



UNIVERSITY OF MARYLAND

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2017

reACT

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U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2017
Design Development Project Manual
February 23, 2017



Table of Contents

Project Overview	4
Intelligent data system	4
Goals and aspirations	5
Applicability to Native American populations	5
UMD’s position	6
Detailed Water Budget	7
Interconnection Application Form	8
Summary of Unlisted Electrical Components	9
Summary of Reconfigurable Features.....	10
Courtyard.....	11
Attic Dryer/Oven	12
HVAC.....	12
Advanced Adaptive Controls.....	13
Complete Energy Analysis and Model	14
Parametric Study for Building Environment	14
Modeling the Courtyard.....	23
Pre-cooling and Pre-heating Effects	27
Effect of Courtyard Control.....	30
Effect of Air Damper Control.....	32
Conclusions.....	35
References:.....	35
Construction Specifications	37
Division 01 - General Requirements	37
Division 05 – Metals	39
Division 06 – Wood, Plastics, and Composites	41
Division 07 – Thermal and Moisture Protection	43
Division 08 – Openings.....	50
Division 09 – Finishes	58
Division 10 – Specialties	61
Division 11 – Equipment	71
Division 21 – Fire Suppression	74
Division 22 – Plumbing.....	76
Division 23 – Heating, Ventilating, and Air-Conditioning (HVAC).....	86
Division 26 – Electrical	93
Division 27 – Telecommunications	103
Division 29 – Integrated Automation.....	104

Division 32 – Exterior Improvements.....	109
Draft Cost Estimate.....	116
Summary of Changes.....	120
February 23, 2017 Revision.....	120

Project Overview

Team Maryland's house, *reACT*, features 940 SF of built interior, surrounding a spacious 160 SF glazed courtyard, with 400 SF of outdoor deck area, on about 8000 SF of developed site for the competition. Besides providing additional dining and lounging space, the courtyard aids in regulating light, temperature and humidity in the home, operating in sync with a mechanical core at the heart of the interior; the core contains high-performance, environmentally sensitive systems that interact with one another, managing the flow of water, air and energy throughout the home. Both function together to advance the entire building as more self-sustaining.

Balancing time-trusted practices of bio-climatic design and innovative technological solutions, as well as traditional and modern aesthetics, *reACT* combines exceptional performance with comfort and affordability.

The courtyard:

- Offers additional, dynamic space for dining, leisure and entertainment
- Regulates temperatures and humidity by circulating clean, thermally comfortable air throughout the house (cool in summer months, warm in cool months)
- Supports plants and vegetation for beauty, growing food, converting CO₂ into oxygen Allows integration of nature into residents' daily lives, year-round
- Operable roof and doors allow the courtyard to be both indoor and outdoor
- Enables 'season extension' in Fall and Spring, while diminishing the less desirable impacts of hot summers and cold winters
- Retractable shading fabrics at the ceiling provide full or partial shade when desired

The core:

- Integrates the home's mechanical, electrical, waste and water systems for beneficial exchanges between them
- Links all mechanical functions in a single, fully accessible chassis wall
- Contains predictive, automated, Intelligent data collection and control system

Intelligent data system:

- Features sensors and predictive data (weather forecasts and user profiles influence the system's interaction with power, HVAC, waste, and water)
- Offers resident feedback through an intuitive user interface, via tablet screen
- Provides automatic/human schedule optimization options
- Displays data on power, water, and other resources produced/bought/sold
- Independently upgradable as new technologies become available
- Provides automatic/human schedule optimization options
- Displays data on power, water, and other resources produced/bought/sold
- Independently upgradable as new technologies become available

Goals and aspirations:

- Positioning of reACT as an industry model, embracing principles of the Living Building Challenge, Responsible Industry and Net Zero Waste by exemplifying non-toxic, ecologically restorative, transparent, and socially equitable architecture.
- Proving reACT's adaptability to a diverse range of climates, communities, construction technologies and ecological environments, as well as to other cultural and logistical variables such as building material supply chains;
- Resource conservation through passive and active heating and cooling, green, mold -resistant wall prototypes, rainwater-catchment and grey-water systems;
- Disentangled systems design enables efficient manufacture, transport and assembly alongside flexible configuration, building sizes and forms;
- Extensive use of direct current photovoltaics, following the successes and best practices used by the Sustainable Native Communities Collaborative (SNCC);
- Offering families to incrementally build larger and more technologically advanced infrastructure and features into their evolving homes (e.g. by adding multiple, PV arrays, smartHome control systems, composting toilets, dual-barrel composting, grey-water irrigation, and rain-catchment systems);
- Transfer of intellectual property and development outcomes to a like-minded partner in the construction industry, ready to implement reACT's prototypical "DNA" and flexible configurations.

Applicability to Native American populations:

We are approaching a target market of two separate Native American tribes, specifically the San Carlos Apache Tribe in Blyas, Arizona and the St. Croix Chippewa Indians of Wisconsin in Danbury, Minnesota. Recognizing the extreme housing needs in many Native communities, the vulnerability of reservation land to climate change, we consider sustainability and regenerative design principles as most suitable for promoting quality of life and culture for this audience, applying sustainable construction, energy efficiency, high performance and health, while respecting Native American cultural heritage. Tribal leaders are increasingly seeking sustainable housing and renewable energy technologies to provide their communities with cultural renewal, self-sufficiency, economic opportunity, and sustainable returns on investment (ROI) that compliment tribal culture.

In the case of the Pinoleville Pomo Nation Homes (PPN), the renewable energy-efficient systems were co-designed and built by tribal citizens providing jobs. Rainwater catchment and grey-water systems reduced vulnerability to water shortages and support on site plantings. The University of California Berkeley provided technical assistance through the Center of Community Assessment of Renewable Energy and Sustainability (CARES). This case demonstrates that tribes provided with technical assistance and control of their own financing can achieve green, culturally appropriate housing even after years of marginalization.

Team Maryland is working within the Solar Decathlon framework (sustainability expo, educational events, professional development and consumer workshops) to find opportunities to mindfully facilitate the tribal embrace of and desire for sustainability and self-determination. The team is also seeking to influence the manufacturing partner to develop production plants in close proximity to tribal lands, to contribute to expanding training and economic opportunities for members of the tribal community.

The reACT vision is to design a more easily expanding and contracting home to better accommodate family fluctuations

and transformations, and even to be able to aggregate homes into greater density and efficiency, offering not just one prototype, but a family of houses and housing types, facilitating variations in size, material finishes, and layout configurations to meet the diverse and dynamic needs of a real community.

reACT will also demonstrate the affordability of Living Buildings and Communities when life cycle costs of utilities like water, clean electric power and waste management and repurposing are included. We realize the consideration of the true and total costs of development must be factored in building an authentic sustainable future. Students and faculty, working in collaboration with professional tradesfolk, will focus on quality, efficiency and craft in construction of the reACT prototype.

Assembly, standardization, and flexibility of components, along with an intrinsic disentanglement (to better “future proof” home building) of systems and their interdependence will be among the strategies the reACT team will employ to increase build-ability, reduce construction and transportation costs, and to facilitate changes and/or upgrades over time.

UMD’s position

As a Land-Grant University, University of Maryland is committed to championing ideas that drive the discovery and dissemination of new knowledge in order to solve today’s most pressing challenges. The Solar Decathlon is living proof that bright minds can change our world for the better. reACT has garnered a campus-wide multidisciplinary response to the Solar Decathlon 2017 call for outreach and education that will accelerate the adoption of energy-efficient design and products to combat the effects of the built environment on nature and ecosystem.

reACT’s outreach to our target tribal market is intended to engage tribal Land-Grant colleges in service to this mission. By blending design excellence and smart energy production with innovation, market potential, and energy and water efficiency, reACT embraces the role of catalyst to ignite a paradigm shift in the residential building industry.

Detailed Water Budget

reACT_COMPETITION BASED WATER BUDGET

FACTOR

10%

^[1] THE SOLAR THERMAL COLLECTOR WILL ONLY NEED A 200 GALLON FEED AT ONCE. THE 200 GALLONS WILL BE IN A SEPARATE POTABLE WATER TANK.

^[2] THE LANDSCAPE WILL USE THE LIGHT GREY WATER, WHICH WILL COME FROM THE SHOWER, BATHROOM SINK, AND WASHING MACHINE, THAT IS GENERATED THROUGHOUT THE HOUSE. IT WILL ONLY BE THE FIRST DAY OF THE COMPETITION WHERE 25 GALLONS OF POTABLE WATER WILL BE USED TO WATER THE LANDSCAPE.

Interconnection Application Form

Team Maryland Lot 103

PV SYSTEMS				
Manufacturer	Short Description		DC rating of Array	
SunPower	14 Sunpower X21 BLKs on a standing seam roof		4690 Watts	
SunPower	14 Sunpower X21 BLKs on a standing seam roof		4690 Watts	
			Total DC power of arrays = 9.38 kW.	
DC-DC Optimizers and inverters				
Manufacturer	Model #	Voltage	Rating	Quantity
SolarEdge	P400	60V	400W	28
SolarEdge	SE7600A-USS	240V	5000W	1
Notes:				
1. REACT's one-line electrical schematic can be found on sheet <i>E-602</i> of the drawing set. 2. Calculations of service/feeder net computer load and neutral load are described in the chart below. 3. A plan view of the lot showing the house, decks, walking surface, tour paths and the service point can be found on sheet <i>G-103</i> of the drawing set. 4. Elevation views showing the terminal box, meter, and other service equipment can be found on sheet <i>E-401</i> of the drawing set. 5. <i>Student Electrical Engineer</i> , Srijesh Sudarsanan, srijeshs@umd.edu, (995) 202-1695				
SERVICE CALCULATIONS				
Load Type	Load Value (VA)	Multiplier/Demand	Total (standard method)	NEC reference
General Lighting	1166 sq ft. x 3VA = 3498 VA	3000@ 100% 4998@ 35%	4750 VA	220.12+220.42
Small Appliance branch circuit	min. 2 x 1500VA = 3000VA			220.11(C)(1)+220.52(A)
Laundry Circuit	1 circuit @ 1500 VA			220.11(C)(2)+220.52(B)
Electric Dryer	1 Dryer @ max(5000 VA, nameplate rating)	5000@ 100%	5000 VA	220.54
Hot water heater	Fixed-appliance loads total = 1400 (for dishwasher) + 7200 (for EV charger) +16 (for UV lamp) + 5020 (for water heater) = 13,636VA	Total of 4 fixed appliances @ 75%	10227 VA	220.53
Dishwasher				
EV charger				
UV Lamp				
Electric Range	1 range @ 13300 VA	8000 VA + 5%(8000) = 8400VA	8400 VA	Table 220.19
Pump (SCALA)	550 VA	550 VA@ 100%	550 VA	
Pump (BMQ)	2400 VA	2400 VA@ 100%	2400 VA	
Mini-split condenser unit	max (2490 W for heating, 2310W for cooling) = 2490W	2490VA	2490VA	
Mini split indoor units (x4)	184VA	184VA	184VA	
ERV unit + Drum Humidifier	143W+3VA	146VA	146VA	
Highest motor load	2400VA	2400@25%	600VA	220.14(C)
TOTAL = 15,701 VA			Total = 34,747VA Closest Amp rating = 150A 2/0 AWG Aluminium or 1 AWG copper	

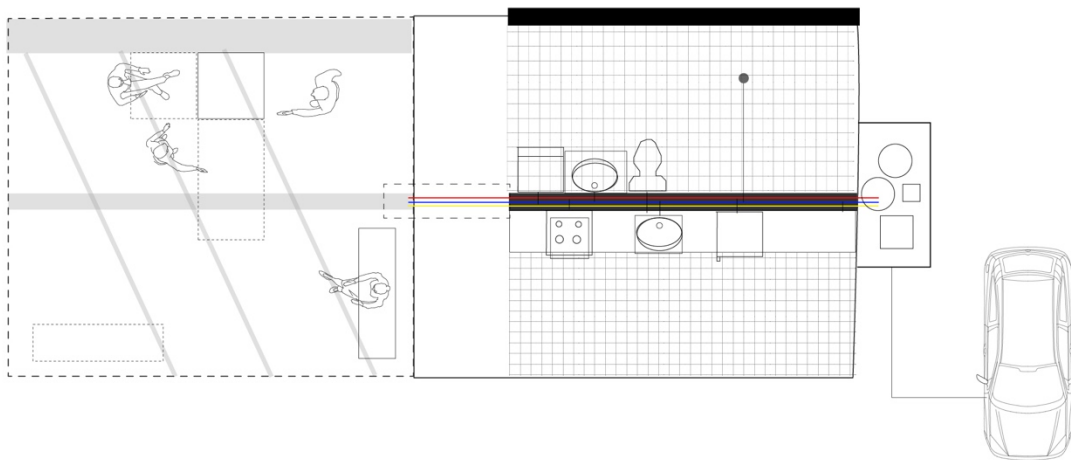
NEUTRAL LOAD		
Load Type	CONTRIBUTION (100% unless otherwise indicated)	TOTAL (STANDARD METHOD)
General Lighting		
Small Appliance branch circuit	7998	7998 VA
Laundry Circuit		
Electric Dryer	5000 @ 70%	3500 VA
Hot water heater		
Dishwasher	Total of 4 fixed appliances= 13636	13636 VA
EV charger		
UV Lamp		
Electric Range	$8000 \text{ VA} + 5\%(8000) = 8400 \text{ VA} @ 70\%$	5880 VA
Pump (SCALA)	550 VA	550 VA
Pump (BMQ)	2400 VA	2400 VA
Mini-split condenser unit	2490VA	2490VA
Mini split indoor units (x4)	184VA	184VA
ERV unit + Drum Humidifier	146VA	146VA
Highest motor load	2400@25%	600VA
		Total = 37,384VA
		Neutral conductor size = 3/0 Copper or Aluminium

Summary of Unlisted Electrical Components

There are no unlisted components.

Summary of Reconfigurable Features

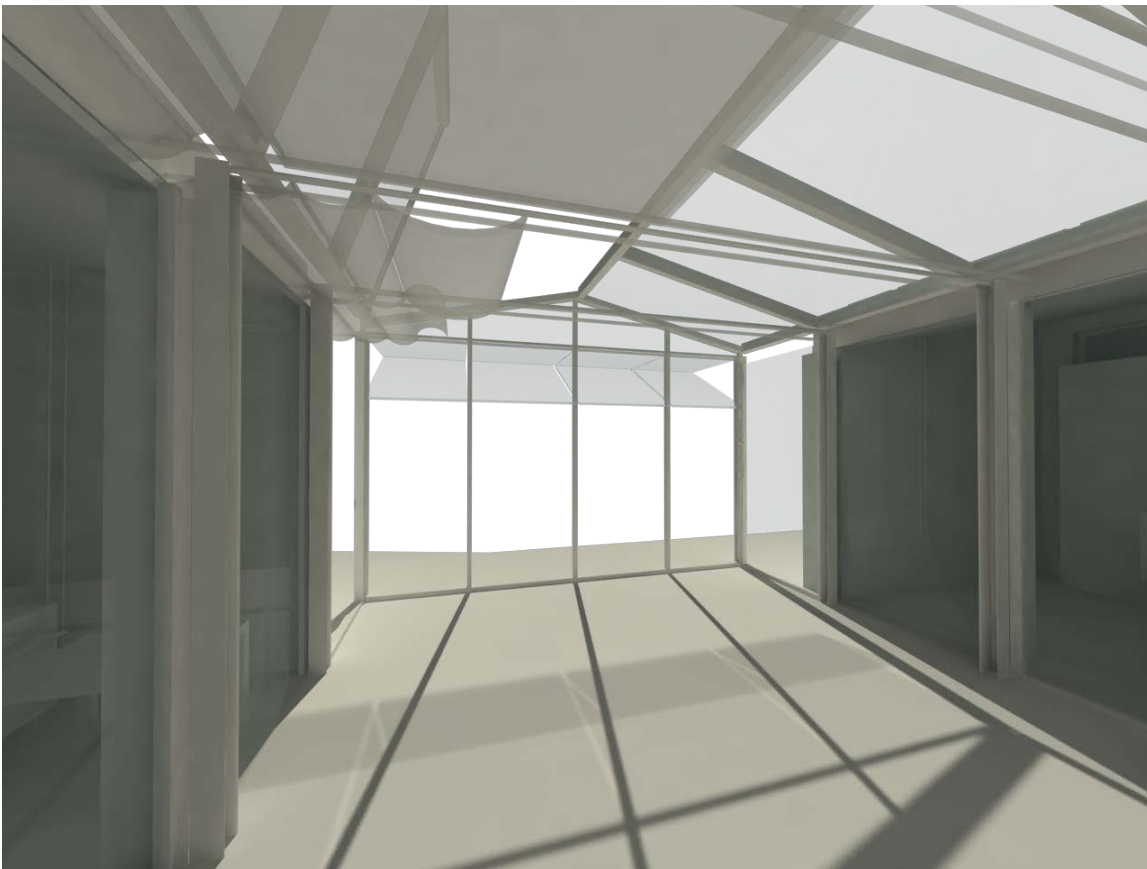
In 2017, the University of Maryland will demonstrate architectural design and technologies that take maximum advantage of both active and passive solar strategies. The heart of the house will be the Core and Courtyard combination. The Core contains the active components including charge controller, batteries, water filtration, heating and cooling systems. The density of the Core is maximized to facilitate efficient use and reuse of energy, including waste heat, water and nutrients. Adjacent to the Core is the Courtyard, intended not only as the social hub of the home, but also as a passive solar collector and greenhouse for plants.



Courtyard

In order to provide maximum benefit in all seasons, day and night, the Courtyard must be flexible, harvesting solar heat when it is available, storing it until needed and then distributing it when useful. In the summer, the Courtyard will serve as a breezy shaded spot, using the operable skylights to promote ventilation, and to escape the intense Denver sunshine during the day, and an enclosed, sheltered spot during cool nights under the stars. The Courtyard will open and close, much as a flower does. It is essentially a nested greenhouse with walls on three sides and an operable roof and one exposed glazed wall to open or close as needed.

Below the glazing, roll-out shades will provide protection from the sun when needed. The operating system for the skylights and door openers will be remote sensor and mechanically operated or over-ridden to operate manually, reflecting the responsive sensibilities of the home.



The Courtyard will be configured appropriately throughout each day during the Competition, depending on weather conditions. Changes in weather may require reconfiguration during public tour hours, and all appropriate safety precautions will be taken during these operations. A full description of the Courtyard's function and reconfiguration options will be included in the materials submitted in advance to the Juries.

Attic Dryer/Oven

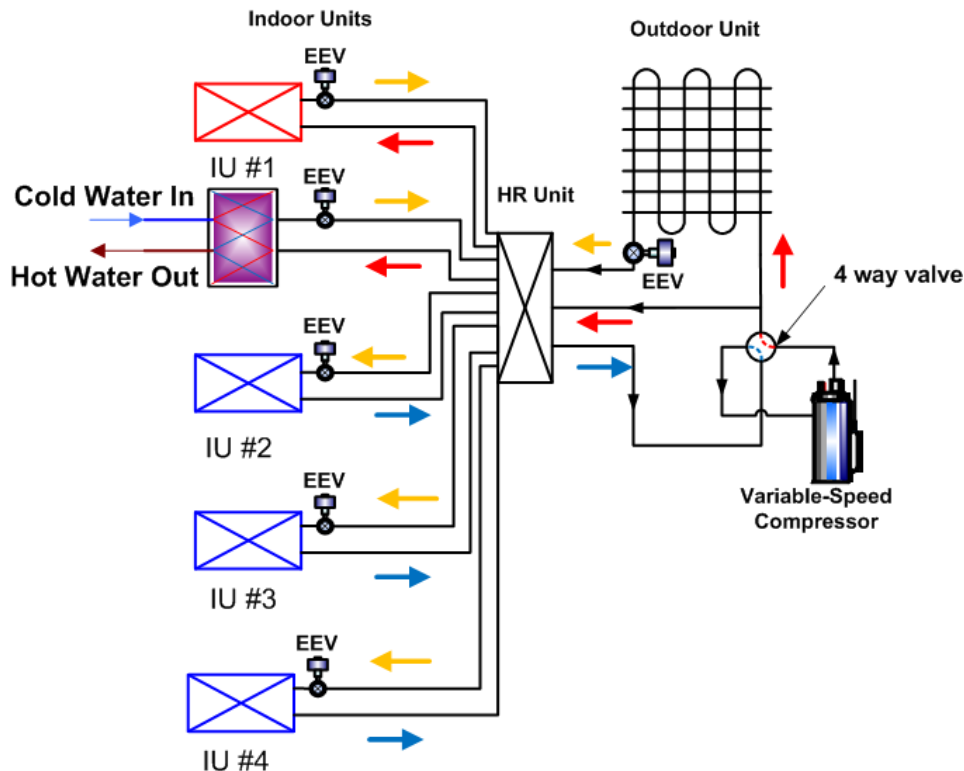
The south end of the attic has a special pair of chambers with lifting devices designed to harvest the beneficial energies of the concentrated sunlight. As one of the more experimental features of the house, depending on the interests and needs of the residents, these attic chambers have suspended racks and trays that nest up into them, where more intense sunlight and solar heat can be employed to provide diverse benefits. Thermal and moisture sensors will be deployed in these chambers, connected to the smart home functions, to monitor progress on chosen functions.

- slow cooking solar oven
- solar food dehydrator
- clothes drying racks and hangers
- dish drying rack
- solar sterilizing chamber (distilled water, medical/dental devices, c-pap's, etc.)

Operation of these various features will be demonstrated as required by the Rules during the public tours and Jury walk-throughs.

HVAC

The HVAC system housed in the Core is designed to be reconfigurable also, capturing waste heat from various components (such as the oven, dishwasher, clothes dryer, solar attic, and refrigerator) and storing that energy in the hot water tank for later use. Depending on exterior conditions, heat may be drawn from the attic or courtyard to maximize thermal efficiency of the system.



Advanced Adaptive Controls

Maryland's house will also be prescient to changes in the weather, and will adapt itself preemptively. The Model Based Controller (MPC) will collect weather predictions from the Internet and adjust the operation of the house to provide optimum comfort and efficiency. If a cold night is predicted, it will recommend reconfiguration of the Courtyard to collect and store heat for the evening. If rain is predicted, it will adjust the operation of the water harvesting and reuse system to take advantage of that resource. This automated assistant will help the residents make the best use of their advanced regenerative dwelling. The architecture of this system will be hierarchical and decentralized so that subsystem controllers provide basic autonomic control of each component while the MPC focuses on managing resources and adjusts the set-points of the subsystems accordingly.

The operation of the MPC will be demonstrated during all public tours as well as for the Juries.

Complete Energy Analysis and Model

Parametric Study for Building Environment

BEOpt was used to explore different design options through many successive parametric runs. Many different factors including window to wall ratio, R-value of the walls, roof and floor, and assumed infiltration rate were studied using this model. These factors were also considered in terms of their impacts on architectural expression and site development strategies. Ultimately, these studies led to the configuration shown in Figure 6-1. This is a basic representation of the house geometry in the current proposed U-Shape. After parametric studies were completed, the Table 6-1 presents the final configuration for this model.

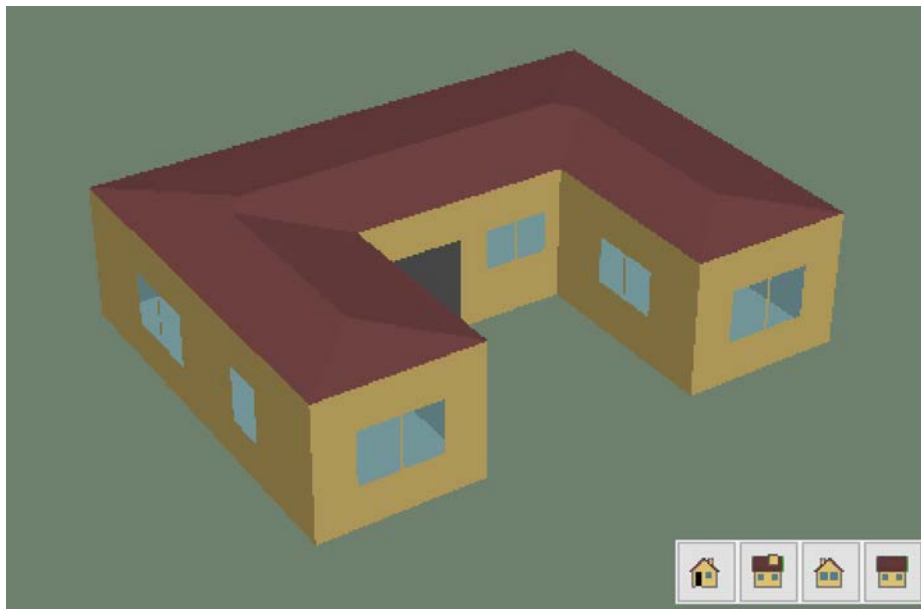


Figure 6-1: 3D Geometry of UMD Solar house in BEOpt

The University of Maryland Solar Decathlon Team made use of BEOpt’s parametric study capabilities to show how changing certain parameters affected the cost and energy consumption. The following four tables and figures show parametric studies for the wall insulation, window type, roof insulation, and total window area. The first parameter of interest is the wall insulation of reACT. As seen on Figure 6-2, the horizontal axis shows the site energy savings (kWh/Year) and the vertical axis shows the energy related costs (\$/year) which are defined as follows:

- Site Energy Savings (kWh/year): The average site energy savings is the difference in average site energy use between a prototype building and the reference (NREL, 2017a).
- Energy Related Costs (\$/year): Energy related costs is identical to a life cycle cost (LCC), except for the following:
 - Cash flows are annualized rather than converted to the present value
 - Cash flows are relative to the reference point rather than converted to the present value

A life cycle cost refers to the total cost of ownership over the life of the technology (NREL, 2017b). When one compares two technologies, the lower energy related cost indicates a more worthwhile investment. Table 6-1 and Figure 6-2 show that as the wall insulation's R-value increases from the reference value of R-33, the site energy savings increases. Hence, this team should use the highest R-Value insulation possible to increase energy savings; however, the energy related costs need to be considered as well. As the R-value increases, the energy related costs generally increase as well. The most desirable wall insulation would be a point farthest to right and the bottom of Figure 6-2. A material with a high R-value may be too expensive, and the decrease in affordability will outweigh the associated energy savings.

Table 6-1: Parametric Case Study for Wall Insulation R-Value

Case	Wall Insulation	Site Energy Savings (kWh/yr)	Energy Related Costs Annualizes (\$/yr)
Reference Value	R-33 Fiberglass Batt, Gr 1, 24 in o.c.	-	70
Point 2	R-33 Fiberglass Batt, Gr-1, 2x4 Staggered, 24 in o.c.	2.92	69.96
Point 3	R-39 Fiberglass Batt, Gr-1, 2x4 Centered, 24 in o.c.	46.77	72.00
Point 4	R-39 Fiberglass Batt, Gr-1, 2x4 Staggered, 24 in o.c.	52.61	71.85
Point 5	R-45 Fiberglass Batt, Gr-1, 2x4 Centered, 24 in o.c.	78.92	78.51
Point 6	R-45 Fiberglass Batt, Gr-1, 2x4 Staggered, 24 in o.c.	81.84	78.29
Point 7	R-33 Cellulose, Gr-1, 2x4 Centered, 24 in o.c.	0.00	62.95
Point 8	R-33 Cellulose, Gr-1, 2x4 Staggered, 24 in o.c.	2.92	62.79
Point 9	R-39 Cellulose, Gr-1, 2x4 Centered, 24 in o.c.	46.77	64.83
Point 10	R-39 Cellulose, Gr-1, 2x4 Staggered, 24 in o.c.	52.61	64.67
Point 11	R-45 Cellulose, Gr-1, 2x4 Centered, 24 in o.c.	78.92	71.34
Point 12	R-45 Cellulose, Gr-1, 2x4 Staggered, 24 in o.c.	81.84	71.12
Point 13	R-33 Fiberglass, Gr-1, 2x4 Centered, 24 in o.c.	0.00	61.31
Point 14	R-33 Fiberglass, Gr-1, 2x4 Staggered, 24 in o.c.	2.92	61.14
Point 15	R-39 Fiberglass, Gr-1, 2x4 Centered, 24 in o.c.	46.77	63.18
Point 16	R-39 Fiberglass, Gr-1, 2x4 Staggered, 24 in o.c.	52.61	63.02
Point 17	R-45 Fiberglass, Gr-1, 2x4 Centered, 24 in o.c.	78.92	69.69
Point 18	R-45 Fiberglass, Gr-1, 2x4 Staggered, 24 in o.c.	81.84	69.47
Point 19	R-35 Cellulose, DR-1, 2x4 Staggered, 24 in o.c.	17.54	75.08

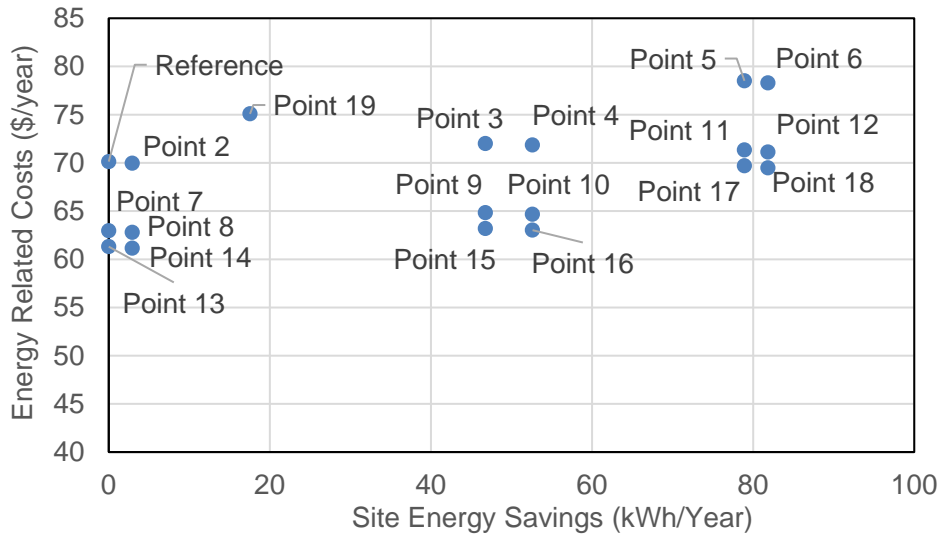


Figure 6-2: Wall Insulation Parametric Case Study

The next parameter varied is the window type. Results are shown in Table 6-2 and Figure 6-3. Differences between the types of windows are the emissivity, number of window panes, and type of gas filling the air gap between panes. Again, the horizontal axis is the site energy savings (kWh/year), and the vertical axis is the energy related costs. Any window type without low emissivity had much lower site energy savings and not a significant reduction in site energy savings. Using argon as the gas filling between panes increased site energy savings, but increased energy related costs. Lastly, as the number of panes increased so did the site energy savings and the energy related costs. To maximize the amount of energy savings, two or three paned, low emissivity, with argon gas filling should be used for the reACT house.

The next parameter studied was the roof insulation. Results are shown in Table 6-3 and Figure 6-4. Much like the wall insulation, as the R-Value increased, the site energy saving and the energy related costs increased. Better insulation decreases the heating and cooling energy consumption. An insulation value above R-30 is recommended for reACT.

Table 6-2: Parametric Case Study for Window Type

Point	Window Type	Site Energy Savings (kWh/yr)	Energy Related Costs, Annualized (\$/yr)
Reference	Clear, Single, Non-metal	0.00	124.73
Point 2	Clear, Double, Metal, Air	283.53	266.06
Point 3	Clear, Double, Thermal-Break, Air	397.53	258.23
Point 4	Clear, Double, Non-metal, Air	520.29	249.09
Point 5	Low-E, Double, Non-metal, Air, H-Gain	710.29	240.53
Point 6	Low-E, Double, Non-metal, Air, M-Gain	645.98	250.60
Point 7	Low-E, Double, Non-metal, Air, L-Gain	526.14	268.10
Point 8	Low-E, Double, Non-metal, Argon, H-Gain	762.90	240.54
Point 9	Low-E, Double, Non-metal, Argon, M-Gain	716.14	251.02
Point 10	Low-E, Double, Non-metal, Argon, L-Gain	602.14	269.68
Point 11	Low-E, Double, Insulated, Air, H-Gain	835.98	250.62
Point 12	Low-E, Double, Insulated, Air, M-Gain	777.52	270.60
Point 13	Low-E, Double, Insulated, Air, L-Gain	657.68	295.58
Point 14	Low-E, Double, Insulated, Argon, H-Gain	903.21	268.64
Point 15	Low-E, Double, Insulated, Argon, M-Gain	847.67	302.71
Point 16	Low-E, Double, Insulated, Argon, L-Gain	739.52	335.83
Point 17	Low-E, Triple, Non-metal, Air, H-Gain	786.29	273.19
Point 18	Low-E, Triple, Non-metal, Air, L-Gain	707.37	294.90
Point 19	Low-E, Triple, Non-metal, Argon, H-Gain	815.52	289.95
Point 20	Low-E, Triple, Non-metal, Argon, L-Gain	762.90	309.34
Point 21	Low-E, Triple, Insulated, Air, H-Gain	935.36	491.86
Point 22	Low-E, Triple, Insulated, Air, L-Gain	873.98	512.13
Point 23	Low-E, Triple, Insulated, Argon, H-Gain	1011.36	504.98
Point 24	Low-E, Triple, Insulated, Argon, L-Gain	923.67	527.08

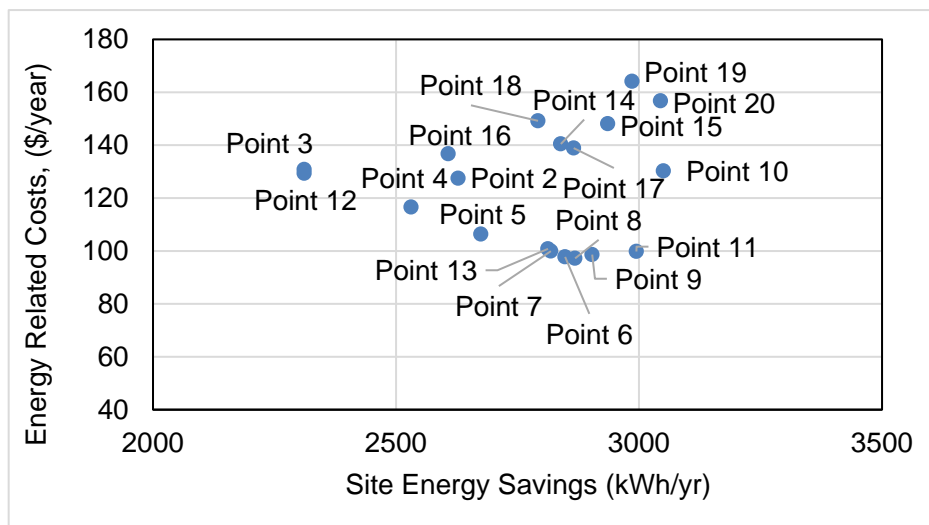


Figure 6-3: Window Type Parametric Case Study

Table 6-3: Parametric Case Study for Roof Insulation

Point	Roof Insulation	Site Energy Savings (kWh/yr)	Energy Related Costs, Annualized (\$/yr)
Reference	Uninsulated, 2x4	0.00	291.22
Point 2	Uninsulated, 2x10, R-15 XPS	2627.97	127.47
Point 3	R-13 Fiberglass Batt, Gr-1, 2x4	2311.20	130.80
Point 4	R-19 Fiberglass Batt, Gr-1, 2x6	2531.18	116.59
Point 5	R-19 Fiberglass Batt, Gr-1, 2x10	2674.90	106.34
Point 6	R-30C Fiberglass Batt, Gr-1, 2x10	2847.94	97.76
Point 7	R-30 Fiberglass Batt, Gr-1, 2x10	2818.61	99.93
Point 8	R-30 Fiberglass Batt, Gr-1, 2x12	2868.47	97.21
Point 9	R-38 Fiberglass Batt, Gr-1, 2x12	2903.67	98.63
Point 10	R-38C Fiberglass Batt, Gr-1, 2x10, R-25 XPS	3050.32	130.25
Point 11	R-30 + R-19 Fiberglass Batt, Gr-1	2994.59	99.81
Point 12	R-13 Fiberglass, Gr-1, 2x4	2311.20	129.35
Point 13	R-30 Fiberglass, Gr-1, 2x8	2812.75	100.81
Point 14	R-36 Closed Cell Spray Foam, Gr-1, 2x6	2839.14	140.46
Point 15	R-47 Closed Cell Spray Foam, Gr-1, 2x8	2935.93	148.08
Point 16	R-20 Open Cell Spray Foam, Gr-1, 2x6	2607.44	136.71
Point 17	R-33 Open Cell Spray Foam, Gr-1, 2x10	2865.54	138.90
Point 18	R-27.5 SIPs	2792.22	149.21
Point 19	R-47.5 SIPs	2985.79	164.12
Point 20	R-63.6 SIPs	3044.45	156.74

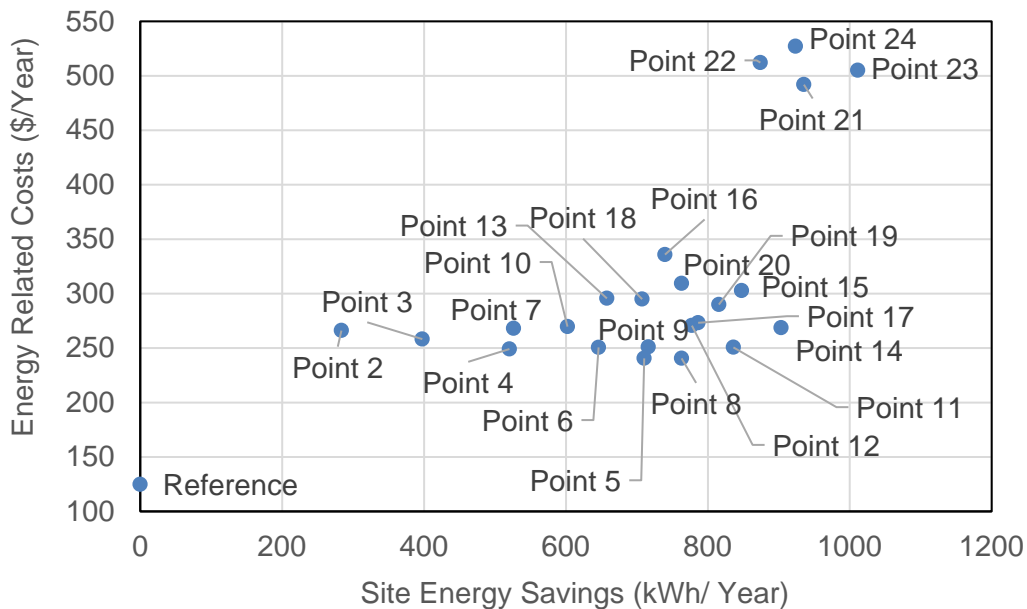


Figure 6-4: Roof Insulation Parametric Case Study

The last parameter studied was the amount of window area covering *reACT*. Results are shown in Table 6-4 and Figure 6-5. As expected, when the window area increased the site energy savings decreased. This was of particular interest due to the courtyard. The inclusion of the courtyard causes *reACT* to have a high amount of window area and potentially decreased energy savings.

Table 6-4: Parametric Case Study for Window Area

Point	Window Area (ft ²)	Site Energy Savings (kWh/yr)	Energy Related Costs, Annualized (\$/yr)
Reference	306	0.00	79.53
Point 2	255	108.41	13.76
Point 3	120	427.78	-166.64
Point 4	204	202.17	-44.77
Point 5	250	23.44	13.24
Point 6	306	8.79	77.77
Point 7	306	-43.95	74.56
Point 8	200	216.82	-49.55
Point 9	216	237.33	-38.42

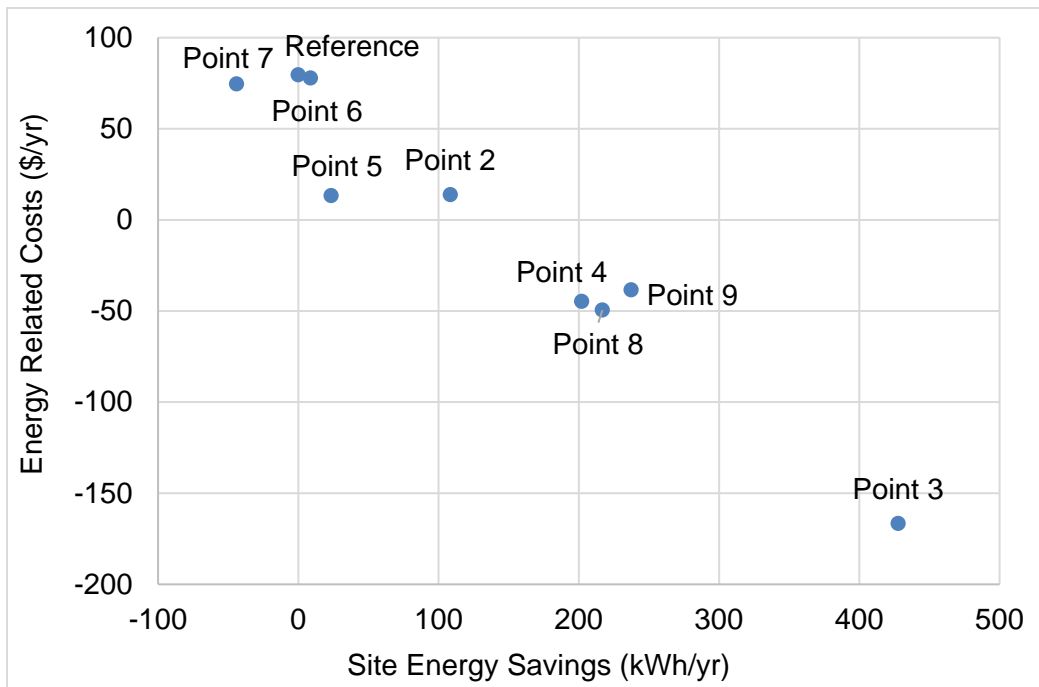


Figure 6-5: Window Area Parametric Case Study

After much of *reACT* had been finalized, BEOpt was used to simulate a final energy model. Table 6-5 shows the model parameters and Figure 6-6 shows the annual energy consumption breakdown.

Table 6-5: BEOpt Model Parameters

Parameter	Value
Finished Floor Area	960 sqft
Neighbors	None
Bedrooms	4
Bathrooms	1
Orientation	South
Double Wood Stud	R-45 Fiberglass, Gr-1, 2x4 Staggered, 24 in o.c.
Wall Sheathing	OSB-with-Rockwool
Exterior Finish	Wood, Light
Finished Roof	R-64, SIP
Roof Material	Metal, Medium
Crawlspace	Uninsulated, Unvented
Interzonal Floor	R-30 Cellulose, Gr-1
Carpet	0% Carpet
Floor Mass	Wood Surface
Exterior Wall Mass	1/2 in. Drywall
Partition Wall Mass	1/2 in. Drywall
Ceiling Mass	1/2 in. Drywall
Window Areas	216 sqft
Windows	Low-E, Double, Insulated, Air, M-Gain
Interior Shading	Summer = 0.5, Winter = 0.95
Door Area	48 sqft
Doors	Fiberglass
Overhangs	2ft, First Story, East and West Windows

Air Leakage	1 ACH50
Ventilation	ERV, 72%, 2010 ASHRAE 62.2
Mini-Split Heat Pump	2.5 Ton, SEER 14.5
Water Heater	HPWH, 50 gal
Lighting	100% LED
PV Panels	10 kW
Cooling Set Point	74°F
Heating Set Point	68°F
Humidity Set Point	50%
Refrigerator	236 kWh/year
Cooking Range	Electric, Induction, 552 kWh/year
Clothes Washer	137 kWh/year
Clothes Dryer	Electric, Energy Factor = 8.22 lb/kWh
Dishwasher	139.1 kWh/year
Schedules	Standard Residential

Table 6-6: Annual Energy Consumption Breakdown

Energy Use (kWh/Year)	
Misc.	2,092.6
Ventilation Fan	427.9
Large Appliances	1,987.1
Lights	548.1
Cooling Fan/Pump	11.7
Heating fan/Pump	23.45
Cooling	471.86
Heating	1,817.1
Hot Water, Suppl.	275.5
Hot Water	404.5
Total	8,060
PV	12,547
Net (PV-Total)	4,487

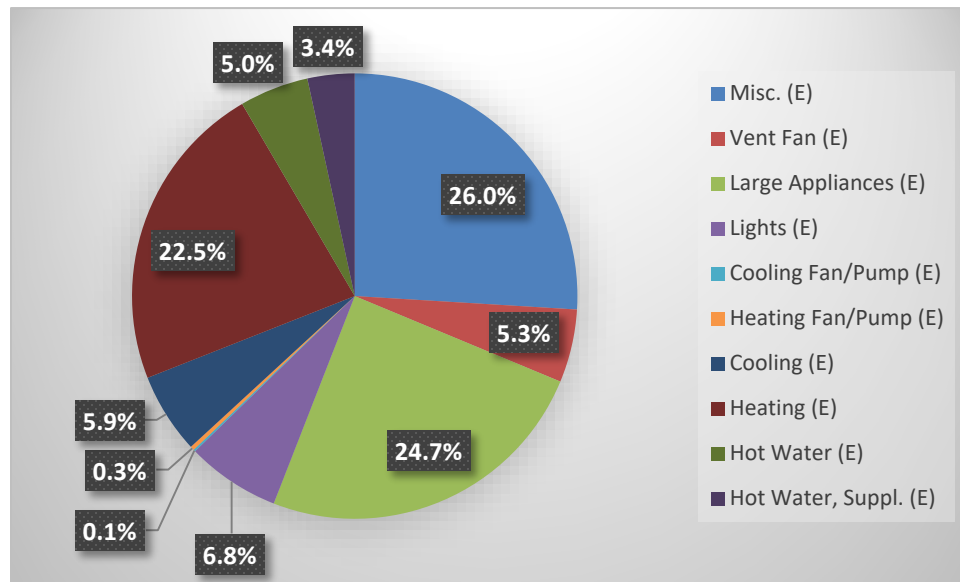


Figure 6-6: Annual Energy Breakdown of reACT

During the initial design of the HVAC system, this team planned to use a heat recovery system with a mini-split system. However, this team discovered that commercially available mini-split systems with heat recovery were oversized for the heating and cooling needs of reACT. The lowest capacity mini-split system with heat recovery found was 3.5 tons, and a system with a capacity of 2.5 tons is desired. This team set to find out if the inefficiencies of using the oversized 3.5 ton unit will outweigh the benefits of using a heat recovery system. For this analysis, BEOpt was used to model reACT with the 2.5 ton mini-split unit and the oversized 3.5 ton mini-split unit. Both systems are not modeled with a heat recovery system. All other parameters of the model were kept the same between the two cases, except the mini-split system used. The results are shown below in Table 6-7.

Table 6-7: Mini Split System Energy Comparison

Operation	2.5 Ton, SEER 22	3.5 Ton, SEER 15.9	Percent Increase
Cooling	471 kWh/Year	680 kWh/Year	44.7%
Heating	1,817 kWh/Year	2,057 kWh/Year	13.2%

The oversized 3.5 ton mini-split system increases the cooling and heating energy consumption by 44.7% and 13.2%, respectively. The oversized unit is at part load operation so that typically its COP is reduced. The increase in energy efficiency using the heat recovery system will not outweigh the inefficiency of using an oversized 3.5 ton mini-split system. Thus, this team made the design decision to use the 2.5 ton mini-split system without a heat recovery system.

Modeling the Courtyard

Perhaps the most important architectural feature of the reACT house is the Courtyard, which takes the form of a greenhouse or sunspace. The potential of this space not only to energize the social life of the house, but also to serve as a reconfigurable passive solar collector is one of the driving concepts behind the overall design for the house.

BEOpt and most other conventional modeling tools do not support the transient analysis of greenhouse, and so the Energy Modeling Team had to develop this model from scratch. The basic formulae used to model the space are found in the literature [Joudi and Farhan, 2015], and are summarized below.

The courtyard model includes 10 control volumes: South wall, North wall, East and west walls in contact with conditioned space, East and west walls in contact with outside, Eastwards and westwards tilted roof, Air and floor. Modelica Buildings Library and components from Modelica Standard Library – Thermal Package were used for the model with some custom components developed. TMY3 weather data for Denver International Airport was used as input using the Weather Input block. For glass covers the energy equation can be written as:

$$\rho_g c_g \frac{dT_g}{dt} = q_a^r - q_e^r + q_i^{co} - q_o^{co}$$

Equation 6-1

Where ρ is the density, c is the specific heat capacity, T is the temperature of glass, t is time, the subscript “g” refers to glass. Right hand side has four heat flux (q) terms with superscript “r” referring to radiative heat transfer while “co” to convection. Subscripts for radiative heat flux a is absorbed, e is emitted, while for convective terms “i” is for inside space while “o” is for outside space.

Constant heat transfer coefficients were given as inputs for convective heat transfer obtained by averaging the parameters from the empirical relations reported in Abdel-Ghany and Toyoki [2006]. For radiation absorbed from sun by each glass surface, dot product of direct normal radiation coming in at solar hourly angle and the glass surface normal was calculated. This was then multiplied by glass surface area and absorptivity to obtain net radiation absorbed from sun. The radiation reflected by the floor and absorbed by the glass surface is neglected because its effect is small (about 10%) as described in Joudi and Farhan [2015]. Another assumption used is that the radiative heat transfer between various glass surfaces is negligible. This assumption prevents accounting for 28 possible heat transfer combinations of the control volumes. In reality, there will be slight temperature differences between various glass surfaces but is expected to be less than 5 K.

For radiative heat losses to outside, sky temperature is calculated by equation mentioned in [Swinbank, 1963]. Radiative heat transfer block from Modelica standard library was used to model this heat transfer. For the floor, the energy equation can be written as:

$$\rho_f c_f \frac{dT_f}{dt} = q_a^r - q_e^r + q_i^{co} - q_o^{co}$$

Equation 6-2

The absorbed radiative heat transfer portion represents the radiation which gets transmitted through various glass surfaces and gets absorbed. In the real case, the transmitted radiation each glass surface undergoes multiple reflections on other surfaces or even gets reflected to outside the greenhouse. For the purpose of modeling, it was assumed that 60% of the radiation coming in from various surfaces would get absorbed into the floor. The absorptivity of opaque surfaces making the floor is typically in the range of 0.8 – 0.9 while reflectivity of glass is about 0.1 and transmissivity 0.85 [Bouadila et al., 2014]. Thus 10% of radiation falling on each glass surface gets reflected, 85% of which gets transmitted in and 80% of which gets absorbed into the floor ($0.9 \cdot 0.85 \cdot 0.8 = \sim 0.6$). The radiation emitted to the glass surfaces was modeled using the radiation block. View factors from floor to walls are 0.18, while from floor to each of the roof is 0.14.

The heat transfer by convection was modeled similar to the glass surface. Since the house was raised over a platform the heat losses term to the outside air was also modeled.

Lastly, to model the air inside the courtyard the energy equation is as follows:

$$\rho_a c_a \frac{dT_a}{dt} = q_s^{co} + q_g^{co} + q_{inf}$$

Equation 6-3

The absorption of radiation in the air was neglected. This is a very common assumption in greenhouse modeling [Joudi and Farhan, 2015; Abdel-Ghany and Toyoki, 2006; Bouadila et al., 2014]. The first term on the right-hand side is the convective heat transfer from soil, the second term is convective heat transfer from glass surfaces while the final term is infiltration.

The heat transfer from the air coming in by infiltration was calculated as:

$$q_{inf} = \rho_a c_a V * \frac{ACH}{3600} * (T_{in} - T_{out})$$

Equation 6-4

This model was implemented in Modelica to find out the temperature of courtyard for various ventilation rates since the actual infiltration cannot be predicted at modeling level. A typical ACH = 2 was set for the condition when outdoor unit was not operational. When the outdoor unit is working, it draws in more air from the courtyard increasing the infiltration. Based on the steady state mass balance, the infiltration in this condition would equal the air drawn by the outdoor unit. The value of this mass flow rate was obtained from EnergyPlus and fed back to the Modelica model to find out the courtyard temperature. Thus, an iterative approach between two models was used to determine the savings to energy from courtyard.

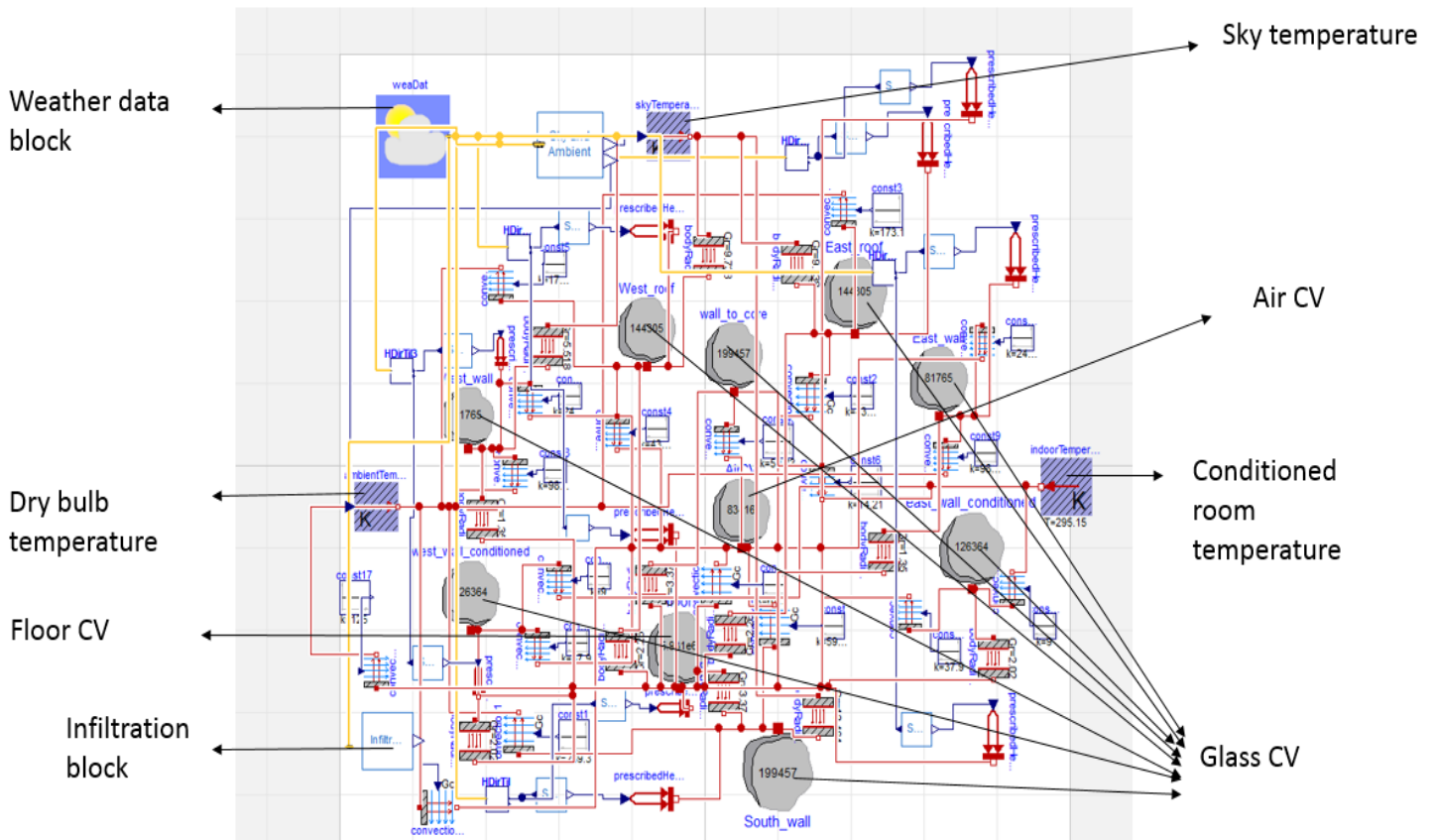


Figure 6-7: Modelica GUI for Courtyard Model

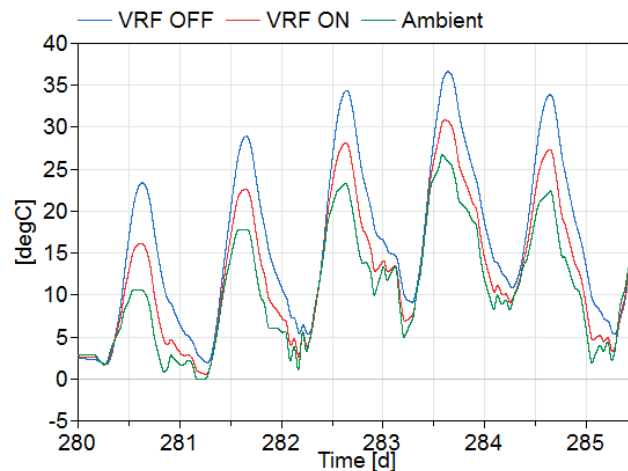


Figure 6-8: Courtyard temperature with VRF ON and VRF OFF in comparison to outdoor temperatures near competition dates (Oct. 8 = 281, Oct. 12 = 285)

As can be observed from Figure 6-8, the model can predict the increased temperature of the courtyard from the greenhouse effect. The floor has the highest specific heat capacity among the materials and captures most of the solar radiation. This energy is then transferred to courtyard air by convection. The heat transfer coefficient for this transport was set from Cholewa et al. [2014]. This factor adds to the courtyard air temperature.

Infiltration is the second important factor affecting the courtyard air temperature. This leads to the heat loss from the courtyard air temperature. Infiltration depends heavily on the construction and so some assumptions were made based on judgement. For the VRF OFF case from Figure 6-8, ACH = 2 was selected. The typical rates for cold climate houses are of the order of 0.5 for conditioned space and so a much higher number was set for the courtyard. Another assumption is that when the VRF is running, the air that gets blown out from the courtyard is accounted for by the infiltration from outside air. In reality, there would be infiltration from the indoor space. Thus, the modeled scenario represents the worst-case scenario.

Pre-cooling and Pre-heating Effects

Pre-cooling and pre-heating of the air sent to the VRF outdoor unit (OU) could reduce the energy consumption of the VRF system in cooling and heating season. The benefits of the precooling and preheating of the inlet air are shown in Figure 6-9 and Figure 6-10, respectively. Figure 6-9 shows the effect of two levels of pre-cooling when VRF system delivers the same amount of cooling capacity as an example. The cooling capacity was selected to be 8.8 kW, which is the rated cooling capacity of the VRF systems installed in the solar house. Similarly, in Figure 6-10, it was assumed that VRF system could deliver a heating capacity of 9.4 kW.

In Figure 6-9, the first level pre-cooling reduces the VRF OU inlet air temperature by 2 K and the second level by 4 K. Similarly, in Figure 6-10, the first level pre-heating increases the OU inlet air temperature by 2 K and the second by 4 K. As can be seen in Figure 6-9, the cooling energy consumption of the system increases along with the increase of ambient temperature. With the pre-cooling of the OU inlet air, the energy consumption is reduced as compared to the baseline. In addition, the second level of pre-cooling has a higher COP and lower energy consumption than the first level of pre-cooling. On average, the first level of pre-cooling reduces the energy consumption by 175 W and the second level by 339 W. Figure 6-10 shows similar results to Figure 6-9. As compared to the baseline, the pre-heating could reduce the heating energy consumption.

Results of Figure 6-10 could be classified into two regions. When the ambient temperature is lower than 5°C, the performance of the baseline system degrades due to the defrosting operation. However, when pre-heating is introduced, the system could maintain a higher COP until a preheated OD inlet air temperature becomes lower than 5°C. As shown in Figure 6-10, when the second level of pre-heating is applied to the system, the performance of the system does not drop until the ambient temperature reaches 0°C. Overall, the first level of pre-heating could reduce the energy consumption by 239 W and the second level by 472 W.

The air-source heat pump water heater (HPWH) provides hot water to the building. The air-source HPWH is similar to the VRF OU in the heating mode. Therefore, it could also benefit from the courtyard pre-heating. The benefit of the preheating of the inlet air of HPWH OU is shown in Figure 6-11. The pre-heating levels are the same as Figure 6-10. In Figure 6-11, the water heating capacity was assumed to be 1.2 kW with a hot water set point of 45°C. The rated COP is 4.62 and the rated energy consumption is 259 W. On average, the first pre-heating level saves 17 W and the second by 34 W.

The concept of pre-cooling and pre-heating was applied to the solar house. In the cooling season, the HPWH is used to pre-cool the air entering the OD of VRF system. In the heating season, the preheated courtyard air, which has a higher temperature than the ambient air, is used.

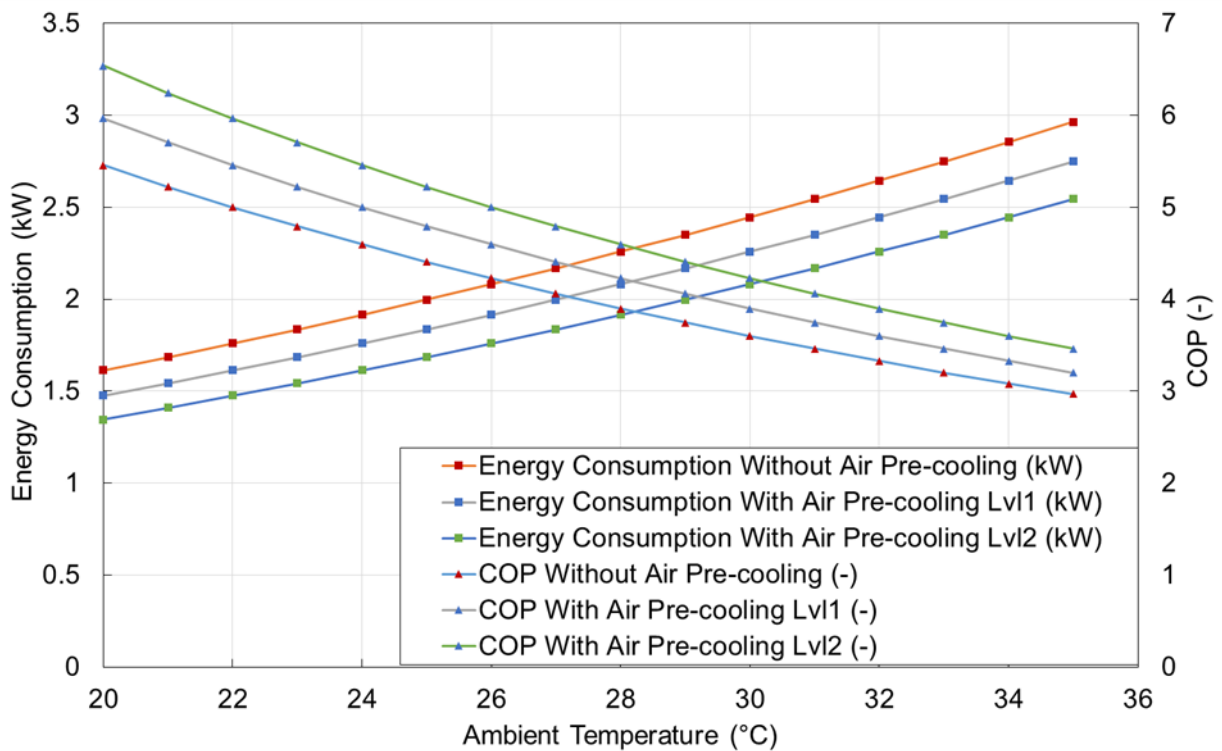


Figure 6-9: Benefit of pre-cooling of VRF OU inlet air in cooling season

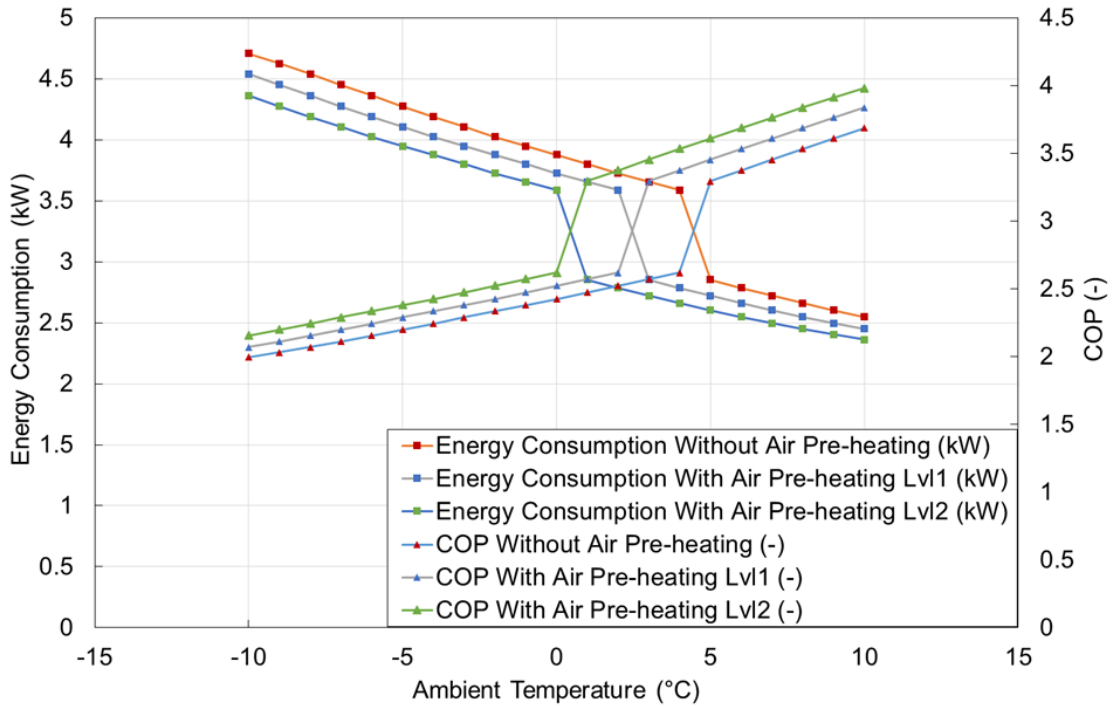


Figure 6-10: Benefit of pre-heating of VRF OU inlet air in heating season

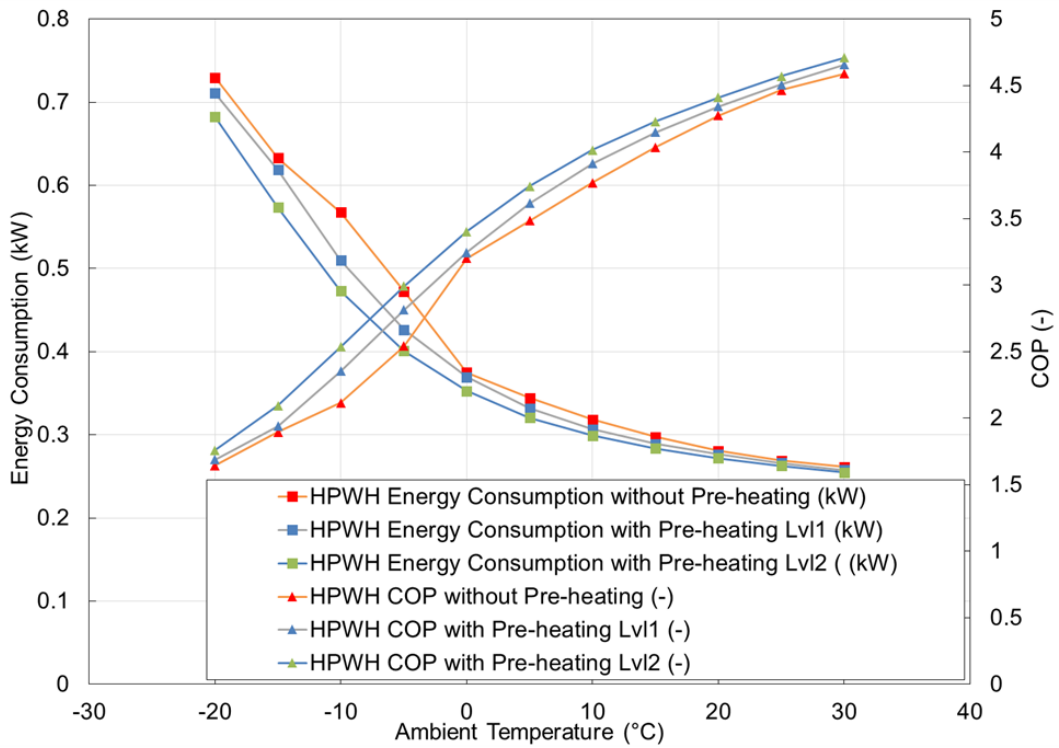


Figure 6-11: Benefit of pre-heating of HPWH OU inlet air

Effect of Courtyard Control

With the movable rooftop installed in the courtyard, it is possible to harvest the solar radiation. In the heating season, a higher air temperature in the courtyard than the ambient is expected. When the VRF system uses the courtyard air instead of the ambient air during the heating operation, a lower heating energy consumption could be achieved. Based on the solar house model described above, an annual simulation of the courtyard air temperature was simulated. The effect of using courtyard air as the VRF OU heat source was estimated in EnergyPlus. The running period was selected to be January to March. TMY3 weather data of Denver was used. From 10 AM to 10 PM, the rooftop was assumed to be controlled to ensure that a higher courtyard temperature than the ambient is achieved. The HPWH was assumed to be turned off to eliminate the cooling effect of the HPWH OU. It was assumed that the VRF system constantly draws 1,728 m³/h of air from the courtyard, which is the highest flow rate it could possibly reach in heating operation. The relationship between the hourly courtyard temperature and ambient air temperature is shown in Figure 6-12. The highest temperature difference achieved is 5.6 K. The summarized daily results are shown in Figure 6-13. As can be seen in Figure 6-13, when using the courtyard air as heat source, VRF system could achieve a lower energy consumption. The overall monthly energy consumption is reduced from 583 kWh to 572 kWh, accordingly.

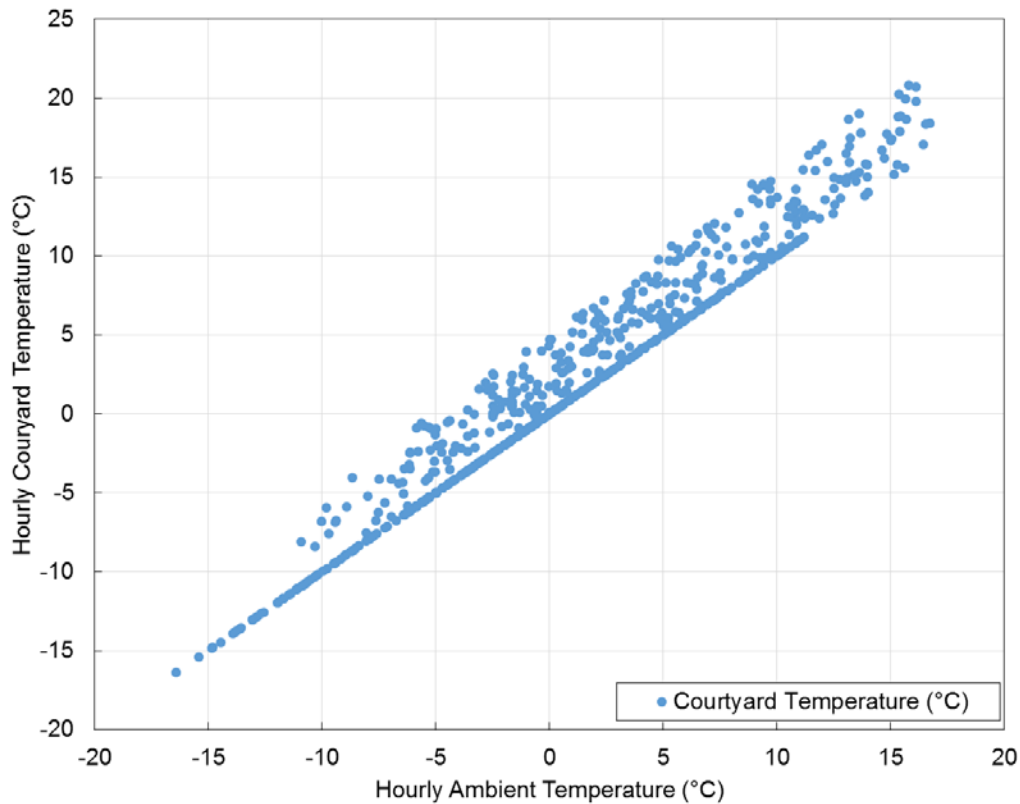


Figure 6-12: Courtyard temperature with the roof top radiation

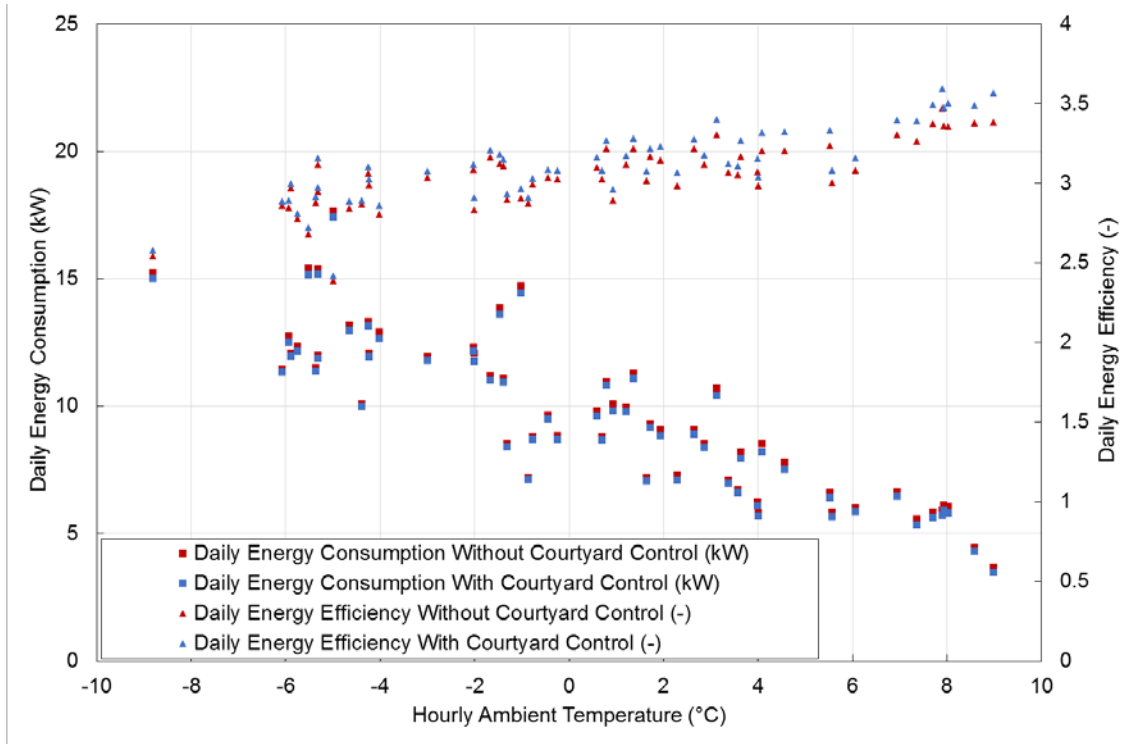


Figure 6-13: Performance of VRF System with and without courtyard control

A typical hourly temperature elevation in the courtyard is shown in Figure 6-14. The date is January 25th, which is also the design day. As can be seen, the highest temperature increase is 2.25 K and the average increase is 1.2 K. The effect of a 1.2 K courtyard temperature increase on the HPWH performance is shown in Figure 6-15. Base on the ambient temperature of January 25th, the power consumption of HPWH could be reduced by 13 W when operated under with the highest preheating of 2.25 K.

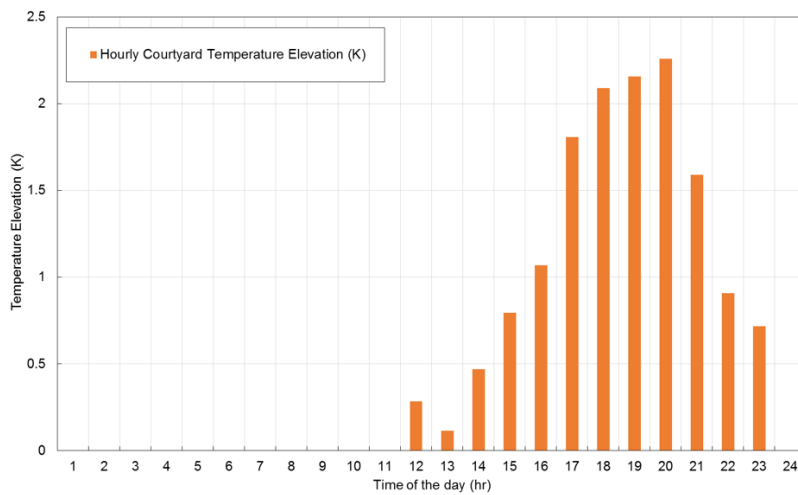


Figure 6-14: Hourly Courtyard Temperature Elevation on January 25th

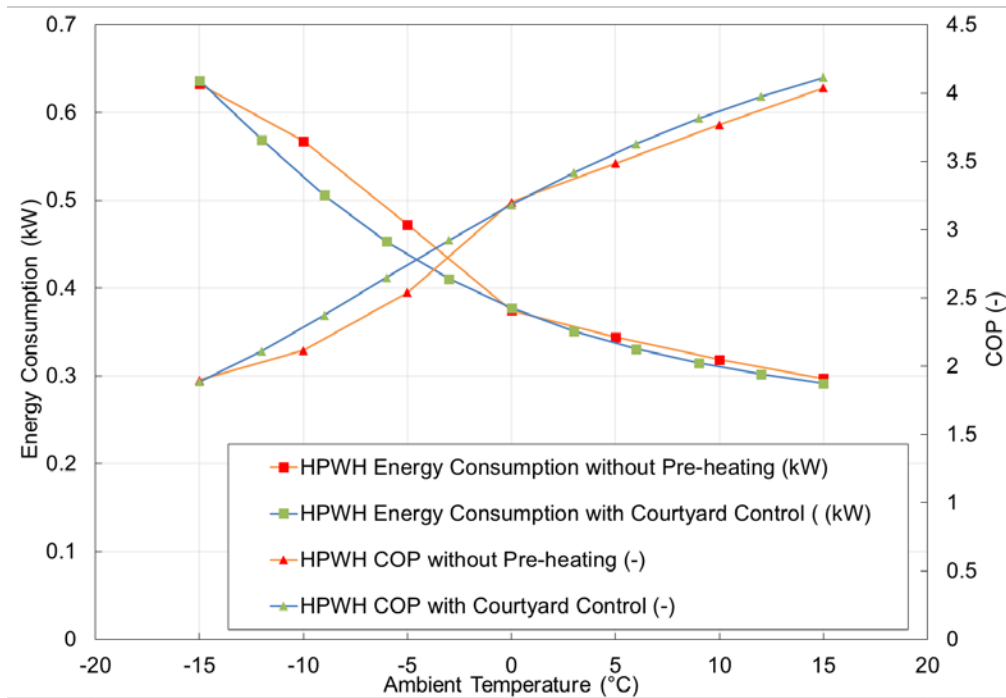


Figure 6-15: Effect of Courtyard Control on HPWH

Effect of Air Damper Control

The solar house has OUs of both VRF system and air-source HPWH installed in the attic. The air-source HPWH absorbs heat from the attic air and heat up the water tank indirectly through the indoor water tank loop. On the contrary, the VRF system rejects heat to the attic in order to cool down the room. For a VRF system, a lower attic air ambient temperature could lead to a lower energy consumption. Therefore, in this solar house, an air damper control concept was introduced to use the air-source HPWH to pre-cool the attic air before entering to VRF OU. The concept is shown in Figure 6-16. The two OUs are installed on the both ends of the attic. The HPWH OU is installed next to the air let where the ambient air is drawn into the attic. The outlet of the attic air is chosen to be placed next to the VRF OU. Dampers A and B are closed to prevent unnecessary air leakage during OUs operation but open for natural ventilation when OUs are not used. Between the two OUs, there are two dampers installed to control the direction of the air flow. In the cooling season, when HPWH is operating, both dampers C and D are still closed. Therefore, the ambient air is pre-cooled by HPWH OU before it reaches the heat exchangers of VRF OU. This control is only designed for cooling season since a lower inlet air temperature could degrade the heating performance of VRF system. In the heating operation, both dampers C and D open up, as shown in Figure 6-18. In Figure 6-18, the air flow of VRF OU is not affected by HPWH. The effect of air damper control was also simulated in EnergyPlus for the cooling season. The running period was July to September. TMY3 weather data of Denver, Colorado was used. It was assumed that the VRF system constantly draws 1,431 m³/h of air from the ambient, which is the highest flow rate it could possibly reach in heating operation. The results are shown in Figure 6-19. Due to the pre-cooling effect of the HPWH OU, the cooling performance of the VRF system is slightly improved. Overall, the energy consumption is reduced from 471.9 to 457 kWh. The overall annual saving of the solar house is listed in Table 6-8.

Table 6-8: Energy savings from HVAC Systems

Source	Energy Use Baseline (kWh/Year)	Energy Use Solar House (kWh/Year)	Change (kWh/Year)
Misc.	2,092.6	2,092.6	N/A
Ventilation Fan	427.9	427.9	N/A
Large Appliances	1,987.1	1,987.1	N/A
Lights	548.1	548.1	N/A
Cooling Fan/Pump	11.7	11.7	N/A
Heating fan/Pump	23.45	23.45	N/A
Cooling	471.86	457	-14.8
Heating	1,817.1	1,782.7	-34.4
Heating, Suppl.	275.5	0	-275.5
Hot Water	404.5	384.2	-20.3
Total	8,060	7,714.7	-345.3
PV	12,547	12,547	0
Net (PV-Total)	4,487	4,832.3	345.3

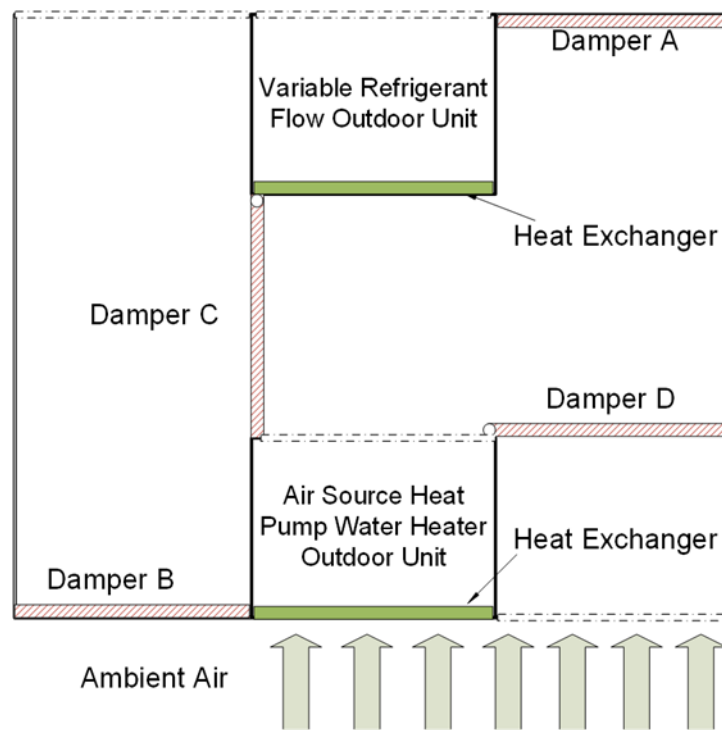


Figure 6-16: Attic air damper control overview

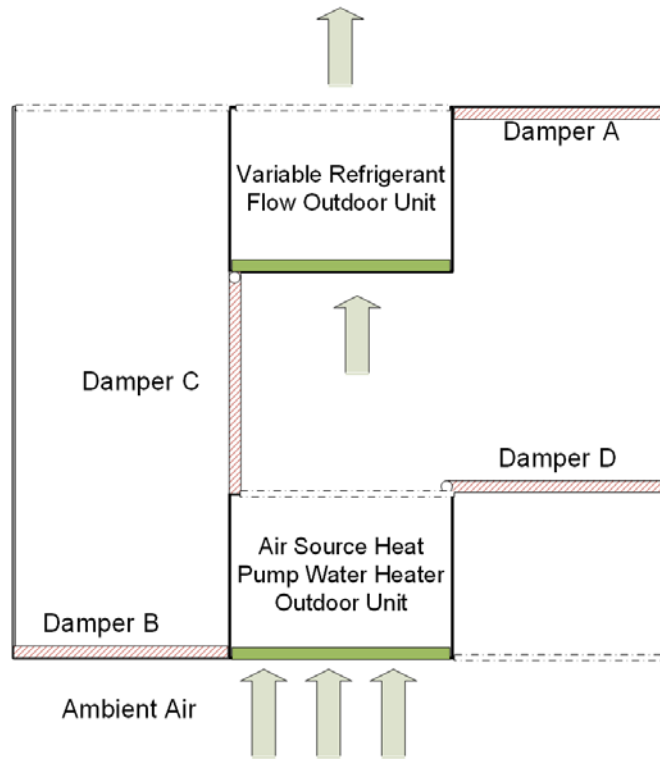


Figure 6-17: Cooling season damper control

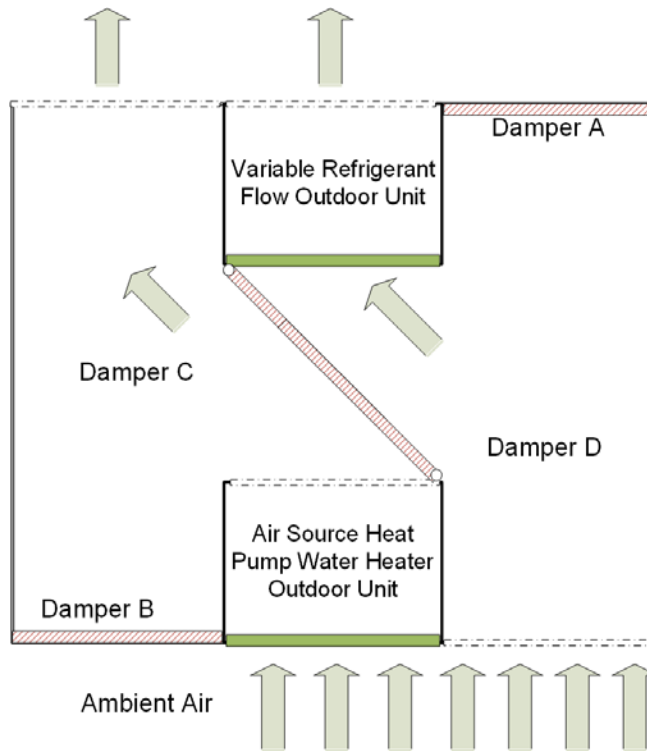


Figure 6-18: Heating season damper control

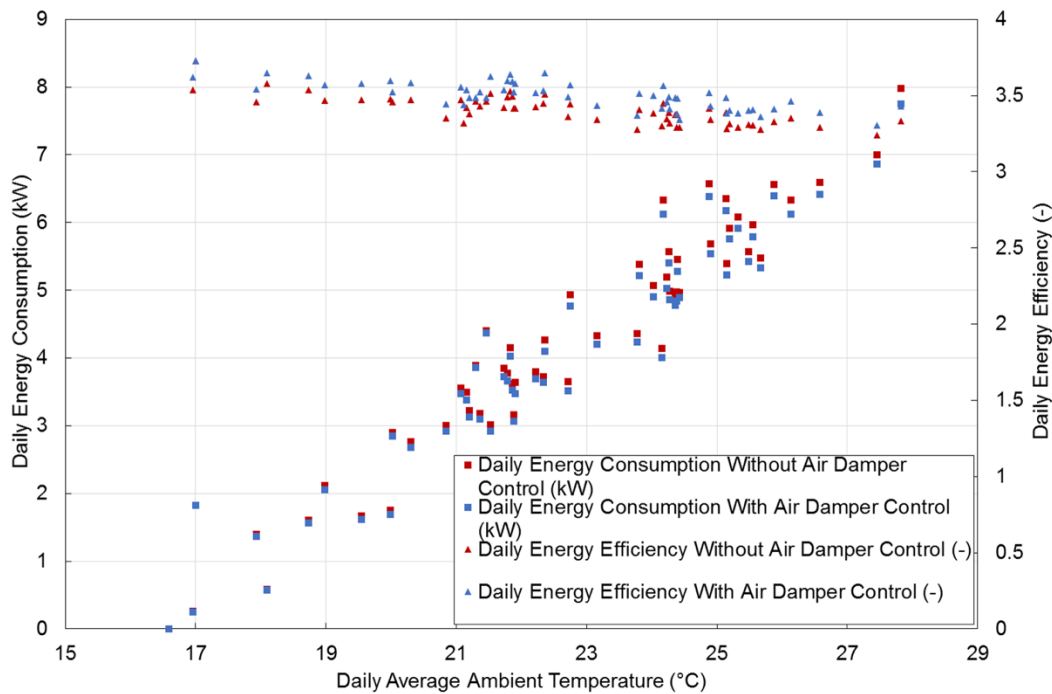


Figure 6-19: Performance of VRF System with and without air damper control

Conclusions

BEOpt was used to explore different design options through many successive parametric runs. Many different factors including window to wall ratio, R-value of the walls, roof and floor, and assumed infiltration rate were studied using this model. The team made use of BEOpt’s parametric study capabilities to show how changing certain parameters affected the cost and energy consumption. Detailed charts containing energy saving and cost for these materials were developed for making trade-offs while selecting building envelope.

BEOpt caters to only conventional residential simulation. For modeling the innovative courtyard, a first-principles based model was developed using Modelica. This model was used to predict the temperature of courtyard during the year round operation. The outdoor unit of VRF system draws air from the courtyard after the HPWH OU to either precool or preheat inlet air based on season. The savings of this operation were calculated by exporting the data from Modelica to EnergyPlus. The savings from this calculation shows that the net savings from the VRF operation is estimated to be 7.7%. Savings in hot water generation are 5%. Total savings in HVAC (Heating and Cooling combined) are 12.7%.

References:

- [1] NREL, Site Energy Savings, Website, Accessed on Feb. 13, 2017, https://beopt.nrel.gov/sites/beopt.nrel.gov/files/help/Site_Energy_Savings.htm.
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- [3] Joudi, K.A., A.A. Farhan, A dynamic model and an experimental study for the internal air and soil temperatures in an innovative greenhouse. *Energy Convers Manag* 2015; 91:76–82.

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Construction Specifications

Division 01 - General Requirements

013200 - CONSTRUCTION PROGRESS DOCUMENTATION

- A. Receipts for all materials, supplies and professional services shall be provided to the Construction Manager, whether or not reimbursement for expenses is required.
- B. Photographs depicting completed elements of the Work shall be provided in digital form to the Construction Manager. Photographs shall be of sufficient quality and scope to verify the correct completion of each element of the Work.
- C. Photographs showing the location of all services (plumbing, wiring, etc.) which shall be hidden by subsequent elements of the Work (drywall, etc.) shall be provided in digital form to the Construction Manager. Recognizable reference points shall be included in the photographs so as to allow unambiguous identification and location of hidden elements.
- D. All elements requiring inspection by responsible authorities (University, Local, State, Competition Organizers) shall be left open until said inspections are complete, and shall not be hidden by other elements of the Work.

END SECTION 013200

013300 - SUBMITTAL PROCEDURES

- A. All Submittals required by other sections of this document shall be provided in both digital and printed (hardcopy) form to the Construction Manager.
- B. All warranties, performance specifications, installation and operating instructions which normally accompany products incorporated into the Work shall be provided to the Construction Manager, whether or not said materials are specifically mentioned in other sections of this document.
- C. Upon request from the Construction Manager, Project Manager, Project Architect or Project Engineer, the manufacturer or their authorized reseller shall provide test data to verify the performance of any given product, whether or not this requirement is specifically cited in other sections of this document.

END SECTION 013300

017300 - EXECUTION

- A. All products shall be installed according to instructions from the product manufacturer. Installation guides for each product shall be provided to the Construction Manager, whether or not said documentation is specifically requested in other sections of this document. Any discrepancies or differences between manufacturer instructions and those found in other sections of this document or in the Drawings shall be called to the attention of the Construction Manager and the Project Architect for resolution before that element of the Work is started.
- B. Execution of all elements of the Work shall be performed in compliance with all applicable laws, building codes and Competition rules. If discrepancies or conflict are noted between said regulations and other sections of this document or in the Drawings, they shall be called to the attention of the Construction Manager and the Project Architect for resolution before that element of the Work is started.

END SECTION 017300

017400 - CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

- A. A Construction Waste Management Plan shall be developed and submitted to and approved by the Construction Manager and the Project Manager prior to commencement of the Work. This Plan shall include measures for diverting at least 99 % of materials from the landfill for composting, recycling or reuse. This Plan shall identify collection locations for various waste streams at the Construction Site.

- B. A Construction Waste Management Plan shall be submitted by each supplier of materials that constitute more than 5% of the Work by weight or value. These Plans shall identify measures taken by the supplier to divert materials from the landfill.

END SECTION 017400**017500 - HEALTH & SAFETY PLANS**

- A. A Health and Safety Plan shall be developed and submitted to and approved by the Health and Safety Officer(s), the Project Manager and the Construction Manager prior to commencement of the Work. This Plan shall clearly identify all equipment and procedures for assuring the health and safety of workers and visitors to the Construction Site, and the Competition Site. The H&S Plan shall also specify training requirements for responsible safety officers and for all workers on site.
- B. Personnel found to regularly or willfully violate provisions of the H&S Plan shall be barred from the Construction Site and/or the Competition Site.

END SECTION 017500**018100 - SUSTAINABLE CERTIFICATION DOCUMENTATION**

- A. The Project Manager, Construction Manager and Project Architect shall review the documentation requirements for the LEED for Homes certification system and shall identify measures to meet all prerequisites and sufficient credits to achieve a Platinum level of certification. All documentation requirements normally associated with LEED certification at this level shall be provided during the Construction, assembly, operation and disassembly of the Work and Competition.
- B. The Project Manager, Construction Manager and Project Architect shall review the documentation and compliance requirements for Full Certification under the International Living Future Institute's (ILFI's) Living Building Challenge and Living Product Challenge systems. All documentation requirements normally associated with LBC and LPC Certification shall be provided during the Construction, assembly, operation and disassembly of the Work and Competition.
- C. For each product and material used in the Work, the manufacturers shall provide either: a) comprehensive list of constituent chemicals sufficiently detailed to verify Compliance with the ILFI Red List, OR, b) an ILFI Declare label for the product or material.

END SECTION 018100**019100 - SUSTAINABLE MATERIAL REQUIREMENTS**

- A. All materials and products used in the Work shall be ILFI Red List Exclusion compliant unless otherwise approved in writing by the Project Architect.

END SECTION 019100

Division 05 – Metals

051200 – STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 SCOPE

Steel structural framing used in the house construction as indicted in the Drawings and other sections of this Specification.

1.2 STANDARDS

- A. All structural steel work shall conform to the following governing standards:
 - 1. American Society for Testing and Materials:
 - a. ASTM Specifications for Structural Steel
 - b. ASTM Specification for Pipe, Welded and Seamless
 - c. ASTM Specification for Cold-Formed Welded and Seamless Steel Structural Tubing in Rounds and Shapes
 - d. ASTM Specification for Hot-Formed Welded and Seamless Steel Structural Tubing
 - 2. American Welding Society:
 - a. AWS Structural Welding Code
 - b. AWS Specifications for Welding Rods and Bare Electrodes
 - 3. Industrial Fasteners Institute:
 - a. IFS Handbook on Bolt, Nut, and Rivet Standards
- B. Structural Performance: Design, engineering, fabrication, and installation of structural steel elements and connections shall meet requirements of the International Residential Code 2015, and all referenced codes.

1.3 SUBMITTALS

- A. Structural Drawings signed and stamped by a licensed engineer
- B. Shop Drawings
- C. Structural Analysis signed and stamped by a licensed engineer

END SECTION 051200**051300 – STRUCTURAL ALUMINIUM FRAMING**

PART 1 – GENERAL

1.1 SCOPE

Aluminum used in the main structural frame for the house, as well as in wiring and plumbing chases.

1.2 STANDARDS

- A. Federal Specifications:
 - 1. TT-P-645 – Paint, Aluminum, Heat Resisting
- B. Aluminum Association:
 - 1. Aluminum Design Manual
- C. ASTM International:
 - 1. ASTM B308 / B308M
 - a. Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles
 - 2. ASTM B221
 - a. Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

3. ASTM B429

a. Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube

D. American Welding Society:

1. AWS D1.2 - Structural Welding Code, Aluminum.

END SECTION 051300**END SECTION 05**

Division 06 – Wood, Plastics, and Composites

061000 – ROUGH CARPENTRY

PART 1 – GENERAL

1.1 SCOPE

Rough carpentry includes splines added to reinforce Structural Insulated Panels (SIPs), framing for floors, interior partitions, sheer walls, and structural reinforcement.

1.2 PERFORMANCE REQUIREMENTS

- A. All wood framing shall be FSC certified.
- B. Wood framing used for sill plates or contacting concrete or earth shall be pressure treated to prevent rotting and insect infestation.
- C. Framing sizes shall be as indicated in the Drawings.
- D. Framing members shall be free of excessive warping, knots, splitting, and other structural defects.

PART 3 – EXECUTION

3.1 STORAGE

- A. Rough carpentry shall be stored under cover, and shall be acclimated prior to use in the Work.

3.2 DISPOSAL

- A. Reminders shall be stored on site for reuse.

END SECTION 061000

061500 – DECKING

PART 1 – GENERAL

1.1 SCOPE

Decking refers to elevated walking surfaces surrounding and attached to the house including porches, walkways, and ramps, but not the courtyard floor.

PART 2 – PRODUCTS

2.1 ACCEPTABLE PRODUCTS

- A. Refer to Drawings.

PART 3 – EXECUTION

- A. Decking boards shall be separated by a gap of no more than 3/16 of an inch.
- B. Decking shall be securely attached to structural members using fasteners approved for use with the decking material.
- C. Decking must be installed flat and level, except at ramps.

END SECTION 061500

061600 – WOOD SHEATHING

PART 1 – GENERAL

1.1 SCOPE

Wood sheathing is used to provide lateral strength on walls other than Structural Insulated Panels (SIPs). This includes walls of the bathroom and kitchen modules, and attic sheer walls.

1.2 PERFORMANCE REQUIREMENTS

- A. Sheathing shall be plywood or composite material approved in writing by the Project Architect.
- B. Minimum thickness ½ inch unless noted otherwise on the Drawings.

- C. Sheathing shall have minimum 1-hour fire rating.

PART 2 – PRODUCTS

PART 3 – EXECUTION

- A. Sheathing shall be secured to framing as specified in the structural drawings.
- B. Sheathing shall be stored flat, and under cover.

END SECTION 061600

065000 – STRUCTURAL INSULATED PANELS

PART 1 – GENERAL

1.1 SCOPE

Structural Insulated Panels (SIPs) constitute the primary structural system and thermal envelope of the house. SIPs provide lateral stability for the walls (wind and seismic), and support floor and roof spans under gravity loads (dead and live).

SIPs are comprised of an insulated core with attached stress skin panels on both interior and exterior surfaces.

1.2 PERFORMANCE REQUIREMENTS

- A. Provide at least R-35 insulation with an 8-inch thick panel.
- B. Provide at least R-60 insulation with a 12-inch thick panel.
- C. Shall support a clear span of at least 12'-0" with a 10-inch thick panel.
- D. Shall support a cantilever of at least 2'-0" with a 12-inch thick panel.

1.3 SUBMITTALS

- A. Manufacturer shall provide qualified test data supporting advertised thermal performance.
- B. Manufacturer shall provide qualified test data supporting advertised structural performance.

PART 2 - PRODUCTS

2.1 SIPS

- A. Acceptable Products: Renegade SIPs Panels
- B. For more information, see www.sipsofthesouth.com/structural-insulated-panels.html
- C. Composite panels shall be custom fabricated to include connection hardware as indicated in the Drawings.
Connection hardware shall be provided to the manufacturer by the University of Maryland.

END SECTION 065000

END SECTION 06

Division 07 – Thermal and Moisture Protection

072100 – THERMAL INSULATION (general purpose site installed)

PART 1 - GENERAL

1.1 SCOPE

Polyurethane spray foam used to insulate and seal around framing members. Used primarily to augment and complement the use of Structural Insulated Panels, which constitutes the primary thermal envelop.

1.2 PERFORMANCE REQUIREMENTS

- A. Insulation shall have a minimum thermal resistance (R-value) of 5.0 BTU/ft²/deg.F/hr per inch of thickness.
- B. Insulation materials shall inhibit infestation by insects and rodents.
- C. Blowing agents for the insulation shall not include CFCs or HCFCs.

1.3 SUBMITTALS

- A. The Contractor shall provide the Architect with technical details of materials data sheets and installation instructions sufficient to verify the performance requirements cited above.
- B. The Contractor shall provide the Owner with a warranty certificate covering materials AND installation of the Insulation.

PART 2 - PRODUCTS

2.1 Acceptable Manufacturers and Products

- A. None specified
- B. Contractor shall specify a product and installer for this material as part of their proposal, and shall provide the documentation indicated in Section 1.2 – Submittals above.
- C. Specified products shall be compatible with the adjacent materials including wood and metal framing, sheathing and finishes.

PART 3 - EXECUTION

- A. Insulation shall fill all voids around framing, blocking, fixtures, plumbing and junction boxes.
- B. Excess insulation (where accidental overfilling of the framing cavities occurs) shall be removed as required for installation of finishes without damaging the remaining installed insulation.

END SECTION 072100**SECTION 072500 – WEATHER RESISTIVE BARRIERS**

PART 1 - GENERAL

1.1 SCOPE

Weather Resistive Barriers (WRBs) are applied to the exterior face of wall and roof sheathing, behind the exterior cladding. WRBs serve as an air barrier and drainage plane for exterior moisture.

1.2 PERFORMANCE REQUIREMENTS

- A. Impermeable to air infiltration.
- B. Wall WRB shall be water vapor permeable – 10 perms or greater
- C. Impermeable to liquid water.
- D. Self-adhesive roll sheeting or liquid applied
- E. UV stable for at least 90 days.
- F. Self-healing around small penetrations like screws or nails.

1.3 SUBMITTALS

- A. Cut sheets documenting performance as noted above.

PART 2 - PRODUCTS**2.1 Self-Adhering Elastomeric Sheeting**

- A. For use on walls only.
- B. Acceptable Products
 - 1. Henry BlueSkin VP100
 - 2. Alternate products may be used with prior written approval of the Project Architect.

2.2 Liquid Applied Membranes

- A. For use on walls only.
- B. Acceptable Products
 - 1. Prosoco R-Guard Cat 5
 - 2. Alternate products may be used with prior written approval of the Project Architect.

2.3 Self-Adhering Roof Underlayment

- A. For use under metal roofing
- B. Acceptable Products
 - 1. GRACE SELECT
 - 2. FABRAL RoofSeal
 - 3. Alternative products which are more sustainable are encouraged, with prior written approval of the Project Architect.

2.4 ACCESSORIES – Sealing Tape

- A. For use sealing joints between WRB sheets, sealing top edges of metal flashing, sealing seams in wood panels, etc.
- B. Acceptable Products
 - 1. First Choice – ProClima TESCON VANA Sealing Tape
 - 2. Subject to investigation of material incompatibilities, alternate sealing tape selection will be according to WRB manufacturer recommendations.

2.5 ACCESSORIES – Termination Mastic

- A. Used to terminate the top edges of flashing and/or sealing tape.
- B. Select termination mastic per manufacturer recommendations.

END SECTION 072500**SECTION 072600 – VAPOR RETARDERS****Part 1 – GENERAL****1.1 SCOPE**

Prevents the migration of air and water vapor. Used in this project only under the floor framing to prevent rising damp from ground.

1.2 PERFORMANCE REQUIREMENTS

- A. Maximum perm rating of 0.1
- B. Preferred per rating < 0.01.
- C. Minimum thickness: 6 mil (0.006")
- D. Shall be tear resistant

Part 2 – PRODUCTS**2.1 ELASTOMERIC VAPOR RETARDER****A. Acceptable Products**

1. InsulationSolutions Inc. - Viper CS Crawl Space Vapor Barrier
 - a. Thickness : 10 mil (0.01 in).
 - b. Perm Rating (English) : 0.0016 perms

- B. Alternative products with similar performance may be substituted with written approval of the Project Architect.

Part 3 EXECUTION

Limit perforation of the membrane for plumbing and attachment. Seal around all penetrations with approved liquid-applied sealant, mastic or tape (approved by membrane manufacturer).

END SECTION 072600**SECTION 073100 – WOOD SIDING****Part 1 – GENERAL****1.1 SCOPE**

Wood siding is used as exterior cladding for walls. For specific information regarding the use of wood siding on this project, refer to the Drawings.

1.2 APPLICABLE STANDARDS

- A. International Living Future Institute (ILFI) Living Building Challenge (LBC)
- B. ILFI Declare Products
- C. ILFI RedList Compliance

1.2 REQUIREMENTS

- A. Shall be FSC Certified as being sustainably harvested from managed forests.
- B. Shall be ILFI RedList Compliant – including any special insect resistance treatments, stains, sealants or paints that are factory applied.
- C. No exotic hardwoods or old growth materials shall be used in the Work.
- D. Wood shall resist infestation by insects.
- E. Wood shall be treated (including stains, coatings and sealants) to resist fading and discoloration (from time, sunlight, UV light, rain, etc.).

1.4 SUBMITTALS

- A. FSC Chain of Custody documentation shall be provided to the Construction Manager.
- B. Comprehensive list of chemicals, include factory-applied insect-resistance, stains, sealers and paints shall be provided to the Construction Manager sufficient to verify RedList Compliance
- C. A copy of the ILFI Declare label (if applicable) shall be provided to the Construction Manager.

Part 2 – PRODUCTS**A. Acceptable Products**

1. Kebony #1243 Scots Pine 21x148 mm Cladding
2. Accoya Wood Cladding
3. Lamboo Rainscreen Architectural wall/ceiling siding
 - a. 3" facing
 - b. 5" facing
 - c. Stock lengths: 8' and 16'. Custom lengths are available with a minimum purchase of 3,000 LnFt (1250 sqft)
 - d. <http://www.lamboo-rainscreen.com>

- B. Alternative Products may be substituted with prior written approval of the Project Architect.

- C. Stains and other coatings and sealants shall be selected and approved in writing by the Project Architect.

Part 3 – EXECUTION

- A. Wood siding shall be applied over a suitable drainage plane to prevent moisture build-up and rot.
- B. Wood siding shall be fastened to the substrate using approved fasteners to prevent warping, popping and corrosion.
- C. Wood siding shall be stored under cover, preferably in conditioned space prior to installation. Follow manufacturer recommendations for stacking and acclimatization.

END SECTION 073100

SECTION 074100 – STANDING SEAM METAL PANELS

Part 1 – GENERAL

1.1 SCOPE

Standing seam metal panels include a cleat that is securely fastened to the substrate, and overlapping seams that can be securely snapped, crimped or clamped to the cleats. Panels may have additional ribs intended to reduce oil-canning or for aesthetic effect. Standing seal metal panels may be made of steel or aluminum and are typically protected by a Kynar finish.

Standing seam metal panels are used primarily as roofing panels on this project, but may be considered for vertical (wall) applications as well.

1.2 REQUIREMENTS

- A. Minimum warranty service life of 50 years.
- B. Low-emissivity coatings and materials shall be used to create a "cool roof" application.
- C. Standing seams must be capable of supporting the attachment of clamps for mounting of solar panels.
- D. Standing seams must be designed to allow removal and reinstallation of sections of the roofing for house assembly and disassembly.
- E. Panel sizes (seam spacing) shall as indicated on the Drawings.

1.3 SUBMITTALS

- A. A copy of the warranty shall be provided to the Construction Manager.
- B. A letter or other official document shall be provided by the manufacturer or their authorized reseller or installer to verify the attachment of solar panels without voiding the warranty (using hardware proposed by the Project Architect). This documentation shall be provided to the Construction Manager and to the Project Architect.
- C. Instructions for removal and reinstallation of panels shall be provided by the manufacturer, their authorized reseller or installer to the Construction Manager and Project Architect.
- D. Samples of all colors noted under Products below shall be provided to the Project Architect for final selection and approval (in writing).

Part 2 – PRODUCTS

2.1 STANDING SEAM METAL PANELS

- A. Acceptable Products
 - 1. Peterson PAC-CLAD
 - a. SnapClad Panels
 - b. Colors : Cityscape, Anodic Clear, Silversmith.
 - 2. FABRAL Panels
 - a. Model : 1-½" SSR 150
 - b. Color : Galvalume Acrylic Coated
- B. Alternate products may be proposed, subject to written approval by the Project Architect. Technical specifications and color samples shall be provided for all suggested alternate products.

Part 3 – EXECUTION

- A. Standing seam metal panels shall be installed without damaging the protective finishes.
- B. Panels shall be installed so as to prevent oil-canning or warping, including from thermal expansion or contraction
- C. Installer shall demonstrate methods for removing and reinstalling panels without damage.

END SECTION 074100**SECTION 074600 – CORRUGATED METAL PANELS****Part 1 – GENERAL****1.1 SCOPE**

Corrugated metal panels exhibit a regular pattern of ridges and valleys, which may be rounded or flattened depending on specific products selected. The panels are generally installed by overlapping panel edges (one or two corrugation widths) and attaching to the substrate through a valley, using exposed fasteners. Corrugated metal panels are typically protected by a Kynar finish.

Corrugated metal panels are used primarily on walls in this project with the corrugations running either vertically or horizontally as indicated on the Drawings, but applications to roofs is also permitted.

1.2 REQUIREMENTS

- A. Minimum warranty service life of 50 years.
- B. Low-emissivity coatings and materials shall be used to create a "cool wall" or "cool roof" application.
- C. Panel sizes (corrugation widths) shall as indicated on the Drawings.

1.3 SUBMITTALS

- A. A copy of the warranty shall be provided to the Construction Manager.
- B. Samples of all colors noted under Products below shall be provided to the Project Architect for final selection and approval (in writing).

Part 2 – PRODUCTS

- A. Acceptable Products
 - 1. Petersen PAC-CLAD
 - a. 7/8" Corrugated Metal Panels
 - 2. Petersen PAC-CLAD
 - a. 7.2 Corrugated Metal Panels
- B. Alternate products may be proposed, subject to written approval by the Project Architect. Technical specifications, corrugation shape and color samples shall be provided for all suggested alternate products.

Part 3 – EXECUTION

- A. Matching color exposed fasteners shall be used for attachment of the panels unless otherwise approved in writing by the Project Architect
- B. Exposed fasteners shall be of materials that are compatible with the panels (without causing corrosion of either panel or fastener).

END SECTION 074600**SECTION 074800 – RAINSCREENS****Part 1 – GENERAL****1.1 SCOPE**

Climate shield clips will be used to support wood siding and to create a cavity behind the wood siding to allow for necessary airflow.

Part 2 – PRODUCTS**2.1 ACCESSORIES – RAINSCREEN CLIPS****A. Acceptable Products****1. Climate-Shield**

- a. Rain Screen Clip CSRSC2
- b. Available Lamboo panel Thickness ½" and ¾". Other thicknesses per request
- c. Maximum spacing from horizontal edge of rain screen panel to clipping system, when using "Z" clip, 4".
- d. Maximum spacing between "Z" clip/rail fastening system 44".
- e. All Lamboo exterior rain screen panels using the "Z" clipping system must use heavy-duty stainless steel "Z" clips and rail.

END SECTION 074800**SECTION 075300 – EPDM MEMBRANE****Part 1 – GENERAL****1.1 SCOPE**

Ethylene Propylene Diene Monomer (EPDM) rubber membranes are in common usage as waterproof protective coverings for roofs and terraces.

EPDM is used in this project primarily as a protective waterproof layer on the floor of the mechanical room.

Part 2 – PRODUCTS**2.1 EPDM Membranes****A. Acceptable Products****1. Firestone RubberGard EPDM**

- a. Website: <http://firestonebpc.com/roofing/epdm-roofing-systems/rubbergard-epdm-roofing-systems/>

2.2 ACCESSORIES – BONDING AGENTS**A. Acceptable Products**

1. For Firestone RubberGard
2. Firestone QuickSeam
3. Firestone RubberGard EPDM Solvent-Free Bonding Adhesive

- B. Bonding agents must be approved by the EPDM membrane manufacturer. Alternative bonding agents to those indicated above may be substituted with written permission of the Project Architect.

Part 3 – EXECUTION

- A. Use only accessories and adhesives approved for use with the EPDM membrane manufacturer.
- B. Use only details (such as for floor drains) approved by the membrane manufacturer.
- C. Seal all seams with an approved sealing "tape" or flashing membrane.
- D. Terminate the top edge of the membrane (where used on floors or roof rakes) to the wall using an approved mechanical termination strip (bar).
- E. Seal the top edge of the termination bar using an approved caulk or mastic.

END SECTION 075300

SECTION 076200 - METAL FLASHING AND TRIM

Part 1 – GENERAL

1.1 SCOPE

Metal flashing is used to cover edges and seams in order to exclude moisture from entering the structure.

Metal trim is generally used for decorative purposes, but may simultaneously serve a role similar to flashing.

1.2 APPLICABLE STANDARDS

- A. SMACNA – Architectural Sheet Metal Manual

1.3 REQUIREMENTS

- A. All metal flashing used in the Work shall be stainless steel.
- B. All fasteners used to attach flashing shall be stainless steel.
- C. All flashings and fascia shall have clear, straight (or smoothly curving) edges, without wrinkles, waviness or oil-canning.
- D. Metal flashing shall be attached and sealed to other elements of the Work as indicated in the Drawings.
- E. All metal flashings and fascia shall be of an appropriate gage as determined by the Construction Manager and installer to achieve acceptable results as defined above.

Part 2 – PRODUCTS

No specific products are required or preferred by this Specification. Contractor or Installer may select sources and manufacturers, provided that a high level of quality in materials and workmanship is maintained.

END SECTION 076200**SECTION 077200 – ROOF ACCESSORIES**

Part 1 – GENERAL

1.1 SCOPE

This section specifies roof hatches, equipment supports, gravity ventilation, and metal grating roof walkway system.

Part 2 – PRODUCTS

2.1 Gravity Ventilation

B. Acceptable Products

- 1. ATAS International, Inc.- Above Sheathing Ventilation

- a. Website: <https://www.atas.com/sustainable/above-sheathing-ventilation#Gallery>

END SECTION 077200**END SECTION 07**

Division 08 – Openings

810000 - WINDOWS

PART 1 - GENERAL

1.1 Scope

There are interior and exterior windows used in the awning, casement, and skylight. They are used to increase the day lighting within the interior of the house to reduce the need for artificial lighting.

1.2 Performance Requirements

- A. Structural Performance: Provide wood windows engineered, fabricated, and installed to withstand normal thermal movement, wind loading, and impact loading without failure, as demonstrated by testing manufacturer's standard window and door assemblies representing types, grades, and sizes required for this Project according to test methods indicated.
- B. Design wind velocity at Project site is 60 mph.
- C. Performance Requirements: Testing shall demonstrate compliance with requirements indicated in NWWDA I.S. 2 for water penetration, and structural performance for the type and performance grade of window units required. Where required design pressure exceeds the minimum for the specified window grade, comply with requirements of NWWDA I.S. 2, Article 6, "Optional Performance Classifications," for higher than minimum performance grades.
- D. Standards: Performance requirements for operating force, air infiltration, water penetration, structural performance, and forced-entry resistance for wood windows are those specified in NWWDA I.S. 2, "Industry Standard for Wood Window Units."
- E. Test Criteria: Testing shall be performed by a qualified independent testing agency based on the following criteria:
- F. Test Procedures: Test window units according to ASTM E 283 for air infiltration, ASTM E 547 for water penetration, and ASTM E 330 for structural performance.
- G. Air-Infiltration Rate for Windows: Not more than 0.05 cfm/sq. ft. for an inward test pressure of 6.24 lbf/sq. ft. (295 Pa).
- H. Water Penetration for Windows: No water penetration as defined in the test method at a static pressure of 12 p.s.f. after 15 minutes with water applied at a rate of five gallons per hour per square foot.
- I. Structural Performance: No failure or permanent deflection in excess of 0.4 percent of any member's span after removing the imposed load, for a positive (inward) and negative (outward) test pressure of 22.5 lbf/sq. ft. (1077 Pa).

1.3 Submittals

- A. Product Data sheets
- B. Shop Drawings
- C. Manufacturer approval for installation

1.4 References

- A. General: Standards listed by reference form a part of this specification section. Standards listed are identified by issuing authority, abbreviation, designation number, title or other designation. Standards subsequently referenced in this Section are referred to by issuing authority abbreviation and standard designation.
- B. American Architectural Manufacturers Association (AAMA):
 1. AAMA 450 - Voluntary Performance Rating Method for Muller Fenestration Assemblies.
 2. AAMA 502 - Voluntary Specification for Field Testing of Newly Installed Fenestration Products.
 3. AAMA 611 - Voluntary Specification for Anodized Architectural Aluminum.
 4. AAMA 902 - Voluntary Specification for Sash Balances.
 5. AAMA 2604 - Voluntary Specification, Performance Requirements and Test Procedures for High

Performance Organic Coatings on Aluminum Extrusions and Panels.

6. AAMA 2605 - Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels.
 7. NAFS - North American Fenestration Standard/Specification for windows, doors and skylights.
- C. ASTM International (ASTM):
1. ASTM C1036 - Standard Specification for Flat Glass.
 2. ASTM C1048 - Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass.
 3. ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
 4. ASTM E1105 - Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference.
 5. ASTM E1886 - Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials.
 6. ASTM E1996 - Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes.
 7. ASTM E2190 - Standard Specification for Insulating Glass Unit Performance and Evaluation.
 8. ASTM F2090 - Standard Specification for Window Fall Prevention Devices with Emergency Escape (Egress) Release Mechanisms.

PART 2 – PRODUCTS

2.1 Acceptable products

A. Acceptable products

1. Product: Push Out Awning E-series Window
 - a. Manufacturer: Anderson Windows
 - b. Dimensions: 1' 6" X 3' (custom built up to 4' X 4')
 - c. Materials: Wood Interior, Aluminum Exterior (finishes optional)
 - d. Glazing Options: Low-E4[®]/Low-E4[®] Sun/Low-E4[®] SmartSun[™]/Low-E4[®]
 - e. PassiveSun/Triple-Pane/Dual-Pane
2. Product: Casement E-Series Casement Window
 - a. Manufacturer: Anderson Windows
 - b. Dimensions: 4' 4" X 3' (custom built up to 6' X6')
 - c. Materials: Wood Interior, Aluminum Exterior (finishes optional)
 - d. Glazing Options: Low-E4[®]/Low-E4[®] Sun/Low-E4[®] SmartSun[™]/Low-E4[®]
 - e. PassiveSun/Triple-Pane/Dual-Pane
3. Product: Fresh Air Electric Deck Mount Skylight
 - a. Manufacturer: VELUX
 - b. Glass: Laminated low-e3 glass
 - c. Dimensions: 21" x 45-3/4"
 - d. Warranty: 10 years
 - e. Control: touch screen control
4. Product: Sun tunnel skylight
 - a. Manufacturer: VELUX
 - b. Model: TCR
 - c. Daylight area: 138 in²
 - d. Curb metal flashing

PART 3 - EXECUTION**3.1 FABRICATION**

- A. General: Fabricate wood window units to comply with indicated standards. Include a complete system for assembly of components and anchorage of window and door units.
 - 1. Comply with requirements of NWWDA I.S. 2 , I.S. 610, and I.S. 620 for moisture content of lumber at time of fabrication.
 - 2. Fabricate.
- B. Provide weather stripping at perimeter of each operating sash.
- C. Factory-Glazed Window and Door Units: Except for light sizes in excess of 100 unites inches (2500 mm width plus length), glaze window and door units in the shop before delivery, unless factory glazing is not available from manufacturer. Comply with requirements of NWWDA I.S.
- D. Mullions: Provide mullions and cover plates as shown, matching window units, complete with anchors for support to structure and installation of window units. Allow for erection tolerances and provide for movement of window units due to thermal expansion and building deflections, as indicated. Provide mullion and cover plates capable of withstanding design loads of window units.

3.02 INSTALLATION

- A. Check with manufacturer on installation guidelines for all products and provide installation requirements to the Contractor and Architect for approval.
- B. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in manufacturer's written instructions.
- C. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.
- D. Fasten door and window frames securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.
- E. Separate dissimilar metals and metal products from contact with wood or cementations materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.
- F. Correct deficiencies in or remove and reinstall windows, doors, glazing, or hardware that does not comply with requirements.
- G. Repair, refinish, or replace windows and doors damaged during installation, as directed by Architect.
- H. Adjust operating parts and hardware for smooth, quiet operation and weather tight closure. Lubricate hardware and moving parts.

END SECTION 810000**083000 - DOORS****PART 1 – GENERAL****1.1 SCOPE**

There are wood entry doors located along the interior exterior of the house as well as two special feature glass doors that are included in the courtyard area.

1.2 Performance Requirements

- A. Provide doors engineered, fabricated, and installed to withstand normal thermal movement, wind loading, and impact loading without failure, as demonstrated by testing manufacturer's standard door assemblies representing types, grades, and sizes required for this Project according to test methods indicated.
- B. No failure or permanent deflection in excess of 0.4 percent of any member's span after removing the imposed load, for a positive (inward) and negative (outward) test pressure of 22.5 lbf/sq. ft. (1077 Pa).

1.3 Submittals:

- A. Product Data.
- B. Shop Drawings.

C. Testing verification.

1.4 Test Criteria:

A. Testing shall be performed by a qualified independent testing agency based on the following criteria:

1. Design wind velocity at Project site is 60 mph.
2. Test Procedures: Test door units according to ASTM E 283 for air infiltration, ASTM E 547 for water penetration, and ASTM E 330 for structural performance.

C. Testing shall demonstrate compliance with requirements indicated in NWWDA I.S. 2 for water penetration and structural performance for the type and performance grade of window and door units required. Where required design pressure exceeds the minimum for the specified window grade, comply with requirements of NWWDA I.S. 2, Article 6, "Optional Performance Classifications," for higher than minimum performance grades.

1.5 Air-Infiltration Rate for Doors:

A. Not more than 0.15 cfm/sq. ft. for an inward test pressure of 1.57 lbf/sq. ft. (75 Pa).

1.6 Water Penetration for Doors:

A. No water penetration as defined in the test method at a static pressure of 4.16 p.s.f. after 15 minutes with water applied at a rate of five gallons per hour per square foot.

PART 2 – PRODUCTS

A. Acceptable products

1. Exterior Doors

- a. Product: 82 – Traditional Panel Exterior Door
 - i. Manufacturer: Simpson Door Company
 - ii. Dimensions: 80" X 36"
 - iii. Panels: 3/8" VG Flat Panel
 - iv. Door size: 1 3/4" double sticking
 - v. Profile: Ovolo Sticking
- b. Product: 7502 – Thermal Sash(TDL)
 - i. Manufacturer: Simpson Door Company
 - ii. Type: Exterior French & Sash
 - iii. Dimensions: 80" X 36"
 - iv. Panels: 1-7/16" Innerbond® Double Hip-Raised Panel Glass:
 - v. Glass: 3/4" Insulated Glazing
 - vi. Privacy Ration: 1

2. Interior Doors

- a. Product: 20 – Interior Panel Door
 - i. Manufacturer: Simpson Door Company
 - ii. Dimension: 80" X 36"
 - iii. Type: Interior panel
 - iv. Panels: 3/8" VG Flat Panel
 - v. Profile: Ovolo Sticking

PART 3 – EXECUTION

3.1 Fabrication

A. General: Fabricate wood door units to comply with indicated standards. Include a complete system for assembly of components and anchorage of door units.

B. Comply with requirements of NWWDA I.S. 2 , I.S. 610, and I.S. 620 for moisture content of lumber at time of fabrication.

3.02 INSTALLATION

- A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in manufacturer's written instructions.
- B. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.
- C. Correct deficiencies in or remove and reinstall doors, glazing, or hardware that does not comply with requirements.
- D. Repair, refinish, or replace doors damaged during installation, as directed by Architect.

END SECTION 083000

083100 – FOLDING GLASS DOOR SYSTEM

PART 1 – GENERAL

1.1 SCOPE

Floor track supported, sliding-folding, thermally broken, aluminum-framed glass panel system to be installed between courtyard and indoor living area

1.2 SUBMITTALS

- A. Detail Drawings: Indicate dimensioning, direction of swing, configuration, swing panels, typical head jamb, side jambs and sill details, type of glazing material, and handle height.
- B. Product Data: Manufacturer's literature including independently tested data listing performance criteria and Owner's Manual with installation instructions.
- C. Contract Closeout Submittal: Submit Owner's Manual from manufacturer. Identify with project name, location and completion date, type and size of unit installed.

1.3 QUALITY ASSURANCE

- A. Manufacturer: Provide complete, precision built, engineered, pre-fitted unit by a single source manufacturer with at least 20 years experience in providing folding/sliding door systems for large openings in the North American market.
 - 1. The manufacturer must have a quality management system registration to the ISO 9001: 2008 standard.
- B. Performance Requirements: Provide from manufacturer that has independently tested typical units. Testing results to include air infiltration in accordance with ASTM E 283 and NFRC 400, water penetration in accordance with ASTM E 547 and E 331, structural loading in accordance with ASTM E 330, and forced entry in accordance with AAMA 1304.
- C. Thermal Performance U factor: Unit to be rated, certified and labeled in accordance with NFRC 100, shown in manufacturer's latest published data for the glazing, sill, and direction of opening specified.
- D. Solar Heat Gain Coefficient: Unit to be rated, certified and labeled in accordance with NFRC 200, shown in manufacturer's latest published data for the glazing, sill, and direction of opening specified.
 - 1. If desired, Energy Star ratings can be achieved by the use of proper glass with the unit. See NanaWall's Performance data for details.
- E. Installer Qualifications: Installer experienced in the installation of manufacturer's products or other similar products for large openings. Installer to provide reference list of at least 3 projects of similar scale and complexity successfully completed in the last 3 years.

1.4 WARRANTY

- A. Provide manufacturer's standard warranty against defects in materials and workmanship.
- B. Warranty Period: Ten years for rollers and for seal failure of insulated glass supplied. For all other components, one year (two years if unit is installed by manufacturer's certified trained installer) from date of delivery by manufacturer.

1.5 SITE CONDITIONS, DELIVERY, STORAGE AND HANDLING

- A. In addition to general delivery, storage and handling requirements specified in Section 01600, comply with the following:
1. Deliver materials to job site in sealed, unopened cartons or crates. Protect units from damage. Store material under cover, protected from weather and construction activities.

PART 2 - PRODUCTS

2.1 Acceptable manufacturer

- A. NanaWall Systems, Inc., which is located at 100 Meadowcreek Drive #250 Corte Madera, CA 94925; Toll Free Tel: 800-873-5673; Tel: 415-383-3148; Fax: 415-383-0132; www.nanawall.com; info@nanawall.com
- B. Frame and Panels: manufacturer's standard profile: provide head track, side jambs, panels with dimensions shown on drawings.
1. Provide panels with: Standard one lite
 2. Provide standard bottom rail.
 3. Aluminum Extrusion: Extrusions with nominal thickness of .078" (2.0 mm). Alloy specified as AlMgSi0.5 with strength rated as 6063-T5 or F-22 (European standard). Anodized conforming to AAMA 611 or powder coated conforming to AAMA 2604.
 4. Thermally broken with a wide Polyamide plastic reinforced with glass fibers. Polyamide plastic less than 7/8 (22 mm) wide or pour and de-bridge thermal break will not be accepted.
- C. Product will be selected by the Contractor in accordance to the Work, and approved by the Architect

PART 3 - EXECUTION

3.1 FABRICATION

- A. Use extruded aluminum frame and panel profiles with male-female interlocking, corner connectors and hinges, sliding and folding hardware, locking hardware and handles, glass and glazing and weather stripping as specified herein to make a folding glass wall. Factory pre-assemble as is standard for manufacturer and ship with all components and installation instructions.
- B. Sizes and Configurations: See drawings for selected custom dimensions within maximum frame sizes possible as indicated in manufacturer's literature. See drawings for selected number of panels and configuration. Inward [OR outward] opening unit. On configurations with a pair of swing panels, looking from inside, primary swing panel on the left [OR right].

3.2 ERECTION

- A. Due to large dimensions involved, weight, and movement of the panels, verify the structural integrity of the header such that the deflection with live load and dead loads is limited to the lesser of L/720 of the span and 1/4 (6 mm). Structural support for lateral loads (both wind load and eccentric load when the panels are stacked open) must be provided. It is recommended that all building dead loads be applied to the header prior to installing the NanaWall. If so and if a reasonable amount of time has been allowed for the effect of this dead load on the header, then only the building's live load can be used to meet the above requirements of L/720 or 1/4 (6 mm). If not, both the dead and live loads need to be considered.
- B. It is recommended that all building dead loads be applied to the header prior to installing the NanaWall. If so and if a reasonable amount of time has been allowed for the effect of this dead load on the header, then only the building's live load can be used to meet the above requirements of L/720 or 1/4 (6 mm). If not, both the dead and live loads need to be considered.

3.3 INSTALLATION

- A. Install frame in accordance with manufacturer's recommendations and installation instructions.
- 3.4 Properly flash and waterproof around the perimeter of the opening.
- 3.5 Installer to provide appropriate anchorage devices, to securely, rigidly fit frame in place, absolutely level, straight, plumb and square. Install frame in proper elevation, plane, location, and in proper alignment with other work.

END OF SECTION 083100

083200 - RESIDENTIAL HANGER DOOR

PART 1 – GENERAL

1.1 SCOPE

Automated hanger door to be installed in courtyard

1.2 PERFORMANCE REQUIREMENTS

- A. The door must be constructed to fit within the dimensions of the courtyard
- B. A sufficient seal must be provided to prevent moisture from entering the interior of the house
- C. The door must be equipped with a locking mechanism
- D. The door width must not exceed 30 ft.

1.3 SUBMITTALS

- A. Product Data: Manufacturer's data sheets on all products to be used, including:
 - 1. Preparation instructions and recommendations
 - 2. Storage and handling requirements and recommendations
 - 3. Installation instructions
 - 4. Cleaning and maintenance instructions
- B. Structural Analysis: Provide confirmation of the capability and adequacy of the structure to carry the dead and live load weights required

PART 2 - PRODUCTS

2.1 ACCEPTABLE PRODUCTS

- A. PRODUCT: WILSON CLEAR-VUE DOOR
 - 1. Acceptable Manufacturer: Wilson Industrial Doors, which is located at PO Box 246 Franksville, WI 53126; Tel: 262-732-5042; Fax: 262-835-2660; info@wilsondoors.com; www.wilsondoors.com
 - 2. Frame: ¼" thick 6061-T6 Aluminum Alloy Tubing
 - 3. Seals: rubber top seal, neoprene side seals, hinge seal, rubber floor seal conforms to contour of the ground
 - 4. Covering: any specified material, to be provided by other manufacturer
 - 5. Lift Cables: galvanized steel, custom-sized to provide a 5:1 safety factor
 - 6. Drive Shaft and Cable Drums: heavy-duty galvanized tubing; 6"x4" mounting angle; mounted above the door and runs the width of the door
 - 7. Locking Mechanism: dual handle manual locking mechanism; lock switch shuts off power to motor until door is unlocked (optional auto lock)
 - 8. Power Operator: electrical controls designed to meet National Electrical Code Section 513
 - 9. Control Box: programmable drive; momentary contact, 3-button controls (Up/Down/Stop standard)
 - 10. Over Travel Switch: back-up switch to prevent the door from reaching its upper limit

END OF SECTION 083200

084000 – VENTS

PART 1 – GENERAL

1.1 SCOPE

Vent openings to be indicated in the drawings. The openings include bathroom ventilation, kitchen, and living areas.

1.2 Submittals:

- A. Product Data

1.3 Standards

- A. ASTM B26 – Aluminum-Alloy Sand Castings.
- B. ASTM B85 – Aluminum-Alloy Die Castings.

PART 2 - PRODUCTS

2.1 No product specified, and needs to be supplied to the Architect for approval

2.2 FINISHES

- A. Wall vent finish: anodized aluminum.

PART 3 - EXECUTION**3.1 COORDINATION**

- A. Coordinate supply of vents with construction of walls to ensure proper sizing and placement of vent openings.

3.2 INSTALLATION

- A. Install vents and dampers in accordance with manufacturer's installation instructions and approved shop drawings
- B. Do not install bent, scratched, or otherwise damaged vents. Remove damaged components from site and replace
- C. Install vents secure, level, plumb, and flush with wall surface.

3.3 CLEANING

- A. Remove excess sealant by moderate use of mineral spirits or other solvent acceptable to sealant manufacturer.
- B. Wash exposed surfaces with solution of mild detergent applied with soft cloth. Take care to remove dirt from corners. Wipe surfaces clean.

END OF SECTION 084000

END OF SECTION 08

Division 09 – Finishes

093100 – COUNTERTOPS

Part 1 – GENERAL

1.1 SCOPE

To be used in the kitchen for atop the cabinets as counters and bathroom vanity.

1.2 PERFORMANCE REQUIREMENTS

- A. Shall contain recycled content
- B. Shall be GREENGUARD certified
- C. Shall receive LEED certification for sustainable design

1.3 RECEIVING, INSPECTION, STORAGE

- A. Sheet Inspection to be completed upon arrival at conditioned storage facility
 - 1. Do not cut the materials before visible inspection and matching process is completed in shop.
- B. Check to ensure the lot numbers are in sequence or within allowable tolerance (+/- 50)
- C. Check for visual defects on the surface or edges once peel coat is removed. Please note that color may vary slightly from run to run and from the sample itself. Lists of inspection items that should be checked;
 - 1. Color difference within same lot.
 - 2. Scratches
 - 3. Bending
 - 4. Pin hole
 - 5. Crack
 - 6. Thickness difference

Part 2 - PRODUCTS

2.1 ENGINEERED STONE

- A. Acceptable Products
 - 1. Hausys HI-MACS Eden Plus – Recycled Content
 - a. Manufacturer: LG
 - b. Recycled content: 12%
 - c. Thickness: ½”
 - d. Sheet width: 30”
 - e. Sheet length: 145”
 - f. Color: Select color in accordance to other requirements and indicated in drawings

2.2 ADHESIVE

- A. Select adhesive approved by countertop manufacturer.

Part 3 - EXECUTION

- A. Product needs to be cut according to drawings and installed according to manufacturers specifications.
- B. Bulk adhesive cartridges typically provide 1000mm of seaming.
- C. Normal cure time is about 40 minutes in 21 degrees C. If hotter, your working time is greatly reduced and, if cooler, your working time is extended. Consider this as you begin assembly. You do not want to get too far ahead of yourself if it is warm.
- D. Remember to consider scuff-sanding joints for better bonding using 60 grit sandpaper.
- E. Before applying the adhesive, clean all areas being bonded with denatured alcohol and a clean white rag. Inspect for dirt, pencil marks, and oily fingerprints on all bonding surfaces and remove them.
- F. Assemble the cartridge in the seaming gun with a fresh disposable mixing tip. After each use, remove and replace this tip. The adhesive in the tip will set up just as the seams do on your materials. If you are finished gluing for the day, you can leave the tip on and place it in the storage refrigerator. The next time you use it you

only need to change the tip.

- G. As you get ready to apply adhesive and begin assembly of your HI-MACS top, remember to purge the tip. This is done by squeezing out a bead of approximately the length of the tip. This ensures trapped air has worked itself from the mixing tip and that the catalyst and adhesive have properly mixed and are ready

END SECTION 093100

092900 – GYPSUM BOARD

PART 1 – GENERAL

1.1 SCOPE

Use on interior wall and ceiling surfaces. Generally finished and painted.

1.2 APPLICABLE STANDARDS

- A. Manufacturing
 - 1. ASTM C 1396 section 5 (C 36)
 - 2. Federal Specification SS-L-30D Type III, Grade X
- B. Installation
 - 1. ASTM C 840
 - 2. Gypsum Association GA-216
 - 3. Gypsum Association GA-214
 - 4. Surface Burning Characteristics
 - 5. ASTM E 84
 - 6. Flame Spread 15
 - 7. Smoke Developed 0

1.3 PERFORMANCE REQUIREMENTS

- A. Minimum 1 hour fire rating (1/2" thick board)
- B. Products manufactured in China shall not be used in the Work.
- C. Locally sourced materials (within 400 miles of construction site) are preferred.
- D. Shall have GREENGUARD Indoor Air Quality certificate status.

PART 2 – PRODUCTS

- A. GYPSUM BOARD
 - 1. Acceptable Products
 - a. Product: FIREBLOC® Type X Gypsum Board
 - i. Manufacturer: American Gypsum
 - ii. Thickness: 5/8"
 - iii. Width: 54"
 - iv. Length: 12'

END SECTION 092900

093013 – CERAMIC TILING

PART 1 – GENERAL

1.1 SCOPE

Wall tiling will be used on the bathroom shower stall walls and the kitchen back splash. The ceramic flooring tile will be used in the kitchen, bathroom and courtyard as indicated on the drawings.

1.2 STANDARDS

- A. Applicable ASTM
 - 1. ASTM C-373
 - 2. ASTM C-99
 - 3. ASTM C-501

4. ASTM E-228
5. ASTM C-484
6. ASTM C-1028

PART 2 – PRODUCTS**A. WALL TILING**

1. Acceptable products
 - a. Eco-gres asia
 - i. Recycled Ceramic Tile
 - ii. Manufacturer: Fire Clay Tile
 - iii. Available sizes: 1" X 6" or 3" X 6" on 12" X 12" sheet in grid or block pattern

B. FLOOR TILING

1. Acceptable products
 - a. Area 3D
 - b. Manufacturer: Stonepeak Ceramics
 - c. Size: 24" x 24" or 12" x 24"

END SECTION 093013**096400 – WOOD FLOORING****Part 1 – GENERAL****1.1 SCOPE**

The hardwood is to be used in the main wings of the house as indicated on the drawing.

1.2 PERFORMANCE REQUIREMENTS

- A. Flooring shall be GREENGUARD certified
- B. Flooring shall be FSC certified

1.3 SUBMITTALS

- A. Sample colors for final color approval by the Architect

PART 2 – PRODUCTS**2.1 HARDWOOD FLOORING**

- A. Acceptable Products
 1. Natural Bamboo Traditions
 - a. Manufacturer: US Floors
 - b. Width: 3.75"
 - c. Length: 37.75"
 - d. Thickness: 0.625"

END SECTION 096400**END SECTION 09**

Division 10 – Specialties

108100 – COMPOSTING TOILET

PART 1 – GENERAL

1.1 SCOPE

Included in this section are the specifications to a composting toilet that allows waste to be recycled into compost. This is a self-contained system used in the bathroom.

1.2 USE DURING SOLAR DECATHLON COMPETITION

- A. The Composting Toilet will not be used during the Solar Decathlon competition
- B. The Composting Toilet will be transported to the Solar Decathlon Competition EMPTY.

1.2 REQUIREMENTS

- A. System will be self-contained.
- B. System will have the capacity for the household.
- C. System will use AC power

1.3 SUBMITTALS

- A. Product owner manual and maintenance
- B. Instructions on setup and installation

PART 2 – PRODUCT SELECTION

2.1 COMPOSTING TOILET

- A. Model: Excel
- B. Manufacturer: Sun-Mar
- C. Dimensions (H x W x D): 32" x 22 1/2" x 33"
 - 1. Product Weight: 60 lbs
 - 2. Depth Required to Remove Drawer: 48"
 - 3. Vent outlet center distance from right side: 10"
 - 4. Height to center of vent: 28 3/8"
 - 5. Vent Pipe: 2" PVC Thinwall, or comparable
 - 6. Drains (Required or Optional Hookup): 1" Drain Required for Residential
- D. Power Requirement
 - 1. Maximum Amps (With Heater On): 2.4
 - 2. Fan Watts: 35 Required
 - 3. Heater Watts: 250
 - 4. Average Power Use in Watts (Heater on 1/2 time): 150
- E. Water Consumption: no water consumption
- F. Color: White or Bone
- G. Temperature Requirement: Above 55 degrees Fahrenheit
- H. Accessories: Compost Quick, Microbe Mix, Compost Sure, Vent Kit, AC Fan Speed Control.

PART 3 – EXECUTION

- A. Venting pipe must be installed and connected to the system.
- B. Regular maintenance of the system is required as directed by the instructions.

END SECTION 108100

108200 – GREYWATER FILTRATION SYSTEM**PART 1. GENERAL****1.1 SCOPE**

The biosand filter provides both aerobic and anaerobic decomposition of contaminants. Its function is to filter greywater from the home's shower, lavatory and clotheswasher to rainwater standards.

1.2 REFERENCES

- A. All procedures modified from: *An introduction to Slow Sand Filtration*. (2005). www.solutionsforwater.org

PART 2. PRODUCTS**2.1 HYDRAID BIOSAND FILTER - PLASTIC (0.77m height by 0.42 m diameter)**

- A. Weight: 3.6 kg (empty), 63.5 kg (full)
B. Flow rate: 0.2 m/hr (average). 0.4 m/hr (maximum).

2.2 SAND AND GRAVEL FROM A QUARRY OR GRAVEL PIT

- A. Filtering layer - 55 cm fine sand (< or = to 3.15 mm diameter)
B. Support layer - 5 cm coarse sand (3.125 to 6.125 mm diameter)
C. Underdrain layer - 5 cm fine gravel (6.25 to 12.25 mm diameter)

PART 3. EXECUTION**3.01 INSTALLATION**

- A. Filter Sand and gravel through sieves of sizes ½ inch, ¼ inch, and 1/16 inch. Material that does not go through the ¼ inch sieve becomes the gravel layer. Material left in the 1/16 inch sieves becomes the coarse layer and material that passes through all three sieves becomes the fine sand layer.
B. Wash Underdrain sand by placing 12 mm in a bucket, then doubling the water in the bucket. Fill the bucket twice as much water as sand, rinsed, and repeated until the water leaving the bucket is clear. This is repeated for the rest of the sand.
C. Supporting sand is washed using the procedure as for underdrain sand, but half as much sand.
D. The fine upper layer of sand is washed using a small amount of sand and double the amount of water. This water is then removed.
E. Media is placed in the sun to dry
F. Install container and standpipe, filling the container halfway with water. Add gravel up to 5 cm. Supporting sand is filled to 10 cm. Place a bucket under the standpipe and add fine gravel is filled to 100 cm. Remove the bucket once water stops coming out. Add or remove sand until water height is 5 cm.

3.02 FLUSHING THE FILTER

- A. Place the diffuser plate above the surface of the water. Place a bucket under the standpipe and then pour water into the filter until the water that comes out into the bucket is clear.

3.03 DISINFECTING THE STANDPIPE (only during initial installation)

- A. Attach a garden hose to the spout. Attach a funnel to this garden hose and hold it above the spout for 2 minutes. Then, drain the bleach into a bucket. Wipe the spout with bleach. Then, put 5 gallons of water into the top of the filter and allow it to drain into a bucket.

3.04 DISINFECTING THE FILTER CONTAINER

- A. Clean the spout and exterior of the container daily with soap and water or chlorine based cleaning product.

3.05 CLEANING THE FILTER

- A. Remove lid, and pour water so that area above diffuser plate is half full. Then, remove the diffuser plate.
B. Gently move sand in the uppermost 1 cm with fingers.
C. Remove water above sand layer.
D. Replace diffuser plate and lid. Pour in 5 gallons.

END SECTION 108200

SECTION 108220 - GAC AND CATALYTIC CARBON FILTER**PART 1. GENERAL****1.1 SCOPE**

The Carbon Filter is part of the system that converts greywater to potable water.

1.2 USE DURING SOLAR DECATHLON COMPETITION

- A. The Carbon Filter will not be used during the Solar Decathlon Competition

PART 2. PRODUCTS**2.1 FUSION CATALYTIC CARBON BACKWASHING SYSTEM****A. Acceptable Products**

1. FSF-150: Service flow rates (Normal-6GPM, Peak-8GPM); Backwash flow rate- 5GPM; Filter media volume- 1.5 ft³; Filter tank size- 10" X 54"; Tank Jacket-included.
2. FSF-200: Service flow rates (Normal-8GPM, Peak-10GPM); Backwash flow rate- 7GPM; Filter media volume- 2 ft³; Filter tank size- 12" X 52"; Tank Jacket-included.
3. FSF-250: Service flow rates (Normal-10GPM, Peak-13GPM); Backwash flow rate- 11GPM; Filter media volume- 2.5 ft³; Filter tank size- 10"X54"; Tank Jacket-included.
4. FSF-300: Service flow rates (Normal-12GPM, Peak-15GPM); Backwash flow rate- No button; Filter media volume- 3 ft³; Filter tank size- 14"X 65"; Tank Jacket-not included.
5. FSF-400: Service flow rates (Normal-15GPM, Peak-20GPM); Backwash flow rate- No button; Filter media volume- 4 ft³; Filter tank size- 16"X 65"; Tank Jacket-not included.

B. Dimension: 60.25" x 10"**C. Plumbing Connections ¾" or 1"****D. Electrical Requirements should have input of 120V 60Hz and should output 12V 650mA****E. Water Temperature Min 39 max 100 degree Fahrenheit****F. Water Pressure 20-125 psi****PART 3. EXECUTION****END SECTION 108220****SECTION 108240 – ULTRAVIOLET STERILIZATION SYSTEM****PART 1. GENERAL****1.1 SCOPE**

The Ultraviolet (UV) Sterilization System is part of the filtration system intended to clean graywater and rainwater to potable standards. The UV water purifier eliminates both viruses and bacteria provided the water is free of physical contaminants. UV dosage is sufficient for >99% removal of microorganisms.

1.2 USE DURING THE SOLAR DECATHLON

- A. The UV System will not be used during the Solar Decathlon Competition.

PART 2. PRODUCTS**2.1 ACCEPTABLE PRODUCTS****A. Manufacturer: Atlantic Ultraviolet Corporation**

1. Model: BIO-1.5
 - a. 1.5 gal/min
 - b. ¾" NPT female inlet and outlet
 - c. Power Consumption: 16.5 W
 - d. (measurements in inches) Length = 14-¼, Width = 3-11/16, Height = 3-¾
 - e. 8 lbs
 - f. Lamp ID Number: 05-1366-R

- g. 10,000 hours rated bulb lifetime

PART 3. EXECUTION

3.01 INSTALLATION

- A. Horizontal installation close to final use
- B. Mounting Kit is standard for resting on ground
- C. Connection to 3-wire grounded outlet
- D. Connection to inlet and outlet

3.02 OPERATION / MAINTENANCE SCHEDULE

- A. Monthly cleaning of quartz sleeve
- B. Bulb replacement approximately every 14 months

END SECTION 108240

SECTION 108300 - HYDROPONIC SYSTEM

PART 1 – GENERAL

1.1 SCOPE

A wall-mounted system for growing plants without soil using nutrient rich water. Used along south wall of the core.

1.3 PERFORMANCE REQUIREMENTS

- A. Use a sustainable non-soil or soil alternative.
- B. Must be partially automatic, leaving room for occupants to interact and care for the system.
- C. Will fit within the dimensions of 4' w X 6"d X 7' h, aligned with the immovable portion of the glazing.
- D. Will not interfere with hallway accessibility.
- E. System must be anchored or stabilized.
- F. System will be safe, and produce food that is also safe to consume.

1.3 SUBMITTALS

- A. Components: Shelving System Design, Shelf Support, Reservoir Design, Pump, Tubing, Net pots/Growing Medium, Wall/Floor Fasteners
 - 1. Specifications
 - 2. Who will install and maintain them
 - 3. Directions on how to maintain the system.
- B. Accessories: pH tester kit, pH adjusters, hydroponic nutrients
 - 1. Specifications
 - 2. Directions on how to maintain the system.
- C. List of indicators to be aware of to monitor plant health, and system functionality.

PART 2 – PRODUCTS

2.1 SHELVING SYSTEM

- A. Acceptable manufacturers and products
 - 1. Product: Fiberglass Molded Custom Shelves
 - a. Manufacturer: Precision Plastics Inc.
 - b. Dimensions: Fits within 4' w X 6"d
 - c. Requirements: Each shelf hold five net pots. Must limit the waters exposure to light.

2.2 SHELF SUPPORT

A. Acceptable manufacturers and products

1. Product: Steel Rods with threaded sections
 - a. Manufacturer:
 - b. Model Number:
 - c. Dimensions: 5/8" diameter
 - d. Requirements: Cut or ordered in size needed
 - e. Additional: will need hexagon nuts to hold the shelf in place at the correct angle

2.3 SHELF SUPPORT COVER

A. Acceptable manufacturers and products

1. Product: Aluminum Sheet
 - a. Manufacturer: MSC Industrial Supply Co.
 - b. Thickness: 0.125"
 - c. Dimensions when folded: fits within 2"w x 6"d x 7'h when folded as cover
 - d. Requirements: Will cover the shelf support and the system tubing
 - e. Additional: will need hexagon nuts to hold the shelf in place at the correct angle

2.4 RESERVOIR DESIGN

A. Acceptable manufacturers and products

1. Product: Fiberglass molded custom reservoir
 - a. Manufacturer: Precision Plastics Inc.
 - b. Dimensions: fits within 4' w X 6"d, matching the shelf width and depth
 - c. Requirements: Hold enough water to keep pump submersed and have capacity to hold all the water moving through the system at any given time. Must not allow light into it. Mad of same material as the shelf system.

2.5 SUBMERSABLE PUMP

A. Acceptable manufacturers and products

1. Product: EcoPlus Eco 396 Submersible Pump 396 GPH
 - a. Manufacturer: EcoPlus
 - b. Model Number: 728310
 - c. Dimensions: 6.4" x 3.1" x 4.5"
 - d. Warranty: 1 year
 - e. Power: 120v, 60Hz, .30 Amps
 - f. Requirements: Must be able to reach the max height of the system, and supply adequate water flow to system.

2.6 TUBING

A. Acceptable manufacturers and products

1. Product: Hydro Flow Premium Vinyl Tubing – Black
 - a. Manufacturer: Hydro Flow
 - b. Dimensions: ½ in. outside diameter, at least 20 ft long
 - c. Requirements: Must not allow light to penetrate the water in the tubing.

2.7 NET POTS/GROWING MEDIA

A. Acceptable manufacturers and products

1. Product: Go Pro Net Pot 3.75"
 - a. Manufacturer: Go Pro
 - b. Dimensions: 3.75" diameter
2. Product: Gold Label Hydrocorn
 - a. Manufacturer: Gold Label
 - b. Model Number: 713750

2.8 ACCESSORIES

A. Acceptable manufacturers and products

1. Product: Milwaukee Instruments Martini H55 pH/Temp Tester and Probe
 - a. Manufacturer: Milwaukee
 - b. Model Number: 716798
2. Product: GH pH Up Liquid
 - a. Manufacturer: General Hydroponics
 - b. Model Number: 722090
3. Product: GH pH Down Liquid
 - a. Manufacturer: General Hydroponics
 - b. Model Number: 722120
4. Product: GH Flora Series Performance Pack
 - a. Manufacturer: General Hydroponics
 - b. Model Number: 718145

Part 3 – EXECUTION

3.1 INSTALLATION

- A. Shelving structure will be built first.
- B. Shelving Units and the Shelf Support will be assembled.
 1. Shelves will be slid into place on the support pipes with the hexagonal support washers holding the shelves in place at a 1% to 2% slope.
 2. Tubing will be run through the system, connecting the shelves to each other and the reservoir.
- C. Reservoir will hold the pump and the water for the system.
 1. Pump will be connected to the tubing leading to the top of the system.
 2. The power cord must have a drip loop to make sure water has a location to drip off the cord, avoiding contact with the electrical outlet.
- D. Place the shelf support covering over the tubing and shelf support.
- E. Add water to the reservoir, test flow of system, check everything if functioning correctly.
- F. Apply additional support as needed with wall or floor fasteners.
- G. Desired plants should be grown or placed in non-soil medium in the net pots, place into the shelf system.
- H. The pH tester kit, pH adjusters, hydroponic nutrients will be used as needed, determined by the instructions.

END SECTION 108300

SECTION 108500 – BARREL FOOD COMPOST SYSTEM**PART 1 – GENERAL****1.1 SCOPE**

This tumbler, barrel shaped, composting system will be placed on the back porch in an area which is easily accessible to the residents.

1.2 REQUIREMENTS

- A. System will be self-contained.
- B. System will have the capacity for the household.
- C. System will be easy to access.

1.2 SUBMITTALS

- A. Product owner manual and maintenance
- B. Instructions on setup and installation

PART 2 – PRODUCTS**2.1 Acceptable Products**

- A. Model #: IM4000
 - 1. Manufacturer: YIMBY
 - 2. Dimensions (H x W x D): 36" x 28" x 26"
 - 3. Product Weight: 60 lbs
 - 4. Capacity: 37 gallons

PART 3 – EXECUTION

- A. The system will produce compost for the resident's gardens and landscaping.
- B. Add material to one side of the barrel and rotate regularly.
- C. When one side becomes full, begin filling the other side
- D. Switch back and forth between the sides unto compost is made.
- E. Remove completed compost batch, keep a small amount of the batch left over to help start the next batch.

END SECTION 108500**SECTION 108600 – SOLAR THERMAL ROOF COLLECTORS****PART 1 – GENERAL****1.1 SCOPE**

The Solar Thermal Roof Collectors harvest thermal energy absorbed by the roof of the Core modules and store that energy to preheat water for domestic uses

PART 2 – PRODUCTS**2.1 ROOF PICK-UP COILS**

- A. Roof pick up coils are comprised of Copper piping, 1/2" diameter.
- B. Source : <http://www.homedepot.com/p/Cerro-1-2-in-x-10-ft-Copper-Type-M-Hard-Temper-Straight-Pipe-1-2-M-10/100354198>
- C. Home Depot: Cerro 1/2" x 10' Type M Hard Temper Straight Pipe (Also Type L Pipe)
- D. Cost: \$9.57 each, bulk price \$8.61 for 10 or more
- E. Pressure rating: Rate at maximum 850 psi at 150 F
- F. Material : Hard temper ASTM-B88 copper is NSF and ANSI Standard 61 certified (Alloy C12200)
- G. Warranty : 1 year limited manufacturer warranty
- H. Inside Diameter: 0.569 in
- I. Outside Diameter: 0.625 in
- J. Length: 10 ft

K. Weight: 1.9 lb

2.2 COPPER ACCESSORIES

2.2.1 Copper piping 1/2" diameter fittings and connectors:

A. 1/2" x 1/2" Copper 90-Degree Sweat x Sweat Elbow (10-pack)

B. Source : http://www.homedepot.com/p/1-2-in-x-1-2-in-Copper-90-Degree-Sweat-x-Sweat-Elbow-10-Pack-CP607HD12/204620480?MERCH=REC-_-PIPHorizontal1_rr_-204620312_-204620480_-N

C. Cost : \$3.96/each

D. Both fittings sized for 1/2", Sweat connections

E. Height: 3/4"

F. Length: 5"

G. Width: 6.5"

H. 90 Degree Bend

I. Weight: 0.38 lb

2.2.2 1/2" Copper Pressure Tee

A. Source: http://www.homedepot.com/p/1-2-in-Copper-Pressure-Tee-C611HD12/100343348?MERCH=REC-_-PIPHorizontal1_rr_-204620312_-100343348_-N

B. Cost: \$1.10/each

C. All three joints are 1/2" size

D. Weight: 0.06 lb

E. Maximum working pressure: 722 psi

F. Meets specifications ASME/ANSI B 16.22

2.2.3 1/2" Copper 90-Degree FTG x C Street Elbow

A. Source: http://www.homedepot.com/p/1-2-in-Copper-90-Degree-FTG-x-C-Street-Elbow-C6072HD12/204620657?MERCH=REC-_-PIPHorizontal1_rr_-204620312_-204620657_-N

B. Cost: \$1.58 each

C. Use with types L and M copper tubing

D. Dimensions: Standard

E. Weight: 0.042 lb

2.2.4 1/2" Copper Tube Straps (5-pack)

A. Source: http://www.homedepot.com/p/1-2-in-Copper-Tube-Straps-5-Pack-C624HD12/204620164?MERCH=REC-_-PIPHorizontal1_rr_-100119054_-204620164_-N

B. Cost: \$2.39 / each (5 pieces)

C. Weight: N/A

D. Material: Copper

2.3 PUMP

A. Pump circulates fluid through the system

B. Acceptable Product: Total Pond 300 GPH Fountain Pump

C. Source <http://www.homedepot.com/p/Total-Pond-300-GPH-Fountain-Pump-MD11300/202017049>

D. customer care@tp-us.com

E. Cost : \$29.92 / each

F. Depth: 3.47"

G. Height: 7.95"

H. Width: 5.75"

I. Maximum Flow: 300 gph

J. Horsepower: 1 hp

K. Weight: 1.95 lbs

L. Tubing Diameter: 0.5" (requires 1/2" vinyl tubing)

M. Power: 120 V 1 A

2.4 PEX Tubing

A. Fluid conduit for system other than pick-up coils.

B. Source <http://www.homedepot.com/p/SharkBite-1-2-in-x-100-ft-Blue-PEX-Pipe-U860B100/202033010>

C. Acceptable Product: SharkBite 1/2" x 100 ft Blue PEX Pipe

D. Cost : \$28.52 / each

E. Length: 100'

F. Actual Inside Diameter: 0.475"

G. Actual Outside Diameter: 0.625"

H. Pipe Size: 1/2"

I. Maximum Working Temperature: 200 F

J. Maximum Working Pressure: 160 psi

K. Weight: 5.315 lb

2.5 TEMPERATURE SENSOR

A. Acceptable Product: Dwyer Series TCS Thermocouple Temperature Switch

B. Source : <http://www.dwyerinst.com/Product/Temperature/Switches/DigitalPanelMount/SeriesTCS#specs>

C. Full unit with programmable functions

D. Probe range: 0 to 700 C (Type J), 0 to 999 C (Type K or Type S)

E. Input: Type J, K, S Thermocouple

F. Output: SPDT relay rated 16 A @ 240 VAC resistive

G. Horsepower Rating: 1 HP

H. Control Type: On/Off

I. Power Requirements: 115 VAC, 230 VAC, depending on model

J. Accuracy: +/- 1 %

K. Resolution: 1 Degree

L. Weight: 2.3 oz (65 g)

2.6 FLAT PLATE HEAT EXCHANGER

A. Acceptable Product: Kelvion Flat Plate Heat Exchanger Gasket NX Series

B. Source: <https://us.kelvion.com/us/products/plate-heat-exchangers/gasketed-plate-heat-exchangers/nx-series/>

C. Cost : \$200.00 each

D. Height: 2.5'

E. Length: 10"

F. Width: 0.5'

2.7 FLUID STORAGE TANK

A. 110 Gallon Low Profile Portable Utility Tank

B. Source: <http://gototanks.com/110-gallon-low-profile-portable-utility-tank-110lprt.html>

C. Cost: \$232.00

D. Dimensions: 36" W x 48" L x 18" H

E. Shipping Weight: 55.000 lbs

F. Fitting Size: 2" PP Bulkhead FPT

2.8 INSULATION

2.8.1 – Batt Insulation

A. Acceptable Product: Home Depot 16" x 48" Denim Insulation Multi-Purpose Roll (for tank)

B. Source: <http://www.homedepot.com/p/UltraTouch-16-in-x-48-in-Denim-Insulation-Multi-Purpose-Roll-6-Pack->

60306-16482/202710055

C. Cost: \$36.00 per case (6 pack)

D. 100% recycled denim

E. Coverage Area: 32 sq ft

F. Thickness: 2"

G. Width: 16"

H. Length: 48"

I. R-Value: 6.7

J. Energy Star certified

2.8.2 – Rigid Insulation

A. Acceptable Product: Owens Corning FOAMULAR 250 2" x 4' x 8' R-10 Scored Squared Edge Insulation Sheathing (for roof)

B. Source: <http://www.homedepot.com/p/Owens-Corning-FOAMULAR-250-2-in-x-48-in-x-8-ft-R-10-Scored-Squared-Edge-Insulation-Sheathing-52DD/202085962>

C. R-value of 10

D. Cost: \$29.00 / each

E. Compressive strength of 15 psi

F. Has higher 4-value than wood fiber, plywood or 1/2" gypsum board products

G. Dimensions: 2" thick, 96" length, 48" wide

H. Unfaced

I. 7.55 lbs per unit

2.9 EMERGENCY DRAIN VALVE

A. Source: <http://www.homedepot.com/p/Everbilt-Brass-Drain-Valve-EB12112G/204834498>

B. Everbilt Brass Drain Valve

C. Cost: \$6.97 each

D. Width: 3.94"

E. Depth: 1.13"

F. Height: 8"

G. Material: Bronze/Brass

H. Weight: 0.44 lbs

I. Size of Pipe Thread: 3/4" NPT (Standard)

J. Connection Size: 0.75"

K. Neither Ball nor Gate Valve (has rubber washer)

2.10 DRAIN PAN

A. Cost: \$100.00 anticipated

B. Weight: 20 lbs anticipated

C. Dimensions: 48"x60"

D. Material: Heavy-Duty Polyethylene

END SECTION 108600

END SECTION 10

Division 11 – Equipment

113100 – RESIDENTIAL APPLIANCES

1.1 SCOPE

Kitchen and bathroom appliances including cooking and cleaning are included in the Drawings.

1.2 PERFORMANCE REQUIREMENTS

- A. When applicable, appliances must have Energy Star Rating or equivalent.
- B. Appliances must have a written warranty with a warranty period of 5 years.
- C. All appliances to be installed per installation instructions included in cut sheets.

1.3 SUBMITTALS

- A. Contractor shall provide Owner and Architect with brochures showing the full range of color, finish and sizes available for each proposed product.
- B. Contractor shall provide Owner and Architect with sample finishes of each product proposed in up to two (2) different colors, as selected by the Architect from the full range of options available.
- C. Contractor shall provide Owner with a valid warranty certificate covering all materials used in the completion of the Work.

2. PRODUCTS

2.1 REFRIGERATORS

A. Acceptable Manufacturers and Products

- 1. Beko– Model BFTF2715SSIM (http://www.beko.us/urun_detay.aspx?urn=22914&kat=6446&lang=en-US)
- 2. Alternative products may be proposed by the Contractor as options for pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Owner and Architect.

B. Width: 27 1/2"

C. Height: 67 3/4"

D. Depth: 25 1/4"

E. Color: as selected by the Architect for each unit, from the full range of colors available from the manufacturer. Up to five different colors may be selected for the project, and each unit in a Triplex or Duplex building may be assigned a different color.

2.2 COOKTOP & OVEN

A. Acceptable Manufacturers and Products

- 1. Electrolux – Model EW30IS65JS (<http://www.electroluxappliances.com/Kitchen-Appliances/Ranges/Induction-Range/EW30IS65JS/>)
- 2. Alternative products may be proposed by the Contractor as options for pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Owner and Architect.

B. Width: 30 in

C. Height: 36 5/8 in

D. Depth: 28 5/16 in

E. Color: as selected by the Architect for each unit, from the full range of colors available from the manufacturer. Up to five different colors may be selected for the project, and each unit in a Triplex or Duplex building may be assigned a different color.

2.3 DISHWASHERS

A. Acceptable Manufacturers and Product

1. Vent-A-Hood--CWEAH6-K30 (<http://www.ventahood.com/index.php/products/ars/ars-wm?id=360&model=CWEAH6-K>)
2. Alternative products may be proposed by the Contractor as options for pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Owner and Architect.

B. Width: 30 in

C. Depth: 19.5

D. Height: 6"

2.4 DISHWASHERS

A. Acceptable Manufacturers and Products

1. Beko-- DIN25400 (http://www.beko.us/urun_detay.aspx?urn=22942&kat=6461&lang=en-US)
2. Alternative products may be proposed by the Contractor as options for pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Owner and Architect.

B. Width: 23.5 in

C. Height: 32.25 in

D. Depth: 21.625 in

E. Color: as selected by the Architect for each unit, from the full range of colors available from the manufacturer. Up to five different colors may be selected for the project, and each unit in a Triplex or Duplex building may be assigned a different color.

2.5 CLOTHES WASHERS

A. Acceptable Manufacturers and Products

1. Beko – Model WMY10148CO (http://www.beko.us/urun_detay.aspx?urn=22948&kat=6450&lang=en-US)
2. Alternative products may be proposed by the Contractor as options for pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Owner and Architect.

B. Width: 23 5/8in

C. Height: 33 1/8in

D. Depth: 24 5/8 in

E. Color: as selected by the Architect for each unit, from the full range of colors available from the manufacturer. Up to five different colors may be selected for the project, and each unit in a Triplex or Duplex building may be assigned a different color.

2.5 CLOTHES DRYERS

A. Acceptable Manufacturers and Products

1. Beko – Model HPD24412W (http://www.beko.us/urun_detay.aspx?urn=22956&kat=6451&lang=en-US)

2. Alternative products may be proposed by the Contractor as options for pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Owner and Architect.

B. Width: 23 3/8 in

C. Height: 33.25 in

D. Depth: 24 in

E. Color: as selected by the Architect for each unit, from the full range of colors available from the manufacturer. Up to five different colors may be selected for the project, and each unit in a Triplex or Duplex building may be assigned a different color.

3. EXECUTION

A. Workers shall wear protective equipment as recommended by the materials manufacturer when installing equipment.

B. All wiring and plumbing hook ups to be per manufacturer instructions.

C. All exposed screw heads shall be countersunk, the hole filled as recommended by the material manufacturer and painted to match the adjacent surface.

END OF SECTION 11310

END OF SECTION 11

Division 21 – Fire Suppression

210000 – WET PIPE SPRINKLER SYSTEM

PART 1 – GENERAL

1.1 SCOPE

TO BE INSTALLED IN THE HOUSE CEILING AREA AND REQUIRES WATER USED FROM THE WATER FILTRATION SYSTEM POTABLE WATER SUPPLY.

1.2 SECTION REQUIREMENTS

- A. Submittals: Product Data for valves, sprinklers, specialties, and alarms.
 - 1. Submit sprinkler system drawings identified as "working plans" and calculations according to NFPA 13. Submit required number of sets to authorities having jurisdiction for review, comment, and approval. Include system hydraulic calculations.
 - 2. Submit test reports and certificates as described in NFPA 13.
- B. Design and Installation Approval: Acceptable to authorities having jurisdiction.
- C. Hydraulically design sprinkler systems according to NFPA 13.
- D. Comply with NFPA 13D and NFPA 70, and IRC 2009 Section P2904.
- E. UL-listed and -labeled and FM-approved pipe and fittings.
- F. Verify dimensions in field measurements before fabrication & indicate on shop drawings.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

- A. CPVC Plastic Pipe: ASTM F 442/F 442M, UL 1821, 175-psig rating, made in NPS for sprinkler service. Include "Listed" and "CPVC Sprinkler Pipe" marks on pipe.
- B. CPVC Plastic Pipe Fittings: ASTM F 438 for NPS 3/4 to NPS 1-1/2 and ASTM F 439 for NPS 2, UL listed, 175-psig rating, for sprinkler service. Include "Listed" and "CPVC
- C. Sprinkler Fitting" marks on fittings.
- D. Black steel piping shall be provided in all exposed areas.
- E. Provide hangers, supports, and seismic restraints with UL listing and FM approval for fire-protection systems.

2.2 VALVES

- A. Fire-Protection Service Valves: UL listed and FM approved, with 175-psig nonshock minimum working-pressure rating. Indicating valves shall be butterfly or ball type, bronze body, and integral indicating device with 115-V ac, electric, single-circuit supervisory switch indicator.

2.3 SPRINKLERS

- A. Automatic Sprinklers: With heat-responsive element complying with the following:
 - a. UL 1626, for residential applications.
- B. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- C. Sprinkler types include the following:
 - a. Pendent Sprinkler: Tyco Rapid Response LFII Flush Residential Sprinkler Head
 - b. Pendent Sprinkler: Viking VK457 Concealed Sprinkler Head
 - c. Pendant Sprinkler: Viking VK468 Semi-Recessed Sprinkler Head
- D. Sprinkler Escutcheons: steel, one piece, with finish to match sprinklers.
- E. Sprinklers shall be low flow residential hidden pendent sprinklers engineered to provide a minimum design density of 0.05 gpm/ft² over the listed coverage area.

- F. Sprinkler frame and deflector shall be of bronze frame construction having a ½" NPT thread.
- G. Water seal assembly shall consist of a Teflon-coated Belleville spring washer with top-loaded extruded or cold head cup with 3 mm glass bulb containing no plastic parts, and having a temperature rating of 155°F, 165°F or 175°F.
- H. Sprinklers shall have a nominal K-factor of as designed in the hydraulic sprinkler design.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Fasten securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.
- B. Correct deficiencies in or remove and reinstall sprinkler that does not comply with requirements.
- C. Repair, refinish, or replace sprinklers damaged during installation, as directed by Architect.
- D. Adjust operating parts and hardware for smooth, quiet operation and weather tight closure. Lubricate hardware and moving parts.

3.2 PIPE AND FITTING APPLICATION

- A. Use steel pipe with threaded, press-seal, roll-grooved, or cut-grooved joints; copper tube with wrought-copper fittings and brazed joints; or CPVC plastic pipe and fittings and metal-to-plastic transition fittings with solvent-cemented joints.

3.3 PIPING INSTALLATION

- A. Install "Inspector's Test Connections" in sprinkler piping, complete with shutoff valve.

3.4 TESTING

- A. Flush, test, and inspect sprinkler-piping systems according to NFPA 13.

END SECTION 210000

END SECTION 21

Division 22 – Plumbing

22 – PLUMBING**221000 – PLUMBING PIPING**

PART 1 - GENERAL

1.1 SCOPE

Included in this section are the piping for the house. There is a difference between feed piping and drain piping, and that will be specified in this section. Depending on the systems and appliances in the house, there will be different sizing to the pipes.

1.2 REQUIREMENTS

- a. Solar Decathlon Building Code
- b. International Residential Code 2015
 - i. Table P2605.1 Piping Support
- c. NSF 14
 - i. Plastic piping, fittings and components from third party vendors
- d. NSF 61

1.3 SUBMITTALS

- e. Product
 - i. Specifications
 - ii. Warranty
 - iii. Installation Requirements

PART 2 - PRODUCTS

2.1 PEX TUBING (COLD WATER)

1. 1" PEX TUBING
 - i. Color: Blue
 - ii. Location: Wet Wall
 - iii. Website: <http://www.homedepot.com/p/SharkBite-1-in-x-500-ft-Blue-PEX-Pipe-U880B500/202688018>
 - iv. Manufacturer: SharkBite
 - v. Certifications: IAMPO Certified
 - vi. Pipe Size: 1"
 - vii. Dimensions (L x W x H x Depth): 500' x 34.24" x 13" x 34.25"
 - viii. Max. Working Temperature: 200 F
 - ix. Min. Working Temperature: 32 F
 - x. Max. Working Pressure: 160 PSI
2. 3/4" PEX TUBING
 - i. Color: Blue
 - ii. Location: Wet Wall and Mechanical Room
 - iii. Website: <http://www.homedepot.com/p/SharkBite-3-4-in-x-300-ft-Blue-PEX-Pipe-U870B300/202687981>
 - iv. Manufacturer: SharkBite
 - v. Certifications: IAMPO Certified
 - vi. Pipe Size: 3/4"

- vii. Dimensions (L x W x H x Depth): 300' x 30" x 12" x 30"
- viii. Max. Working Temperature: 200 F
- ix. Min. Working Temperature: 32 F
- x. Max. Working Pressure: 160 PSI

2.2 PEX PIPING (HOT WATER)

3. 1" PEX TUBING

- i. Color: Red
- ii. Location: Wet wall
- iii. Website: <http://www.homedepot.com/p/SharkBite-1-in-x-100-ft-Red-PEX-Pipe-U880R100/202033016>
- iv. Manufacturer: SharkBite
- v. Certifications: ANSI Certified, CSA Listed, IAMPO Certified
- vi. Pipe Size: 1"
- vii. Dimensions (L x W x H x Depth): 100' x 12" x 29" x 29"
- viii. Max. Working Temperature: 200 F
- ix. Min. Working Temperature: 32 F
- x. Max. Working Pressure: 160 PSI

4. ¾" PEX TUBING

- i. Color: Red
- ii. Location: Wet Wall and Mechanical Room
- iii. Website: <http://www.homedepot.com/p/SharkBite-3-4-in-x-500-ft-Red-PEX-Pipe-U870R500/202033040>
- iv. Manufacturer: SharkBite
- v. Certifications: ANSI Certified, CSA Listed, IAMPO Certified
- vi. Pipe Size: ¾"
- vii. Dimensions (L x W x H x Depth): 500' x 12" x 29" x 29"
- viii. Max. Working Temperature: 200 F
- ix. Min. Working Temperature: 32 F
- x. Max. Working Pressure: 160 PSI

2.3 ABS (ACRYLONITRILE BUTADIENE STYRENE) PIPING

- A. Website: <http://www.homedepot.com/p/2-in-ABS-DWV-90-Degree-Hub-x-Hub-Long-Turn-Elbow-C5807LTHD2/100346300>
- B. Manufacturer: Nibco Inc.
- C. Fitting size: 2"
- D. Dimensions (L x W x H x Depth): 5.38" x 2.73" x 5.38" x 5.38"
- E. Maximum Working Pressure: 5 PSI

PART 3. EXECUTION

1. INSTALLATION

a. PEX TUBING

- i. Website: https://www.huduser.gov/portal/publications/pex_design_guide.pdf
- ii. Requirements:
 - 1. Minimum bending radius for 1" tubing = 7" and ¾" tubing = 9"

2. Do not pull the tubing too much
- b. ABS PIPING
 - i. Website: <https://www.ppfahome.org/abs/absgeneral.aspx#install>

END SECTION 221000**221100 – PEX PIPING MANIFOLD**

PART 1. GENERAL

1.1 SCOPE

Included in this section is the Pex Manifold System that will be the control system where the hot and cold water will be distributed to individual fixtures. This will help with water and energy consumption throughout the house.

1.2 REQUIREMENTS

- A. IAMPO
- B. NSF International Performance and Health Effects
- C. Intertek Testing Services

1.3 SUBMITTALS

- A. Specifications
- B. Warranty
- C. Installation Requirements

PART 2. PRODUCTS

2.1 PEX PIPING MANIFOLD

- A. Website:
https://www.cpesupply.com/2319552/Product/50243?gclid=CjwKEAiApLDBBRC8oICb9NvKsg0SJAD9yOHsMiISQpNWf7PLW2rulMvDjZIA2JLwZ-TjupWSlwnhCxoC9GXw_wcB
- B. Manufacturer: Viega
- C. Material: Brass
- D. Nominal Size: 1" (need another ¾" one for those pipes)
- E. Dimensions (L x W x D): 24-3/8" x 8" x 3"
- F. Number of Outlets: 24 (9 hot, 15 cold)
- G. Includes: 1/4 Turn Valves and T-Handle Valve Key, Port Crimp Connections, Drill Templates, Instruction Guide, Faceplate and Port Labels

PART 3. EXECUTION

A. INSTALLATION

- a. Must be protected from UV exposure and petroleum
- b. Reference to Viega cutsheet

END SECTION 221100**222100 - POTABLE WATER TANKS**

PART 1. GENERAL

1. SCOPE

Included in this section is the tank where the potable, drinking water will be stored. For the competition, this tank will only be filled once. However, after the competition, the grey water filtration system will contribute to the supply in the potable water tank to feed into the water appliances and for drinking.

2. REQUIREMENTS

- a. Solar Decathlon Rules
 - i. Rule 9. Liquids
- b. NSF
- c. ANSI61

3. SUBMITTALS

- a. Product
 - i. Specifications
 - ii. Warranty
 - iii. Installation Requirements

PART 2. PRODUCTS

1. POTABLE WATER STORAGE TANK

- a. Type: Pillow Tank
- b. Website: <http://www.aireindustrial.net/products/750-gallon-potable-water-pillow-tank.asp>
- c. Manufacturer: AIRE
- d. Dimensions (L x W x Loft): 120" x 100" x 16"
- e. Capacity: 750 gallons
- f. Warranty: 1 year limited warranty

PART 3. EXECUTION

1. INSTALLATION

- a. Website: http://www.aireindustrial.net/images/Bladder_Instructions_web.pdf
- b. Precautions upon installation
 - i. Make sure the area is free of sharp objects
 - ii. Make sure that the tank is leveled
 - iii. Do not drag bladder
 - iv. Use Teflon tape for tight connection

END SECTION 221100

222200 – WASTE WATER STORAGE TANKS

PART 1. GENERAL

1. SCOPE

Included in this section are the tanks that will be used to store the grey water that is coming from the light grey water appliances (i.e. washing machine, bathroom sink, and shower) and the tank that will store the water after the biosand filtration and rainwater. In total, it should be two tanks.

2. REQUIREMENTS

- a. Solar Decathlon Rules
- b. Solar Decathlon Building Code
- c. NSF

d. ANSI61

3. SUBMITTALS

- a. Product
 - i. Specifications
 - ii. Warranty
 - iii. Installation Requirements

PART 2. PRODUCTS

1. GRAY 1, WASTE WATER, TANK

- a. Type: Pillow Tank
- b. Website: <http://www.aireindustrial.net/products/150-gallon-waste-water-pillow-tank.asp>
- c. Manufacturer: AIRE
- d. Dimensions (L x W x Loft): 66" x 48" x 12"
- e. Capacity: 150 Gallons
- f. Warranty: 1 year limited

2. TREATED COMBINED LIGHT GRAY AND RAIN TANK

- a. Type: Pillow Tank
- b. Website: <http://www.aireindustrial.net/products/750-gallon-waste-water-pillow-tank.asp>
- c. Manufacturer: AIRE
- d. Dimensions (L x W x Loft): 120" x 100" x 16"
- e. Capacity: 750 Gallons
- f. Warranty: 1 year limited

END SECTION 222200**222400 – WATER PUMPS**

PART 1 - GENERAL

1.1 SCOPE

Included in this section is the pressure boosting pump for our water filtration system. This pump will be in between the first grey water storage tank and the biosand filter. There is going to be a significant vertical head that the water will need to travel in order to reach the biosand filter, and this pump will accomplish that.

1.2 SUBMITTALS

- A. Specifications
- B. Installation Requirements

PART 2 - PRODUCTS

2.1 SCALA PUMP

- C. Purpose: Pump water from GREY 1 tank to biosand filter which cannot be gravity fed.
- D. Website: <http://us.grundfos.com/products/find-product/SCALA2.html#brochures>
- E. Manufacturer: Grundfos
- F. Dimensions (L x W x H): 15.9" x 7.6" x 11.9"
- G. Power Requirement: Max. 600 W

H. Flow Rate: Max. 16 GPM

2.2 BMQE PUMP

- A. Purpose: Provides constant pressure and works with low pressure feed. Able to set the desirable pressure.
- B. Website: http://us.grundfos.com/products/find-product/grundfos-bmqe-system/_jcr_content/tabbedpanel/brochures/download_list/downloads/download_0/file/file.res/L-DWS-PG-01.pdf
- C. Manufacturer: Grundfos
- D. Dimensions (L x W x H): 22.44" x 8.58" x 12.74"
- E. Power Requirement: 200 W
- F. Flow Rate: 22 GPM

PART 3 - EXECUTION**3.1 INSTALLATION****PUMP #1**

- A. Website :<http://us.grundfos.com/content/dam/GPU/Literature/SCALA2/SCALA2-IO.pdf>
- B. Location
 - a. Must not be exposed to frost
 - b. Near drain or in a drip tray connected to a drain
 - c. Space Requirement: 17" x 8.5" x 12.8"

END SECTION 222400**223000 – HOT WATER HEATER****PART 1 - GENERAL****1.1 SCOPE**

Will be used for the hot water in the house and both components will be located in the mechanical closet.

1.2 SPECIFICATION REQUIREMENTS

- 1. Energy efficiency
- 2. Corrosion resistant tank
- 3. 149 degree F hot water temperature
- 4. Support four person family
- 5. CO2 refrigerant
- 6. Heat pump warranty 10 years
- 7. Heat storage tank warranty 15 years

1.3 SUBMITTALS

- 1. Product specifications
- 2. Drawing with installation location

PART 2 - PRODUCTS**2.1 HEAT PUMP WATER HEATER**

- 1. Volume: 43 gallons
- 2. Energy factor: 3.5
- 3. Water temperature: 149
- 4. Pipe size: ½"

2.2 STAINLESS STEEL STORAGE TANK**END SECTION 223000****224100 – RESIDENTIAL PLUMBING FIXTURES****PART 1 – GENERAL****1.1 SCOPE**

Fixtures that are used in the kitchen and bathroom plumbing fixtures.

1.2 STANDARDS

- A. ASME A112.18.1/CSA B125.1 NSF 61 NSF 372 All applicable US Federal and State material regulations DOE - Energy Policy Act 1992 ADA ICC/ANSI A117.1 CSA B651 OBC

PART 2 – PRODUCTS

2.1 BATHROOM SINK

A. Acceptable Product

1. Product: Purist Wading Pool Bathroom Sink
2. Model: K-2314-1
3. Manufacturer: Kohler
4. Website:
5. Size: 24" (610 mm) x 23-1/2" (597 mm)
6. Overflow: None
7. Faucet hole: 1-3/8"
8. Warranty: 1 year limited
9. Colors: White, Biscuit, and Almond

2.2 BATHROOM SINK FIXTURE

A. Acceptable Product

1. Product: Elliston single-handle bathroom sink faucet
2. Model: K-R72782-AD
3. Manufacturer: Kohler
4. Website:
5. Spout reach: 5"
6. Max flow rate: 1.5 gal/min
7. Pressure: 60 psi
8. Warranty: 1 year limited
9. Color: Polish chrome, or vibrant brushed nickel

2.3 KITCHEN SINK

A. Acceptable Product

1. Product: Undermount Stainless Steel Kitchen Sink
2. Manufacturer: Elkay
3. Single bowl
4. Length: 24"
5. Width: 18-1/4"
6. Depth: 9"
7. Faucet holes: 0
8. Size: 24"x 18.25" x 9"
9. Undermounted
10. Colors: Stainless Steel
11. <http://www.homedepot.com/p/Elkay-Undermount-Stainless-Steel-24-in-0-Hole-Single-Bowl-Kitchen-Sink-HDU24189F/206889274>

2.4 KITCHEN SINK FIXTURE

A. Acceptable Product

1. Product: Coralasis Kitchen Sink Faucet
2. Model: K-15175-P
3. Manufacturer: Kohler
4. Spout reach: 8-1/2"
5. Flow rate: 1.8 gal/min
6. Pressure: 60 psi
7. Color: Polished chrome

2.4 SHOWER FIXTURE

A. Acceptable Product

1. Product: Contemporary Round Rain Showerhead
2. Model: K-45201
3. Manufacturer: Kohler
4. Flow rate: 2.0 gpm (gallons per minute)
5. Connection: 1/2-inch NPT

END SECTION 224100

224200 PRESSURE BOOSTER TANK

Part 1. GENERAL

1.01 Section Requirements

- A. Comply with NSF 61 for clean, safe drinking water standards

Part 2. PRODUCTS

2.01 Amtrol

- A. Water Worker Pressure Booster System
 - a. Water pressure feed: 40 to 80 psi

- b. Flow rate: 15 gpm
- c. Motor: ½ hp
- d. Pump power requirement: 5.3 amps, 230 volts
- e. Pipe size: 1 in.
- f. Dimensions:
 - i. Depth: 17 in.
 - ii. Diameter: 17 in.
 - iii. Height: 30 in.
 - iv. Width: 17 in.

2.02 Valves and Fittings

- A. Nibco 1-¼" x 1" Press x Male NPT Adapter, ANSI 61, ASTM B-75, CSA MSE 13, NSF 61-G
- B. Watts 1" 100 psi FNPT Bronze Relief Valve, ANSI 1105, ASME Section IV
- C. Nibco 1" 600# Brass Solder Full Port Ball Valve, NSF 372, NSF 61
- D. Everbilt 1" Brass Check Valve, Spring Loaded

Part 3. EXECUTION

3.01 Pre-Installation and Servicing

- a. Use only with cold potable water systems
- b. Do not set water pressure feed too high since it may overheat
- c. A relief valve must be installed to prevent pressure in excess
- d. Pump must be shut off in order to service the pressure tank
- e. Shut off switch should be visible and near pump
- f. Metal piping at inlet and outlet for this system
- g. Turn off all electrical power before servicing

3.02 Installation Requirements

- h. Remove protective air valve cap
- i. Fix pressure 2 psig below the desired pressure feed
- j. Replace protective air cap
- k. Install a spring loaded check valve
- l. Connect to house supply line using 100 psig maximum relief valve before shut off valves at all times

END SECTION 224200

END SECTION 22

Division 23 – Heating, Ventilating, and Air-Conditioning (HVAC)

SECTION 23 – HEATING VENTILATION & AIR CONDITIONING**231000 – INSTRUMENTS**

Part 1 – GENERAL

1.1 SCOPE

Used to measure various physical parameters for recording by digital systems and feedback for control systems.

1.2 REQUIREMENTS

- A. Requirements for measurement range and sensitivity vary from sensor to sensor and from location to location.
- B. Provide hardwired data and power connections to all instrumentation that requires it. Connections shall be shown on the appropriate (telecommunications) sheets of the Drawings.

Part 2 – PRODUCTS

2.1 THERMOSTAT

A. Acceptable thermostat products

1. NEST
2. Website: <https://store.nest.com/product/thermostat?selectedVariantId=T3007ES>
3. Assembled mass: 8.6 oz (243.7 g)
4. Assembled diameter: 3.3 in (8.4 cm)
5. Assembled height: 1.21 in (3.08 cm)
6. Wireless: Wi-Fi 802.11b/g/n @ 2.4GHz, 5GHz
7. Battery: Built-in rechargeable lithium-ion battery
 - i. Power consumption: Less than 1 kWh/month
8. Connectivity: Nest app on phone or tablet with iOS 8 or later, or Android 4.1 or later
9. Warranty: 2-year limited

2.2 TEMPERATURE SENSORS - TBD

2.3 HUMIDITY SENSORS - TBD

2.4 MOTION DETECTORS – NEAR FIELD - TBD

2.5 MOTION DETECTORS – FAR-FIELD - TBD

2.6 AMBIENT LIGHT - TBD

2.7 ELECTRICAL CURRENT SENSORS - TBD

2.8 POWER CONSUMPTION SENSORS-TBD

2.9 RESIDENTIAL WEATHER STATION

- A. Provide accurate real-time data for the specific location of the house. Wireless all-in-one integrated sensor array measures wind speed, wind direction, temperature, humidity, wind speed, wind direction, rainfall, UV and solar radiation.
- B. Any portion of the weather station which violates the prescribed solar envelope of the house shall have a form factor which does not interfere with the operation or performance of neighboring houses. Installation of the weather station is subject to approval by the Solar Decathlon Competition Organizers.
- C. Acceptable manufacturer and products:
 1. Ambient Weather WS-1400-IP
 - a. Manufacturer: Ambient Weather
 - b. Website: <http://www.ambientweather.com/amws1400ip.html>
 - c. Wireless: transmits at 915MHz to ObserverIP
 - d. Outdoor Temperature Sensor Range: -40 to 149 °F

- e. Outdoor Humidity Accuracy: $\pm 5\%$
 - f. Solar Radiation Accuracy: $\pm 15\%$
 - g. UV Accuracy: ± 1
 - h. Wind Direction Accuracy: $\pm 1^\circ$
 - i. Wind Speed Accuracy: ± 2.2 mph or 10% (whichever is greater)
 - j. Barometric Pressure Accuracy: ± 0.08 inHg (within range of 27.13 to 32.50 inHg)
 - k. Dimensions (LxWxH): 14" x 6" x 12"
 - l. Weight: 4 lbs
 - m. Location: Wide open area either on the roof or ground (Outside)
 - n. Warranty: 1 years
2. Davis Instruments 6250 Vantage Vue Wireless Weather Station
- a. Manufacturer: Davis Instruments
 - b. Website: <http://www.davisnet.com/solution/vantage-vue/>
 - c. Wireless: transmits to LCD console via RF (902 to 928 MHz), max range 1000 ft
 - d. Outdoor Temperature Sensor Range: -40 to 150 °F
 - e. Outdoor Humidity Range: 0-100%
 - f. Wind Speed: 2-180 mph
 - g. Rainfall accuracy: $\pm .01$ "
 - h. Barometer: Arrow indicating increase/decrease
 - i. Dimensions (in): 14 x 9 x 6
 - j. Weight: 7 lbs
 - k. Location: Wide open area either on the roof or ground (Outside)
 - l. Warranty: 1 year

END SECTION 231000

SECTION 232000 - DAMPERS

Part 1 – GENERAL

1.1 SCOPE

Back-Draft Dampers are used with the intake or exhaust duct systems to prevent infiltration of outside air when the ventilation system is not active.

Control Dampers are used to activate or deactivate specific duct paths in the system.

Part 2 – PRODUCTS

2.1 Back-Draft Prevent Dampers

A. Acceptable damper products

1. Product: Galvanized Back Draft Prevention Damper

- a. Manufacturer: Speedi-Products
- b. Website: <http://www.homedepot.com/p/Speedi-Products-4-in-Galvanized-Back-Draft-Prevention-Damper-AC-BD-04/202907123>
- c. Size: 4 inch diameter; 30 gauge
- d. Material: Steel
- e. Warranty: 1 year

Part 3 – EXECUTION

1. Seal joints with approved duct mastic sealants
2. Insulate ductwork for improved energy efficiency and comfort
3. Consult local building codes for approved installation practices

END SECTION 232000

SECTION 233000 – ENERGY RECOVERY VENTILATOR

Part 1 - GENERAL

1.1 SCOPE

Energy Recovery Ventilator is used to provide a continuous flow of fresh outdoor air to the house interior in a pressure balanced system (neither pressurizing nor depressurizing the house). This is required by ASHRAE 62.2 because most high-efficiency modern homes are tightly sealed against air infiltration. ERVs provide transfer of sensible and latent heat (humidity) between incoming fresh and outgoing stale air streams, enhancing the energy efficiency of the system overall.

1.2 REQUIREMENTS

A. Applicable Standards

1. ASHRAE 62.2
2. ASHRAE 90.1
3. Interior CO₂ levels shall not exceed 1000 PPM.

B. Provide minimum of 0.5 ACH fresh outside air (based on 4 occupants and 1000 square foot home size for).

C. Provide booster mode (additional capacity) to handle maximum anticipated CO₂ load (based on 12 people).

Part 2 – PRODUCTS

1. Acceptable products for Energy Recovery Ventilator (ERV)

1. Product: ComfoAir 350
 - a. Manufacturer: Zehnder
 - b. Filters: class G4 for general and F7 for pollen
 - c. DC Motors
 - d. Dimensions: (H x W x D) 31.5" x 24.6" x 22.5"
 - e. Thermal output: up to 95%

Part 3 – EXECUTION

A. Maintenance

1. Regular replacement and cleaning of the filter in front of the unit
2. The heat exchanger should be cleaned every 3-4 years depending on how dirty the outside air is
3. Please see the unit manual for additional servicing tasks.

END SECTION 233000

SECTION 234000 – COMPRESSOR / CONDENSER UNIT

Part 1 – GENERAL

1.1 SCOPE

The compressor / condenser unit is located outside the thermal envelope of the house. Its function is to reject heat from the interior (cooling mode) or absorb heat from the exterior (heating mode).

1.2 REQUIREMENTS

- A. Applicable Standards
 - 1. ASHRAE 90.1
- B. Installed unit shall be UL Listed. Any modifications to the unit for increased efficiency shall be thoroughly tested and the results provided to the Solar Decathlon Competition Organizers prior to acceptance of the design.
- C. Capacity of the unit shall be determined according to the total system heat and cooling loads as determined by energy modeling.

Part 2 – PRODUCTS

2.1 VRF CONDENSER

- A. Acceptable Products
 - 1. VRF Mini-Split Condenser
 - a. Manufacturer: LG
 - b. Model: LMU30CHV
 - c. Website: <http://www.totalhomesupply.com/30000-btu-22-seer-quad-zone-multi-f-mini-split-air-conditioner/p/LG-LMU30CHV>
 - d. Dimensions (HxWxD): 32.8" x 37.4" x 15.7"

Part 3 - EXECUTION

- A. If the outdoor unit is installed on a roof structure be sure to level the unit. Ensure the roof structure and anchoring method are adequate for the unit location.
- B. Consult local codes regarding rooftop mounting.
- C. Unit shall be kept free of snow.
- D. Unit shall not be installed in areas where corrosive gases, such as acid or alkaline gas, are produced.
- E. Unit shall not be installed where it could be exposed directly to sea winds.

END SECTION 234000

SECTION 236000 – INTERIOR HEAT PUMP UNITS

Part 1 – GENERAL

1.1 SCOPE

Interior heat pump units provide heated or cooled air (heating and cooling modes respectively). In cooling mode, these units also dehumidify the air. Air is drawn from the space in which the unit is located, heated or cooled / dehumidified and recirculated into the space.

Interior units are generally installed high on the wall or in the ceiling (different products for each application). A separate unit is generally installed in each living space (living room, bedroom, etc.) and are controlled separately by proprietary remote control systems.

1.2 REQUIREMENTS

- A. Applicable Standards
 - 1. ASHRAE 90.1
- B. Capacity of each unit is selected from range of products commercially available, and based on energy analysis of the house and space served
- C. Minimum Seasonal Energy Efficiency Rating (SEER) : 22
- D. Minimum Coefficient of Performance (COP) : 4.0

Part 2 – PRODUCTS

2.1 WALL-MOUNTED UNIT

- A. Acceptable Products:
 - 1. Mini-split Wall-mounted Unit
 - a. Manufacturer: LG
 - b. Model:
 - c. Web Link <http://www.totalhomesupply.com/7000-btu-standard-indoor-wall-unit-heat-pump/p/LG>
 - d. Height 8.2" Width 35.6" Depth 11.4"

2.2 CEILING MOUNTED UNIT

- A. Acceptable Products
 - 1. Mini-Split Ceiling Mounted Unit
 - a. Manufacturer LG
 - b. Model LMN096HVT
 - c. Web Link <http://www.totalhomesupply.com/7000-btu-standard-indoor-wall-unit-heat-pump/p/LG>
 - d. Dimensions L
 - i. Height 8.2"
 - ii. Width 35.6"
 - iii. Depth 11.4"

Part 3 - EXECUTION

- A. Indoor units with product-specific mounting kits. Route the indoor refrigerant lines to the required piping hole position and connect to exterior condensing unit. Route the condensate drain line to a convenient exterior location and discharge to ground. No air ducts are required for this unit.

END SECTION 236000

SECTION 235000 – HUMIDIFIER**PART 1 – General****1.1 SCOPE**

Humidifiers are designed to regulate the relative humidity of an indoor area by evaporating water particles into the air. This project includes a central humidifier located in the mechanical space.

1.2 PERFORMANCE REQUIREMENTS

- A. Shall be capable of maintaining relative humidity level of the house within healthy range (40-60%)
- B. Shall not pose a hazard to occupants of the house (i.e. scalding)

1.3 SUBMITTALS

- A. The Contractor shall provide the Architect with technical product performance details and installation instructions sufficient to verify the performance requirements cited above.
- B. The Contractor shall provide the Owner with a warranty certificate covering materials AND installation of the Insulation.

Part 2 - PRODUCTS**2.1 BY-PASS DRUM HUMIDIFIER**

- A. Acceptable Manufacturers and Products
 - 1. HE120 By-pass Drum Humidifier
 - a. Manufacturer: Honeywell
 - b. Width: 12-3/8"
 - c. Height: 10-15/16"
 - d. Depth: 11-11/16"
- B. Alternative products may be proposed by the Contractor as options for pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Project Architect & Project Engineer.

2.2 ACCESSORIES

- A. Included Installation kit
- B. Replacement evaporation pads

3. EXECUTION**3.1 INSTALLATION**

- A. All cuts should be done using the provided template and in a place along ventilation duct as recommended by the manufacturer.
- B. Workers shall wear protective equipment as recommended by the materials manufacturer when cutting or finishing the materials.

3.2 FINISHING

- A. The end users shall refer to the manual provided by the manufacturer for the recommended humidity setting based on outdoor temperature, unless a more accurate humidistat is being used.
- B. The end users shall perform annual maintenance as described by manufacturer in product manual.

END SECTION 235000**END SECTION 23**

Division 26 – Electrical

26 - ELECTRICAL**260500 – WIRING**

PART 1 – GENERAL

1.1 SCOPE

Insulated electrical conductors for distributing power throughout the dwelling.

PART 2 – PRODUCTS

2.1 Acceptable manufacturers and products

A. Romex 14/3 NM-B Copper Wire

1. Website: https://hdsupplysolutions.com/shop/p/14-3-romex-nm-b-copper-wire-50-length-p301398?gclid=CjwKEAiA6YDBBRDwtpTQnYzx5IASJAC57ObMT2woaN3w8dcOmLCrc59SM7MrzqMJE0muc5CbtzG5xoC6qjw_wcB
2. Manufacturer: Southwire
3. Dimensions (in): 8.9x9.1x2.1
4. Length of pack (ft): 50
5. Amps (A): 15
6. Price: \$36.00

- B. Alternative products may be proposed by the Contractor to the Owner to provide options based on pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Owner and Architect.

PART 3 – EXECUTION

- A. All electrical wires shall be run through a central location (preferably near a fuse box)
- B. Red and black wires denote live wires, white wires serve as the ground, and blue yellow or other colors are used for switches.
- C. Avoid laying conduit around sharp corners.
- D. Each major appliance shall have a dedicated circuit and circuit breaker in the panel.
- E. Each hard-wired appliance of piece of equipment shall have a dedicated circuit and circuit breaker in the panel.

261100 – LIGHTING CONTROLS**PART 1 – GENERAL****1.1 SCOPE**

The lighting control system will allow for automatic control of the lighting. This will allow for advanced energy saving capabilities and the ability of the occupants to control the lighting in each portion of the house by smartphone or tablet “apps”.

1.2 PERFORMANCE REQUIREMENTS*Main Controller*

- a. cULus Listed
- b. FCC approved
- c. Operates on standard 120V, 50/60 Hz
- d. Operational between 32 and 104 degrees F
- e. Operates between 0% and 90% humidity
- f. Controls on frequency signals between 431 and 437 MHz
- g. Remains unharmed when exposed to static discharge-conforms to IEC 61000-4-2
- h. Remains unharmed when exposed to surge voltages-conforms to IEEE C62.41-1991
- i. Retains memory after power failure
- j. Able to connect to the internet
- k. Can relay signals between occupant and room controllers
- l. Programmable
- m. Can control the settings of lighting in each room based on different “set modes” produced by the user
- n. Can schedule lighting turning on and off based on schedules provided by the user
- o. Connects to Lutron Cloud, enabling remote control

Room Controller

- a. Controllable by frequency signals between 431 and 437 MHz
- b. Can control LED lamps and fixtures
- c. Retains set mode of lighting level prior to power failure
- d. cULus Listed
- e. FCC approved
- f. Operates on standard 120V, 50/60 Hz
- g. Remains unharmed when exposed to static discharge-conforms to IEC 61000-4-2
- h. Remains unharmed when exposed to surge voltages-conforms to IEEE C62.41-1991
- i. Can be mounted in standard 1-gang electrical receptacles
- j. Operational between 32 and 104 degrees F
- k. Operates between 0% and 90% humidity
- l. Can connect to 10 devices
- m. Can connect to devices visible within 60 feet.
- n. Can connect to devices through walls within 30 feet

1.3 SUBMITTALS

- A. Main Controller
 - a. Specs
 - b. Warranty

- c. Who will install and maintain
 - d. Installation instructions
- B. Room Controller
- a. Specs
 - b. Warranty
 - c. Who will install and maintain
 - d. Installation instructions

PART 2 – PRODUCTS

2.1 Main Controller

2.1.1 Lutron

A. Connect Bridge

- a. Size: W: 2.75", L: 2.75", H: 2.75"
- a. Power Supply: 5V, 300 mA
- b. Typical Power Usage: 1.3W
- c. Used in conjunction with Lutron Main Repeater to connect to devices
- d. 1 year warranty
- e. Price: \$209

B. Main Repeater

- a. Operates on frequency of 434 MHz
- b. Antenna length of 6.25 in
- c. Signal operates up to 30 ft
- d. Electrical input: 9V @ 300 milliAmps
- e. Consumes 3.1W
- f. Connects with devices operating on frequencies between 431 and 437 MHz
- g. Can connect to internet
- h. Remains unharmed when exposed to static discharge-conforms to IEC 61000-4-2
- i. Remains unharmed when exposed to surge voltages-conforms to IEEE C62.41-1991
- j. Retains memory after power failure
- k. Size: W: 4.25", L: 5.25" (disregarding antenna attachment), H: 1 1/16"
- l. Size: W: 2.75", L: 2.75", H: 2.75"
- f. Power Supply: 5V, 300 mA
- g. Typical Power Usage: 1.3W
- h. Must be used with Lutron Main Repeater to connect to devices
- i. 1 year warranty
- j. Price: \$341.01

C. Smart Bridge

- a. Size: W: 2.75", L: 2.75", H: 2.75"
- b. Power Supply: 5V, 300 mA
- c. Typical Power Usage: 1.3W
- d. 1 year warranty
- e. Price: \$110.00

2.1.2 Developed System

- A. See performance requirements above that need to be met for a developed system to be considered.

2.2 Room Controller

2.2.2 Lutron

- A. Caseta Wireless In-Wall Dimmer
 - a. Size: W:2 15/16", L: 4 11/16", D: 1 7/16"
 - b. Needs to be wired to ground
 - c. Price: \$72.00
- 2.2.3 Developed System
 - A. See performance requirements above that need to be met for a developed system to be considered.
- 2.3 Accessories
 - 2.5.1 Wire
 - A. See Power specification
 - 2.5.2 Junction Boxes
 - A. See Power specification
 - 2.5.3 Switch Covers
 - A. Lutron
 - a. Size: W: 2.75", L: 4.75", D: 0.25"
 - b. Style of Switch: Rocker
 - c. Number of Gangs: 1-6
 - d. Shape: Rectangular
 - e. Color: Multiple options
 - f. Material: Plastic
 - g. Price: \$4.90
 - B. Generic Model
 - a. Size: W: 2.75", L: 4.75", D: 0.25"
 - b. Style of Switch: Rocker
 - c. Number of Gangs: 1-6
 - d. Shape: Rectangular
 - e. Color: Multiple options
 - f. Material: Plastic
 - g. Price: \$0.79 and up

PART 3- EXECUTION

Installation of the system shall be in compliance with local, and national codes. The trained technicians installing the system shall follow the instructions provided by the manufacturer in the "Installation Instructions". Controller will be integrated with the relevant lighting sensors provided in integrated automation.

3.1 Installer

- A. Electrical Contractor
 - a. Shall have applicable licensure
 - b. Shall have qualified technicians installing product
 - c. Shall troubleshoot issues at the site for best installation
 - d. Shall follow applicable building codes
 - e. Shall follow installation instructions
 - f. Shall ensure all components are operating correctly at the site

END SECTION 261100

261200 – LIGHTING FIXTURES**PART 1 – GENERAL****1.1 SCOPE**

This section addresses the lighting needs through asking for spaces with ambient lighting, tasked lighting and accent lighting highlighting the structure at the same time.

1.2 REQUIREMENTS

Good quality day lighting

Use of LED lights which integrates with the integrated automation system

1.3 SUBMITTALS

Product data sheets

PART 2 – PRODUCTS

1. Products have been selected for all rooms within the house according to the lighting schedule
2. Product data sheets are included
3. Any alternatives need to be approved by Owner

PART 3 - EXECUTION

Installation of the system shall be in compliance with local, and national codes. The trained technicians installing the system shall follow the instructions provided by the manufacturer in the "Installation Instructions". Controller will be integrated with the relevant lighting sensors provided in integrated automation.

Installer

Electrical Contractor

- Shall have applicable licensure
- Shall have qualified technicians installing product
- Shall troubleshoot issues at the site for best installation
- Shall follow applicable building codes
- Shall follow installation instructions
- Shall ensure all components are operating correctly at the site

END SECTION 261200

SECTION 263100 – PHOTOVOLTAIC SOLAR COLLECTORS**PART 1 – GENERAL****1.1 SCOPE**

Photovoltaic panels used to convert sunlight into DC electricity, and when accompanied by built-in microinverters, into AC electricity.

1.2 PERFORMANCE REQUIREMENTS

- A. Panels shall have a useful service life of at least 25 years.
- B. A typical 60" x 42" panel shall have a peak power output of at least 300 W.
- C. Panels shall be UL Listed.

1.3 SUBMITTALS

- A. Documentation of UL Listing.

PART 2 - PRODUCTS**2.1 Acceptable manufacturers and products**

- A. Sunpower SPR-X21-335-BLK
 1. Website: <https://us.sunpower.com/sites/sunpower/files/media-library/data-sheets/ds-x21-series-335-345-residential-solar-panels-datasheet.pdf>
 2. Manufacturer: Sunpower
 3. Dimensions (in): 61.24x41.18 x1.81
 4. Area (ft²): 17.54
 5. Max Power (W): 335
 6. Warranty: 25 years
- B. Alternative products may be proposed by the Contractor to the Owner to provide options based on pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Owner and Architect.

PART 3 – EXECUTION

- A. Solar panels add 5-6 lbs per square foot of roof loading.
- B. Most companies want to install the panels themselves.
- C. There must be adequate insulation between the solar panel and roof to ensure that the solar panels do not heat up. Need some space for convective heat transfer to cool down solar.

END SECTION 263100

SECTION 263120 – MICROINVERTERS**PART 1 – GENERAL****1.1 SCOPE**

Microinverters convert the DC power from each photovoltaic panel into AC power.

PART 2 – PRODUCTS**2.1 Acceptable Manufacturers and Products****A. Solar Edge SE10000A-US**

1. Website: <http://www.solaredge.com/sites/default/files/se-single-phase-us-inverter-datasheet.pdf>
2. Manufacturer: Solar Edge
3. Dimensions: 775 mm x 315 mm x 260 mm (without mounting bracket)
4. Max DC Volt Rating (V): 500
5. Max Power (W): 4050 at STC
6. Nominal AC Voltage (V): 240
7. Max AC Current (A): 12.5
8. Max OCPD Rating (A): 20

- B. Alternative products may be proposed by the Contractor to the Owner to provide options based on pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Owner and Architect.

PART 3 – EXECUTION**END SECTION 263120**

SECTION 263130 – DC-DC OPTIMIZER

PART 1 – GENERAL

1.1 SCOPE

PART 2 – PRODUCTS

1.2 Acceptable Manufacturers and Products

A. Solar Edge P400

1. Website: <http://www.solaredge.com/sites/default/files/se-P5-series-add-on-power-optimizer-datasheet-na.pdf>
2. Manufacturer: Solar Edge
3. Dimensions: 128 mm x 152 mm x 35 mm
4. Max DC Input Voltage (V): 80
5. Max DC Input Current (A): 10
6. Max Input Power at 40C (W): 400
7. Max Output Voltage (V): 60
8. Max Output Current (A): 15
9. Max OCPD Rating (A): 20

- B. Alternative products may be proposed by the Contractor to the Owner to provide options based on pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Owner and Architect.

PART 3 – EXECUTION

END SECTION 263130

SECTION 263300 – BATTERY SYSTEMS**PART 1 – GENERAL****1.1 SCOPE**

Battery systems used to store energy from the photovoltaic array and from the utility grid for when the demand from the house exceeds power available from the panels or the grid. Battery systems may also be used when the grid is down if the system includes protective measures as required by local authority.

PART 2 – PRODUCTS**2.1 Acceptable Products****A. Tesla Powerwall 1**

1. Website: <https://www.tesla.com/powerwall>
2. Manufacturer: Tesla
3. Dimensions (in): 44x29x5.5
4. Capacity (kWh): 7.0
5. Cost: \$3,000
6. Price per capacity (\$/kWh): 429
7. Location: Indoor or outdoor
8. Warranty: 10 years
9. Operating temperature (oF): -4-121
10. Power (kW): Peak- 3.3 Continuous- 2
11. Installation: wall mounted
12. Color: white

B. Alternative products may be proposed by the Contractor to the Owner to provide options based on pricing. If an alternative product is proposed, Contractor shall provide performance, cost, installation and other product information as requested by the Architect. All material substitutions shall be subject to approval by the Owner and Architect.

PART 3 – EXECUTION

F. Need to be cautious of where these batteries need to be installed. Tesla Powerwall can go inside or out but lead acid batteries such as the Torjan ones need an outdoor ventilated space.

END SECTION 263300**END SECTION 26**

Division 27 – Telecommunications

27 – TELECOMMUNICATIONS**271000 – ROUTER AND MODEM**

1.1 SCOPE

In order to ensure connectivity of sensors, smart appliances, and wifi, the following products have been specified. Connectivity is tantamount to the communications between users, our "smartHouse" control system, and appliance accessibility.

1.2 PERFORMANCE SPECIFICATIONS

- A. Wireless functionality throughout the house
- B. These products will work with any appropriate internet provider for the area

1.3 SUBMITTALS

WIRELESS ROUTER

- a. Acceptable manufacturers and products
 - i. NETGEAR AC1750 Dual Band Router
 - i. Website: https://www.amazon.com/NETGEAR-Router-AC1750-Gigabit-R6300v2/dp/B00EM5UFP4/ref=cm_cr_arp_d_pdt_img_sims?ie=UTF8
 - ii. Manufacturer: Netgear
 - iii. Wireless: 802.11 A/C, 5.8 GHz Radio Frequency, 802.11 a/b/g/n
 - iv. Total Wi-Fi speed: 1750Mbps
 - v. Processor Speed: Dual Core 800Mhz
 - vi. Dimensions (in): 10.12 x 12.01 x 2.83 in
 - vii. LAN Ports: 4
 - viii. Location: Core or Office space/Bedroom

B. Cable Modem

- b. Acceptable manufacturers and products:
 - i. ARRIS SURFboard SB6141 DOCSIS 3.0 Cable Modem
 - i. Description: 3 products in 1: a DOCSIS 3.0 Cable Modem, Dual-Band Concurrent 802.11ac Wi-Fi Access Point and 2-Port Gigabit Ethernet Router.
 - ii. Website: https://www.amazon.com/gp/product/B00AJHDZSI/ref=pd_cp_147_1?ie=UTF8&psc=1&refRID=QFD15A0SW6GNW4MZ5A8M
 - iii. Manufacturer: ARRIS
 - iv. Wireless: 802.11ac
 - v. Download speed: 343 Mbps wireless, 1600 Mbps wired
 - vi. Dimensions (in): 2 x 6.4 x 8.7 in
 - vii. Weight: 1.3 lbs
 - viii. Location: Core or Office space/Bedroom

END SECTION 271000**END SECTION 27**

Division 29 – Integrated Automation

29 - INTEGRATED AUTOMATION**SECTION 291000**

PART 1 - GENERAL

1.1 SCOPE

The “SmartHouse” control system for the house is included in this section. The role that the control system takes is that of a supervisory mode. The effective range of control from the controller of a feature of the house will be limited to that which can be conducted manually by occupants. To define this role, the use of sensors as well as predictive data in terms of forecasts will influence the way in which the control system interacts with power, HVAC, and water. The goal of the “smartHouse” will be to autonomously enable the occupants to generate more effective cost-saving as well as resource-saving techniques and actions.

1.2 PERFORMANCE SPECIFICATIONS

- A. Predictive simulation through a physically based model of the house design (virtual house)
- B. Real-time data through a personal weather station & a wide range of sensors to assist and confirm the projected performance of the house.
Note: many of the other system’s products do already come with integrated sensors and accessibility to data.
- C. Intuitive user Interface and accessibility for occupants. Main control would be featured in the core in the form of a tablet while performing necessary calculations.
- D. Minimal invasiveness to actual imbedded system controllers. This is to disentangle and prove the modularity of the control system to be able to be implemented in many cases.
- E. Case designs made by the “smartHouse” will focus on event scheduling, such as the charging of the electric vehicle for maximizing profits.

1.3 SUBMITTALS

- A. Products: Sensors, actuators, controllers, user Interface & accessibility
 - 1. Specs and performance
 - 2. Warranty
 - 3. Installation

Part 2- PRODUCTS

2.1 SENSORS

A. Comfortability

- 1. Acceptable manufacturers and products
 - a. Comet America – H6520 Temperature, humidity, CO2 transmitter with two relay outputs
 - i. Description: “All-in-one temperature, humidity, and CO2 wireless sensor”
 - ii. Website: <http://www.cometsystem.com/products/h6520-temperature-humidity-co2-transmitter-with-two-relay-and-ethernet-outputs/reg-H6520>
 - iii. Manufacturer: Comet America
 - iv. Dimensions: 136 x 213 x 45 mm (W x H x D), stem length 75 mm

- v. Accuracy of CO₂ concentration measurement: $\pm(50\text{ppm} + 2\%$ from reading) at 25°C and 1013hPa
 - vi. Accuracy of relative humidity measurement: $\pm 2.5\%$ relative humidity from 5 to 95% at 23°C
 - vii. Accuracy of temperature output: $\pm 0.4^\circ\text{C}$
 - viii. Wireless: IEEE 802.11b/g/n
 - ix. Location: Plugged in key locations (each room) near outlets for hardwiring
 - x. Warranty: 3 yrs
- b. Senmatic – InClimate: Temperature, Humidity & CO₂ Sensor
- i. Description: “Combined temperature-humidity-CO₂ controller/transmitter for comfort control of indoor climate”
 - ii. Website: <http://www.senmatic.com/sensors/inclimate>
 - iii. Manufacturer: Senmatic
 - iv. Dimensions: 80 x 80 x 23 mm (W x H x D)
 - v. Accuracy of CO₂ concentration measurement: $\pm 75\text{ppm}$ at 20°C, max range 0-2000ppm (adjusted to 600-1200ppm)
 - vi. Accuracy of relative humidity measurement: $\pm 5\%$ relative humidity from 0 to 100% (adjusted to 20% to 95%)
 - vii. Accuracy of temperature output: $\pm 1^\circ\text{C}$, Range 0oC to 50oC (adjusted to 5oC to 30 oC)
 - viii. Wired: Can be read by anything that can read 0-10V min. load 10k Ω
 - ix. Power Consumption: 1.0W
 - x. Location: Plugged in key locations (each room) near outlets for hardwiring
 - xi. Rated Voltage: 24V AC/DC
 - xii. Weight: 85g

B. Energy Management

1. Acceptable manufacturer and products

a. Neurio W1-HEM Home Energy Monitor (North American Version)

- i. Description: Monitor & manage power consumption with smartphone accessibility
- ii. Website: <http://www.homedepot.com/p/Neurio-Home-Electricity-Monitor-W1-HEM/206639413>
- iii. Manufacturer: Neur.io
- iv. Model Number: W1-HEM
- v. Power Consumption: less than 2W
- vi. Dimensions (in): 8.3 x 6.5 x 1.8
- vii. Weight: 1.4 lb
- viii. Accuracy: $\pm 1\%$
- ix. Max load capacity: EU: 16A/230VAC; UK: 13A/240VAC
AU: 10A/240VAC; US: 15A/120VAC
- x. Wireless: IEEE 802.11n
- xi. Operating Frequency: 2.4 GHz
- xii. Certification: UL/CSA/IEC 61010-1
- xiii. Location: Installed in electrical box
- xiv. Warranty: 1 yr

C. Light Management

1. Acceptable manufacturer and products

- a. Radio Powr Savr Wireless Occupancy Sensor
 - i. Description: The sensor can sense whether a room is occupied or unoccupied
 - ii. Manufacturer: Lutron
 - iii. Battery life: 10 yr
 - iv. Wireless: RF signals between 431 and 437 MHz
 - v. Size: Diameter: 3.57", Depth: 1.13"
 - vi. Voltage/Ampage: 120V/6A
 - vii. Coverage: 900 sqft (major motion)/400 sqft (minor motion)
 - viii. Location: Ceiling mounted in each room
 - ix. Notes: Compliant with RoHS, cULus Listed, FCC approved
- b. Radio Powr Savr Wireless Daylight Sensor
 - i. Description: The sensor detects light in the space and then wirelessly transmits the appropriate commands to the compatible dimming and switching devices
 - ii. Manufacturer: Lutron
 - iii. Battery life: 10 yr
 - iv. Wireless: RF signals between 431 and 437 MHz
 - v. Size: Diameter: 1.6", Depth: 0.7"
 - vi. Operating voltage: 3 V
 - vii. Operating current: 7 μ A
 - viii. Light range: 0-1600 lux
 - ix. Location: Ceiling mounted in each room
 - x. Warranty: 1 yr
 - xi. Notes: Compliant with RoHS, cULus Listed, FCC approved

D. Water sensors

1. Acceptable manufacturer and products
 - a. WIRELESS LEVEL MONITOR
 - i. Website: <http://www.rainharvest.com/aquatel-d110-wireless-tank-level-monitor.asp>
 - ii. Manufacturer: AQUATEL
 - iii. Power Requirement for Display Unit: 6V DC
 - b. WATER FLOW RATE METER
 - i. Website: <https://www.instrumart.com/assets/Dwyer-WMT2-Datasheet.pdf>
 - ii. Manufacturer: Dwyer
 - iii. Power Requirement for Display Unit: N/A
 - iv. Max. Flow Rate: 160 GPM
 - v. Temperature Limit: 104 F
 - vi. Pressure Limit: 232 PSI

2.2 CONTROLLER

A. Raspberry Pi

1. Description: To act as hub for automation
2. Website: <https://www.amazon.com/Raspberry-Pi-RASP-PI-3-Model-Motherboard/dp/B01CD5VC92>
3. Manufacturer: [Raspberry Pi](#)
4. Processor: 1.2GHz 64-bit quad-core ARMv8 CPU, 1 GB RAM
5. Wireless: 802.11n Wireless LAN, 10/100Mbps Lan Speed
6. Auxiliary: 4 USB ports, 40 GPIO pins, Full HDMI port, Combined 3.5mm audio jack and composite video

7. Dimensions: 4.8 x 2.99 x 1.34 inches
 8. Location: Core
 9. Operating Temperature : -55°C to +85°C
- B. Power Supply
1. Description: Cord for Raspberry Pi
 2. Website:
https://www.amazon.com/gp/product/B00MARDJZ4/ref=pd_bxgy_147_2?ie=UTF8&psc=1&refRID=2495Q2WEDFQSN9QQ4Z17
 3. Manufacturer: CanaKit
 4. Output: 5V DC 2.5A Regulated Input 100V to 240V AC
 5. Dimensions (in): 3.75 x 2.75 x 1.25 inches
 6. Cord length: 5 ft
 7. Location: Core, attached to outlet
- C. Case
1. Description: Houses the raspberry pi
 2. Website:
https://www.amazon.com/gp/product/B01F1PSFY6/ref=pd_bxgy_147_img_3?ie=UTF8&psc=1&refRID=JB5PZWD6VF3C5T3CFQ5A
 3. Manufacturer: Raspberry Pi
 4. Dimensions (in): 1.2 x 4.2 x 3 inches
 5. Mass: 0.3 ounces
 6. Location: Core

2.3 USER INTERFACE & ACCESSIBILITY

- B. Touchscreen Display (Tablet)
1. Acceptable manufacturers and Products:
 - a. Eleduino Raspberry Pi Touchscreen Display
 - i. Website: https://www.amazon.com/Eleduino-Raspberry-1280x800-Capacitive-TouchScreen/dp/B01HZCUSHA/ref=sr_1_2?ie=UTF8&qid=1478057133&sr=8-2&keywords=Eleduino+TouchScreen+Display
 - ii. Manufacturer: Eleduino
 - iii. Dimensions (in): 12 x 7.8 x 1.8 inches
 - iv. Weight: 3.1 pounds
 - v. Location: Core
- C. Human and technology interface
- a. Acceptable manufacturers and products:
 - i. Amazon Echo
 - i. Description: Voice control with smartphone accessibility
 - ii. Website: <https://www.amazon.com/Amazon-Echo-Bluetooth-Speaker-with-WiFi-Alexa/dp/B00X4WHP5E>
 - iii. Manufacturer: Amazon
 - iv. Wireless: 802.11a/b/g/n Wi-Fi networks
 - v. Dimensions: 9.3" x 3.3" x 3.3" (235 mm x 84 mm x 84 mm)
 - vi. Warranty: 1 yr
 - vii. Location: Living Space

PART 3 - EXECUTION

- A. Sensors will be installed in appropriate locations (either plugged in or powered by battery)
- B. Raspberry pi will be installed in core with appropriate accessories
- C. Calibration of sensors and smartHouse software will be ran

END SECTION 29

Division 32 – Exterior Improvements

32 – EXTERIOR IMPROVEMENTS & LANDSCAPING**329300 – GREEN WALL**

PART 1 – GENERAL

1.1 SCOPE

Two wall-mounted system for growing plants without soil. Used along south wall of the exterior.

1.2 PERFORMANCE REQUIREMENTS

- A. Use a sustainable non-soil or soil alternative.
- B. Must be partially automatic, leaving room for occupants to interact and care for the system.
- C. Will fit within the dimensions of 4' w X 2' d X 7' h
- D. Will not interfere with patio accessibility.
- E. System must be anchored or stabilized to the wall.
- F. System needs to be able to function outside.

1.3 SUBMITTALS

- A. List of indicators to be aware of to monitor plant health, and system functionality.

PART 2 – PRODUCTS

2.1 WALL PANEL SYSTEM

A. Acceptable manufacturers and products

- 1. Product: VGP Panel (VGP-1636)
 - a. Manufacturer: Tournesol Siteworks
 - b. Dimensions: 16-1/2" x 36-3/8" mounting panel
 - c. Empty Weight: 2 lbs per panel
 - d. Mounting system: minimum recommendation at least six mounting points per panel

2.2 WALL TRAY SYSTEM

A. Acceptable manufacturers and products

- 1. Product: VGP Tray (VGP-01)
 - a. Manufacturer: Tournesol Siteworks
 - b. Dimensions: 7-7/8" x 6" x 7-5/8" planting tray
 - c. Requirements: 8 (Extended-Spacing) to 12 (Close-Spacing) pieces per panel
 - i. Approximate Planting Weight Extended Spacing (1.5 trays per sq. ft.): 12.7 to 20 lbs./sq.ft.
 - ii. Approximate Planting Weight Close Spacing (2 trays per sq. ft.): 19 to 30 lbs./sq.ft.
 - iii. Empty Tray Weight: 1 lbs per tray
 - iv. Tray planting volume: 110 cu. in. or .47 gal

2.3 IRRIGATION

A. Acceptable manufacturers and products

1. Product: ½" irrigation Black Polyethylene Tubing
 - a. Manufacturer: DIG Corp
 - b. Dimensions: 0.600 ID x 0.700 OD
 - c. Pressure: maximum 60 PSI
 - b. Requirements: Connection to the main water system placed at top of wall panels and down the panels. Controlled by a timer. Irrigate to top of wall, allow water to flow down the system wall. Water plants between 4-7am or 6-9pm to minimize evaporation losses
2. Product: 1/4" distribution Black Polyethylene Tubing
 - a. Manufacturer: DIG Corp
 - b. Dimensions: 0.170 ID x 0.250 OD
 - c. Pressure: maximum 60 PSI
 - d. Requirements: Used for distribution from irrigation laterals to trays
3. 1/2 in. Universal Nut Lock Elbow (15-056)
 - a. Manufacturer: DIG Corp
 - b. Requirements: To connect the third irrigation lateral
4. 1/2 in. Universal Nut Lock Tee (15-057)
 - c. Manufacturer: DIG Corp
 - d. Requirements: Used for distribution from main line to irrigation laterals
5. 1/4 in. Drip Line Barb Tee (25-002)
 - a. Manufacturer: DIG Corp
 - b. Requirements: Used for connection of irrigation laterals to the trays
6. FC 0-10 GPH Adjustable 8 Stream Drip Emitter 1/4 in. Barb (06-011)
 - a. Manufacturer: DIG Corp
 - b. Requirements: Used for controlling the flow out of the distribution tubing
7. 1/2 in. Hose End (16-021)
 - a. Manufacturer: DIG Corp
 - b. Requirements: Use for closing off the end of the irrigation line

2.4 ACCESSORIES

A. Acceptable manufacturers and products

1. Product: 3/4 in. FHT Hose Bib Drip Connection Kit (SW9000)
 - a. Manufacturer: DIG Corp
 - b. Components:
 1. Hose End Backflow Preventer D45
 - a. Prevents dirty water from backwashing into your potable water system
 - b. Inlet x Outlet: 3/4 in. FHT x 3/4 in. MHT
 2. "Y" Filter with 155 mesh screen (P16-155)
 - a. Screen can be extracted from filter for easy cleaning
 - b. Interchangeable screen and disc elements with a wide range of filtration degrees
 3. 3/4" x MNPT Swivel Adapter (P09-155)
 - a. 3/4" FHT x MNPT with washer
 4. 30PSI Preset Pressure Regulator (18-030)
 - a. Regulator set to 30 PSI.
 - b. Reliable control regardless of fluctuation in upstream pressure or flow
 5. 3/4" FHT Compression FNPT Swivel (15-024)

- c. Specifications:
1. Maximum Flow Rate
 - a. Single Drip Line: 220 GPH
 - b. Two Drip Lines: 440 GPH
 2. Operating Pressure: 10 to 60 PSI
 2. Product: 3/4 in. Hose End Timer w/ LCD Display (B09D)
 - a. Manufacturer: DIG Corp
 - b. Requirements: allow irrigation to flow at a set rate for a specific amount of time.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Plant tray preparation.

1. Insert bottom mesh, snap into place
2. Slide irrigation baffle into top
3. Slide anti lift arm into both sides
4. Complete tray
5. Plant plants in trays

B. Installed panels onto home and connected to the manifold.

1. Install VGP mounting panel on to exterior wall three panels per wall to create a planted surface on each south facing wall.
2. Minimum of six connections to are required per panel.
3. Begin panel installation at bottom of panel and work from left to right.
4. Adjacent panels may interlock to share a mounting point.
5. Spacers should be used to cinch panels to the mounting surface to secure and prevent bending of panel corners.

C. Irrigation

1. Size the 1/2" irrigation line to the top of the system, connect the two 1/2 in. Universal Nut Lock Tee and the one 1/2 in. Universal Nut Lock Elbow to connect main line to the irrigation laterals.
 - a. The 1/2" nut lock elbow should be on the end of the irrigation line.
2. Cut the irrigation line to the length of tubing required, connect the irrigation laterals to the nut lock connections in three different laterals, one lateral in the middle of each panel.
3. On the top most level and then every other level connect the 1/4 in. Drip Line Barb Tee.
4. Connect the 1/4 inch irrigation line to the barb tee on each end.
5. Repeat steps for the other irrigation laterals.

D. Test flow of system, check everything is functioning correctly.

E. Seal off the ends of the 1/2" irrigation line.

E. Install planters in desired arrangement and place the 1/4" irrigation tubes in the designated planters.

END SECTION 329300

329400 - TRELLIS WALL

PART 1 – GENERAL

1.1 SCOPE

Trellis system will be located next to the main door. Will support plants along the wall.

1.2 PERFORMANCE REQUIREMENTS

- A. Support a vining plant to grow up the wall.
- B. Connected to the timed irrigation system.
- C. Will fit within the dimensions of 4' w X 1' d X 7' h
- D. Will not interfere with door accessibility.
- E. System must be anchored or stabilized to the wall.

1.3 SUBMITTALS

- A. List of indicators to be aware of to monitor plant health, and system functionality.

PART 2 – PRODUCTS

2.1 WIRE ROPE PLANT TRELLIS SYSTEM

- A. Acceptable manufacturers and products
 - 1. Product: Wire Rope Trellis System
 - a. Manufacturer: Jakob
 - b. Model Number: 30790-0000
 - c. Dimensions:
 - i. Depth: 2"
 - ii. Maximum Height: 96"
 - iii. Maximum length: 3'
 - iv. Rope Diameter: 5/32"

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Secure and size the system to the specified dimensions.
- B. Install system with suggested manufacturer procedures.
- C. Set vining plants at the bottom to grow and cover the area.

END SECTION 329400

329500 LANDSCAPE IRRIGATION**PART 1 – GENERAL****1.1 SCOPE**

The landscaping will cover the exterior of the home.

1.2 REQUIREMENTS

- A. The landscaping planting will be watered with timed irrigation system.
- B. The plants will be chosen to suit the environment.
- C. The irrigation system will cover the 300 square feet of expected planting area immediately surrounding the house.

1.3 SUBMITTALS

- A. Instructions on setup and installation for planting plan.
- B. Information on irrigation maintenance.

PART 2 – PRODUCT**2.1 LANDSCAPE IRRIGATION TUBING****A. Acceptable manufacturers and products**

1. Product: ½" irrigation Black Polyethylene Tubing.
 - a. Manufacturer: DIG Corp
 - b. Requirements: Connection to the main water system.
2. Product: 1/4" distribution Black Polyethylene Tubing.
 - a. Manufacturer: DIG Corp
 - b. Requirements: Used for distribution from main irrigation line to plant containers.

2.2 IRRIGATION FITTINGS**A. Acceptable manufacturers and products**

1. 1/2 in. Universal Nut Lock Tee (15-057)
 - a. Manufacturer: DIG Corp
 - b. Requirements: Used for distribution from main line to other sections of landscape.
2. 1/4 in. Drip Line Barb Tee (25-002)
 - a. Manufacturer: DIG Corp
 - b. Requirements: use for distribution of water from main line to ¼" distribution tubing.
3. 1/2 in. Hose End (16-021)
 - c. Manufacturer: DIG Corp
 - d. Requirements: Use for closing off the end of the irrigation line.

2.3 DRIP EMITTERS**A. Acceptable manufacturers and products**

1. FC 0-10 GPH Adjustable 8 Stream Drip Emitter 1/4 in. Barb (06-011)
 - a. Manufacturer: DIG Corp
 - b. Requirements: Used for controlling the flow of irrigation out of the distribution tubing.
2. Flag 1 GPH Drip Emitter 1/4 in. Barb (06-009)
 - a. Manufacturer: DIG Corp

- b. Requirements: Used for controlling the flow of irrigation out of the distribution tubing.
- 3. 12-Outlet Self-Cleaning Drip Emitter (TOP-005)
 - a. Manufacturer: DIG Corp
 - b. Requirements: Used for splitting the flow of irrigation out of the distribution tubing.
 - c.

2.4 ACCESSORIES

A. Acceptable manufacturers and products

- 1. Product: 3/4 in. FHT Hose Bib Drip Connection Kit (SW9000)
 - a. Manufacturer: DIG Corp
 - b. Components:
 - i. Hose End Backflow Preventer D45
 - 1. Prevents dirty water from backwashing into your potable water system
 - 2. Inlet x Outlet: 3/4 in. FHT x 3/4 in. MHT
 - ii. "Y" Filter with 155 mesh screen (P16-155)
 - 1. Screen can be extracted from filter for easy cleaning
 - 2. Interchangeable screen and disc elements with a wide range of filtration degrees
 - iii. 3/4" x MNPT Swivel Adapter (P09-155)
 - 1. 3/4" FHT x MNPT with washer
 - iv. 30PSI Preset Pressure Regulator (18-030)
 - 1. Regulator set to 30 PSI.
 - 2. Reliable control regardless of fluctuation in upstream pressure or flow
 - v. 3/4" FHT Compression FNPT Swivel (15-024)
 - c. Specifications:
 - i. Maximum Flow Rate
 - 1. Single Drip Line: 220 GPH
 - 2. Two Drip Lines: 440 GPH
 - ii. Operating Pressure: 10 to 60 PSI
- 2. Product: 3/4 in. Hose End Timer w/ LCD Display (B09D)
 - a. Manufacturer: DIG Corp
 - b. Requirements: allow irrigation to flow at a set rate for a specific amount of time.
- 3. Product: Rain Bird 1/4 in. Universal Tubing Stake (TS-025)
 - a. Manufacturer: DIG Corp
 - b. Requirements: Use to secure the irrigation emitter line.
 - c. Component: Complementary Emitter for TOP 12-Outlet

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Layout the irrigation line from water connection to reach the plants.
- B. Using a punch tool, make a hole in the 1/2" hose wherever you want to place a 1/4" barbed fitting for connection to distribution tubing.
- C. Cut distribution tubing to size, attach desired tees and length of distribution tubing.
- D. Assemble the Hose Bib Drip Connection Kit and attach the irrigation tubing.
- E. Run the water through the system to flush
- F. After flush seal off the end and attach the emitters.

END SECTION 329500**END SECTION 32**

Draft Cost Estimate

CONSTRUCTION COST SUMMARY					
SYSTEM DESCRIPTION		SUB-TOTAL	TOTAL	\$/SF	%
A10	FOUNDATIONS				
	A1010 Standard Foundations	\$0			
	A1020 Special Foundations	\$3,600			
	A1030 Lowest Floor Construction	\$0	\$3,600	\$ 3.65	1.5%
A20	BASEMENT				
	A2010 Basement Excavation	\$0			
	A2020 Basement Walls	\$0	\$0	\$ -	0.0%
B10	SUPERSTRUCTURE				
	B1010 Upper Floor Construction	\$5,920			
	B1020 Roof Construction	\$8,880	\$14,800	\$ 15.03	6.2%
B20	EXTERIOR CLOSURE				
	B2010 Exterior Walls	\$12,225			
	B2020 Windows	\$6,200			
	B2030 Exterior Doors	\$10,300	\$28,725	\$ 29.16	12.1%
B30	ROOFING				
	B3010 Roof Coverings	\$12,350			
	B3020 Roof Openings	\$9,400	\$21,750	\$ 22.08	9.2%
C10	INTERIOR CONSTRUCTION				
	C1010 Partitions	\$1,975			
	C1020 Interior Doors	\$400			
	C1030 Specialties/Millwork	\$0	\$2,375	\$ 2.41	1.0%
C20	STAIRCASES				
	C2010 Stair Construction	\$0			
	C2020 Stair Finishes	\$0	\$0	\$ -	0.0%
C30	INTERIOR FINISHES				
	C3010 Wall Finishes	\$8,084			
	C3020 Floor Finishes	\$5,110			
	C3030 Ceiling Finishes	\$1,764	\$14,958	\$ 15.19	6.3%
D10	CONVEYING				
	D1010 Elevator	\$0			
	D1020 Escalators and Moving Walkways	\$0			
	D1090 Other Conveying Systems	\$0	\$0	\$ -	0.0%

D20	PLUMBING					
D2010	Plumbing Fixtures	\$1,841				
D2020	Domestic Water Distribution	\$2,450				
D2030	Sanitary Waste	\$2,906				
D2040	Rain Water Drainage	\$588				
D2090	Other Plumbing Systems	\$13,016	\$20,800	\$	21.12	8.8%
D30	MECHANICAL					
D3010	Energy Supply	\$65,367				
D3020	Heat Generating Systems	\$3,098				
D3030	Cooling Generating Systems	\$0				
D3040	Distribution Systems	\$5,100				
D3050	Terminal & Package Units	\$4,211				
D3060	Controls & Instrumentation	\$2,878				
D3070	Systems Testing & Balancing	\$600	\$81,254	\$	82.49	34.3%
D40	FIRE PROTECTION					
D4010	Fire Protection	\$1,860				
D4020	Standpipes	\$0				
D4030	Fire Protection Specialties	\$325	\$2,185	\$	2.22	0.9%
D50	ELECTRICAL					
D5010	Electrical Service & Distribution	\$1,402				
D5020	Lighting & Branch Wiring	\$6,251				
D5030	Communications & Security Systems	\$150				
D5090	Other Electrical Systems	\$3,500	\$11,302	\$	11.47	4.8%
E10	EQUIPMENT					
E1010	Commercial Equipment	\$0				
E1020	Institutional Equipment	\$0				
E1030	Vehicular Equipment	\$625				
E1090	Other Equipment	\$8,744	\$9,369	\$	9.51	4.0%
E20	FURNISHINGS					
E2010	Fixed Furnishings	\$2,500				
E2020	Movable Furnishings	\$2,400	\$4,900	\$	4.97	2.1%
F10	SPECIAL CONSTRUCTION					
F1010	Special Structures	\$9,052				
F1020	Integrated Construction	\$0				
F1030	Special Construction Systems	\$0				

F1040	Special Facilities	\$0	\$9,052	\$	9.19	3.8%	
F20	SELECTIVE BUILDING DEMOLITION						
F2010	Building Elements Demolition	\$0					
F2020	Hazardous Components Abatement	\$0	\$0	\$	-	0.0%	
G10	SITE PREPARATION						
G1010	Site Clearing	\$0					
G1020	Site Demolition and Relocations	\$0					
G1030	Site Earthwork	\$0					
G1040	Hazardous Waste Remediation	\$0	\$0	\$	-	0.0%	
G20	SITE IMPROVEMENT						
G2010	Roadways	\$0					
G2020	Parking Lots	\$0					
G2030	Pedestrian Paving	\$0					
G2040	Site Development	\$0					
G2050	Landscaping	\$12,115	\$12,115	\$	12.30	5.1%	
G30	SITE MECHANICAL UTILITIES						
G3010	Water Supply	\$0					
G3020	Sanitary Sewer	\$0					
G3030	Storm Sewer	\$0	\$0	\$	-	0.0%	
G40	SITE ELECTRICAL UTILITIES						
G4010	Electrical Distribution	\$0					
G4020	Site Lighting	\$0					
G4030	Site Communications and Security	\$0					
G4090	Other Electrical Utilities	\$0	\$0	\$	-	0.0%	
TOTAL DIRECT COST (Trade Costs)			\$237,186	\$	240.80	100.0%	
MARKUPS							
	General Conditions, Overhead &	0.00%	\$0	\$0	\$	-	0.0%
SUBTOTAL CONSTRUCTION			\$237,186	\$	240.80	100.0%	
CONTINGENCIES/ESCALATION							
	Design and Pricing Contingency		\$0				
	Trucking 2 trucks		\$4,000				
	Crane tim 5 days		\$8,125				
TOTAL PROJECT COST			\$237,186	\$	256.41	100.0%	

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\$ 237,186	\$ 237,186
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Summary of Changes

Significant changes to the project manual that have occurred between submissions have been outlined below. The Construction Drawings should also be reviewed for relevant revisions.

February 23, 2017 Revision

The Project Manual has been updated from the previous issue. Revisions include:

- Revision 1: original exterior SIPS have been replaced with an ICC certified panel, requiring significant revision structural, vapor barrier, and assembly procedure
- Revision 2: Courtyard Skylights, complete revision of original custom skylight system to off-the-shelf Velux skylights in a custom structural frame.
- Revision 3: Significant Landscape development and revisions
- Revision 4: design plan layout and house configuration revisions
- Revision 5: Attic uses and design layout
- Revision 6: Mechanical Room and component layout, access, and design
- Revision 7: Flooring has shifted from SIP panels to more wood conventional framing.