Basin region of the state. With the rapidly growing Washington State real estate market, this is the ideal location for a new, affordable family home. Demand for efficient and comfortable homes is on the rise and the Tri-Cities Homestead 2.0 design is a great example of a net zero home design.

- Final Price Tag for Construction
- $597,313.81
- $224.13/sq ft
- Significantly higher than median price of homes in Kennewick
- Consider efficiency measures and energy savings
- Slightly higher cost per square foot for new home construction (w/o land) than national average
- House: $152.46 vs Nat. Avg: $100-155
- Original House Costing:
- $534,300
- $190/ sq ft

	COSTS
SOLAR SYSTEM (AFTER 1ST YEAR SAVINGS)	$ 39,498.66
MISC. (SMART STRIPS/SMART THERMOSTAT)	$ 422.00
LAND	$ 191,000.00
BUILDING/ LANDSCAPING/PROPERTY PREP	$ 360,213.04
EV SETUP	$ 6,000.00
PERMITS @ 0.05% BUILD COST	$ 180.11
TOTAL	$ 597,313.81
PER SQFT	$ 224.13
TOTAL WITHOUT LAND	$ 406,313.81
PER SQFT	$ 152.46

Conclusions

- Successful in designing a significantly more efficient home
- Pricing and energy analysis more accurate and robust
- Interesting comparison of different efficiency measures
- Solar Decathlon Challenge
    - Working with a team over zoom is difficult
    - Designing a house from start to finish and including all the details takes a lot of work
- Project applies to future job and future career goals in net zero home design

Thank you to the original team members of the Tri-Cities Homestead Design

APPENDIX

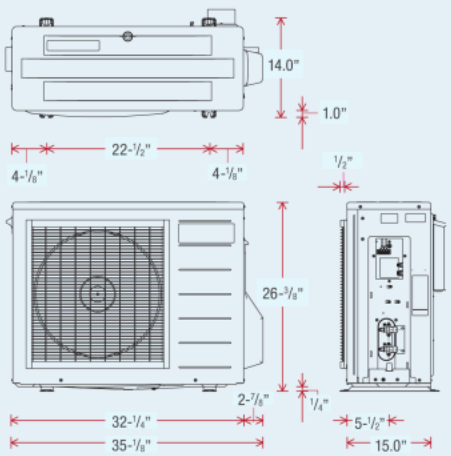
SanCO2 Hot Water Heat Pump Specifications

SANCO2 GEN4 Specifications

Heat Pump

3 YEAR LABOR GUARANTEED HEAT PUMP WARRANTY · 10 YEAR GUARANTEED HEAT PUMP WARRANTY

All dimensions displayed in inches.



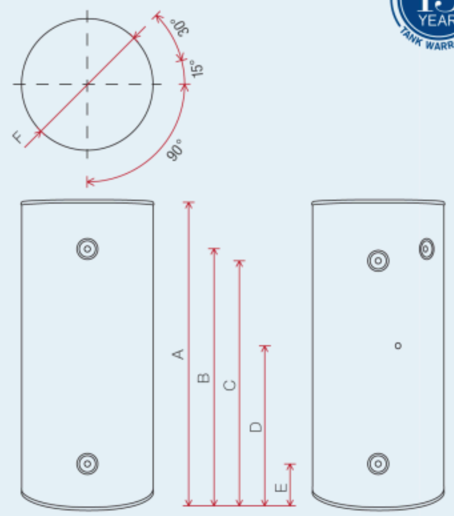
Outdoor Unit (Heat Pump) **Model No. GS4-45HPC**

Performance	43 Gal Sys	83 Gal Sys	119 Gal Sys
Uniform Energy Factor	3.1	3.75	3.4
First Hour Rating	69 gallons	115 gallons	135 gallons

Specifications	
Water Temperature Setting	145 or 150°F
Ambient Air Operating Range	-25 to 104°F
Nom Heating Capacity (Btu/h)	15,400 Btu/h
Nom Heating Capacity (kw)	4.5kw
Heating COP @ 80/47/17°F	5.5 / 4.2 / 2.8
Refrigerant Type	R744 (CO_2)
Power Voltage	208/230v-1Ph-60Hz
Breaker Size	15 Amps
MCA (Amps)	7.2 Amps
Compressor Type	Rotary
Noise Level (DbA)	37
Weight (lbs)	108lbs
Pipe Size (Tank to Heat Pump)	1/2" (Both Hot Supply & Cold Return)
Max Length inc Vertical Sep	66 ft
Max Vertical Separation	23 ft
Max Incoming Water Pressure	95 Psi

Stainless Steel Storage Tank*

15 YEAR PRO RATA TANK WARRANTY



	Tank Model No:	SAN-43SSAQA	SAN-83SSAQA	SAN-119GLBK*
A	Height	38-1/8"	68-7/8"	63-3/5"
B	Hot Water Outlet & PR Valve	29-1/2"	60-1/4"	56"
C	Heat Pump Return	29-1/2"	60-1/4"	60-1/4"
D	Sensor Port	9-3/4"	40-3/8"	56"
E	Cold Water Inlet / Cold Water to HP	8-3/4"	8-3/4"	4"
F	Diameter	24-1/2"	24-1/2"	28"
	Weight (lbs)	88 lbs	115 lbs	345 lbs
	Tank Capacity (gallons)	43 gallons	83 gallons	119 gallons
	Warranty	15 years	15 years	10 years*

Connection Sizes	
Cold Water Inlet	3/4" NPT (1 1/2" SAN-119GLBK)
Hot Water Outlet	3/4" NPT (1 1/2" SAN-119GLBK)
Cold Water to Heat Pump	3/4" NPT
Hot Water Return from Heat Pump	3/4" NPT
Pressure Relief Valve Setting (Psig)	125 Psig

REV 02032021

*SAN-119GLBK tank is a glass-lined steel tank with a 10 year warranty.
Note: Materials and specifications are subject to change without notice.

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For more information, please call **1-844-SANDCO2** or email **info@eco2systemsllc.com**

ECO2 SYSTEMS

Eco2 Systems LLC
P.O. Box 1358, Walled Lake, MI 48390
Phone : 1-844-726-3262 or 1-844-SANDCO2
E-mail : info@eco2systemsllc.com
Website : www.eco2waterheater.com

475 HIGH PERFORMANCE BUILDING SUPPLY
foursevenfive.com 800-995-6329

Window Schedule

East			Sq Ft
E1.1	Kitchen	fixed	9
E1.2	side	casement	8.75
E1.3	middle	fixed	17.5
E1.4	side	casement	8.75
North			
N1.1	Living rm back door	door	20
N1.2	Stairs	fixed	8
N1.3	Bdrm 1	sliding	16
N1.4	Dwn Bath	awning	4.04688
N1.5	Bdrm 2	sliding	16
N2.1	Up Bath	sliding	9.40625
West			
W1.1	Bdrm 2	Fixed	8
South			
S1.1	Office	partial casement	32
S1.2	Gym/Rec	partial casement	32
S1.3	Sliding Door	door	40
S1.4	Kitchen	fixed	9
S2.1	Clearstory Up	fixed	8.33333
S2.2	Clearstory Up	awning	8.33333
S2.3	Clearstory Up	fixed	8.33333
S2.4	Clearstory Up	awning	8.33333
S2.5	Clearstory Up	fixed	8.33333
S2.6	Clearstory Up	awning	8.33333
S2.7	Clearstory Main	awning	6
S2.7	Clearstory Main	awning	6
S2.9	Clearstory Main	fixed	6
S2.10	Clearstory Main	fixed	6

Solar Costing Data

	Cost
Panels (31)	$ 9,757.00
Battery	$ 11,200.00
Extra Components	$ 4,428.00
Labor Costs @ approx 1000 per panel	$ 31,000.00
Total pre Incentives	**$ 56,385.00**

Federal Investment Tax Credit (26% through 2023)	$ 14,660.10
WA State Incentive of $0.16 per kWh generation	$ 2,226.24
Total Savings after 1st yr	$ 16,886.34
Total System Cost after 1st yr savings	**$ 39,498.66**

Appliance Lists

Water Heater	
Sanden CO2 Heat Pump	
	https://foursevenfive.com/sanco2/
HRV	
Zehnder ComfoAir 200	
	https://www.zehnderamerica.com/wp-content/uploads/2019/08/CA200-Specifications-2019.08.30.pdf
Refrigerator	
Samsung 28.2-cu ft French Door Refrigerator with Ice Maker (Fingerprint Resistant Stainless Steel) ENERGY STAR	
	https://www.lowes.com/pd/Samsung-19-6-cu-ft-French-Door-Refrigerator-with-Ice-Maker-Fingerprint-Resistant-Stainless-Steel-ENERGY-STAR/1003081538
Dishwasher	
Maytag 48-Decibel Top Control 24-in Built-In Dishwasher (Fingerprint Resistant Stainless Steel) ENERGY STAR	
	https://www.lowes.com/pd/Maytag-48-Decibel-and-Hard-Food-Disposer-Built-In-Dishwasher-Fingerprint-Resistant-Stainless-Steel-Common-24-in-Actual-23-875-in-ENERGY-STAR/1000551587
Washing Machine	
LG Smart Wi-Fi Enabled 4.5-cu ft High Efficiency Stackable Steam Cycle Front-Load Washer (White) ENERGY STAR	
	https://www.lowes.com/pd/LG-Smart-Wi-Fi-Enabled-4-5-cu-ft-High-Efficiency-Stackable-Steam-Cycle-Front-Load-Washer-White-ENERGY-STAR/5000140751?cm_mmc=shp-_-c-_-prd-_-app-_-google-_-pla-_--_-laundry-_-5000140751-_-0&placeholder=null&ds_rl=1286981&ds_rl=1286890&gclid=Cj0KCQjw--GFBhDeARIsACH_kdYkXxOxu6mYcwW-P_Lg5PYGMQe54uNNddFbC6Lz4-9vj4h55ItOOA8aAoYyEALw_wcB&gclsrc=aw.ds
Dryer	
LG ThinQ 7.4-cu ft Electric Dryer (White) ENERGY STAR	
	https://www.lowes.com/pd/LG-7-4-cu-ft-Reversible-side-swing-Electric-Dryer-White-ENERGY-STAR/5000140753
Smart thermostat	
	https://store.google.com/us/product/nest_learning_thermostat_3rd_gen?hl=en-US
Mini Tank Water Heater	
	https://www.homedepot.com/p/Bosch-4-Gal-Mini-Tank-Electric-Water-Heater-ES-4/206393135
Ductless Heat Pumps (mini splits)	
	https://hvacdirect.com/aciq-27k-btu-2-zone-aciq-27-hh-m3-9-18.html