TEAM LAS VEGAS

SOLAR DECATHLON 2013

SCHEMATIC SUMMARY
APRIL 19, 2012

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

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1 TEAM MISSION STATEMENT

Team Las Vegas will design and build a self-sufficient, net-zero leisure home that responds to the unique environment of the Mojave Desert and adapts to the changing needs of a modern family. By capturing the ever abundant sunlight and conserving rare and precious water, the Autonomy House will allow its occupants to live independently and age comfortably in a home that touches the ground lightly but lives large.

Figure1.A - The Autonomy House

2 CONTEST STRATEGIES

(Total 948 out of 1000 points)

2.1 Architecture (95 out of 100 points)

Based on the concept of an Autonomy House, Team Las Vegas will design its prototype house to achieve the following goals:

• Delineate public and private spaces using shading screens and the water feature, creating a sense of place for the family. Celebrate indoor-outdoor relationship by opening up the rooms with a series of pocketed sliding doors.

• Designed interior spaces to have bilateral daylighting with windows that have good solar orientation and are properly shaded. Electric lighting will be supplemental to daylight and is to be used to create ambience for various occasions.

• Use exterior shading screens to mitigate heat gain from the desert sun, and create light and shadow play when sunlight or nighttime architectural lighting interacts with the screens.

• Integrate technology and controls into the architectural and interior design to act as supporting systems for the architectural experience.

• Design water feature (constructed wetland) for evaporative cooling, rain collection and gray water filtration.

2.2 Market Appeal (90 out of 100 points)

Our aspiration is to create a new housing prototype that will be attractive to residents of Las Vegas and the Southwest. While the design targets the vacation home market, our offer of an off-the-grid, small family house can also be appropriate for the senior and retiree market, young couples, or empty-nest families anywhere in the country. These are emergent markets that are currently transforming the social and economic landscape of the real estate housing market. Demographic trends in the Southwest, and Southern Nevada in particular, illustrate the need for housing that meets the needs of a rapidly aging population; the existing housing stock in our region is incapable of meeting this need. According to data from the 2010 U.S. Census, the percentage of seniors in Nevada is 11.2%, vs. 12.6% nationally. The U.S Census Bureau states that senior citizens will be the fastest-growing segment of Nevada's population over the next ten years.

Our design will offer these smaller family units an opportunity to live sustainably in the environment. The house is designed to be easily transported and assembled on various sites, from the wilderness and mountain ranges of Nevada to the bustling city block in Las Vegas. Our design aims to provide the feeling of a custom home without the high cost by offering our expertise in digital fabrication technologies. This is a practical approach to manufacturing and mass production of our housing prototype. We aim to fully integrate systems and technologies so that they will not be present in the resident's sensory foreground, but act as hidden supporting systems for the architectural experience. This is an essential strategy, particularly for seniors who may be uncomfortable with 'high tech' interfaces. In order to be inclusive, it is critical that our design is easy to understand and use, as it will encourage its users to maximize the house's efficiency.

2.3 Engineering (95 out of 100 points)

The engineering team will integrate commercially available components into efficient, reliable, durable, and sustainable systems to make the home energy efficient and comfortable as well as easy to use and maintain.

Detailed drawings, construction specifications, energy analysis results and discussion, and design narratives will be provided for jury review. All design motives, inspiration, alternatives and options will be documented and discussed. Detailed calculations and specifications for structural, plumbing, electrical, mechanical, and solar mechanical systems will be provided in a complete, clear and professional package. Building energy simulations will be conducted throughout the design and construction phases to compare our systems to conventional systems to calculate the energy the systems will save over the course of an entire year.

Indoor environmental systems will maintain indoor air quality, temperature and humidity through the use of high-efficiency energy recovery ventilators, exhaust systems, high efficiency mini-split heat pumps, and radiant floor heating. Complementary systems will provide efficiency through staging and integrated control schemes.

Sustainability will be achieved by designing and building solar thermal and photovoltaic systems to provide a net zero energy use for the home when located in the desert environment of Las Vegas.

2.4 Communications (90 out of 100 points)

The communications strategy of Team Las Vegas integrates all the project's technical aspects and processes, public outreach activities, public education and exhibits, and advocacy efforts. Our strategy aims to successfully educate our audiences by delivering clear and consistent textual, verbal and graphic messages that represent our vision, experiences and results. To deliver these messages effectively, our communications strategy will include general public and media relations, website communication, and public exhibits and events. We will extensively use news and social media campaigns and website promotion. For social media, we will launch our Facebook and Twitter accounts to reach out to our diverse audiences. For news media, we will use local newspapers and magazines to feature newsworthy developments related to the project and the team. Moreover, we will use our team website to communicate with our audience. Our website will contain explanations and illustrations of the project's technical aspects; our goal and mission statement; team and contact information; and drawings, photos and videos related to the project.

2.5 Affordability (90 out of 100 points)

Our team will work tirelessly to create an exquisitely crafted home that includes all the conveniences of conventional homes while keeping the target construction cost between $250,000 and $325,000. Team Las Vegas will use the appropriate increment of complexity and cost when addressing design issues and it is anticipated that the majority of systems will employ readily available components, typical construction methods, and rational assumptions for power production.

Ensuring high efficiency operation, selecting reliable products and sizing the right capacity of the systems are the goals of the engineering team. Although plenty of exotic technology and products are currently on the market, fixtures, equipment and systems will be carefully selected for a balance between performance and cost. Life-cycle analysis of the products will also be taken into consideration. The team will carefully design systems to meet the demand, and use research and analysis to achieve the optimization of efficiency and performance using engineering techniques to create relatively low-cost but efficient systems. Several design alternatives will be considered simultaneously to ensure maintaining functionality benefits and cost savings on construction.

2.6 Comfort Zone (90 out of 100 points)

2.6.1 Temperature: The Autonomy House will maintain occupant thermal comfort through a combination of passive architectural design strategies and active engineering systems. The high-efficiency and hybrid HVAC system will be enhanced by a tight, thermally efficient building envelope. The roof assembly will make use of a high R-value insulation, cool roofing, and an integrated shading assembly. Exterior decks and ramps adjacent to the house incorporate fixed and operable screens and horizontal projections to shade the south exposure, while other openings use fixed, exterior-mounted shade louvers.

6.2 Humidity: Exhaust systems will remove humidity as it is generated in the kitchen, bath and laundry areas. The high-efficiency energy recovery ventilators will bring in tempered fresh outdoor air and remove excess moisture in the air, maintaining the interior relative humidity below 60%.

2.7 Hot Water (100 out of 100 points)

The hot water supply system will use a combined solar thermal water heater with supplemental on-demand heater. Hot water will first be drawn from the solar thermal storage and if the water is not hot enough it will then be heated by the supplemental heater. An average temperature of at least 110F will be delivered when water draws occur.

2.8 Appliances (95 out of 100 points)

Accessibility and aging in place considerations are essential components of the Autonomy House, and they will influence the selection of all appliances.

2.8.1 & 2 Refrigerator/Freezer: The refrigerator and freezer will be a combined unit that is sleek-yet-spacious. It will be chosen for its energy efficiency, ability to maintain stable temperature and market value. The product will be reasonable priced, ENERGY STAR qualified and use advanced refrigeration technology to generate ideal temperature and humidity levels separately in the refrigerator and freezer while cool air is circulated.

2.8.3 & 4 Clothes Washer/Dryer: A modern, high efficiency front load all-in-one, water-conserving clothes washer and dryer will be chosen to meet the laundry task. A unit with smart sensor system that automatically sets the water level and measures moisture levels during the drying cycle is to be chosen. The compact style requires less space.

2.8.5 Dishwasher: A conventional and reliable ENERGY STAR certified unit is to be chosen. The on-demand heater will assure that the water temperature in the dishwasher reaches 120 F during wash cycle.

2.9 Home Entertainment (98 out of 100 points)

2.9.1 Lighting: Lighting will be chosen for its energy efficiency, light output, color rendering, heat output, size, and aesthetic merit. Accessibility and aging in place considerations are essential components of the Autonomy House, and they will influence the selection of lighter appliances. Lighting requirements change with age, and lighting systems that allow for easy modulation of color rendering and light intensity will be used. The home automation control system will allow us to create customizable, easy-to-use lighting scenes, which can be selected with the touch of a button.

2.9.2 Cooking: Cooking appliances shall be chosen based on their ability to meet the requirements of the contest task, energy efficiency, size, and aesthetic merit. Accessibility and aging in place considerations are essential components of the Autonomy House, and they will influence the selection of cooking appliances. We are considering using an induction cooktop, which heats only the food; this has the potential to offer a safe, efficient alternative to resistance-type heating elements.

2.9.3 Dinner Party: As Las Vegas is considered the 'entertainment capital of the world,' the Autonomy House is designed around entertaining guests. The dinner party will be planned to balance the areas of high quality entertainment and ambiance with areas allowing for simple preparation. Due to our mild climate during much of the year, Las Vegas is ideally suited to outdoor entertaining; the Autonomy House's flow of exterior to interior space, multifunction interior furniture, and lighting quality will feature prominently in this contest.

2.9.4 Home Electronics: The TV and home computer will be integrated into the interior of the home. These systems will be chosen based on their energy efficiency, screen quality, performance, and compatibility with furniture elements. In addition, accessibility and ease of use will be primary considerations in the selection process.

2.9.5 Movie Night: The movie night contest is an additional opportunity to highlight the flexible entertainment capabilities the Autonomy House offers. Lighting, home theater, furniture and space configuration will all be designed to allow flexibility and heighten experience.

2.10 Energy Balance (100 out of 100 points)

The net energy balance will be achieved by using high-efficiency appliances, lighting and equipment that consumes minimal electricity. In addition, alternative renewable energy sources such as solar thermal for heating hot water and a photovoltaic system for energy generation will be used. Electrical systems will be monitored by the home automation system, which gives energy use feedback to the occupants so that they can modulate energy uses. Systems will be carefully sized to provide more energy than needed for the operation of the home.

3 DESIGN NARRATIVES

3.1 Architectural Design Narrative

Intense sun, relentless wind, and vast vacant valleys surrounded by rugged mountains are typical of the Mojave Desert. Living in a harsh environment of extremes where natural resources are scarce makes Team Las Vegas particularly aware of the need for sustainable design practices. By learning from Desert inhabitants like the Paiute Native American community, we can be part of the natural and dynamic cycle of the desert, be reciprocal with what the environment provides, and most importantly, leave minimal impact. The Team Las Vegas Autonomy House is formed around three major considerations: engineering, energy balance and technological innovations; conservation, ecology and resources; and architecture, phenomenology and culture.

Using these considerations as guidelines, our goal is to create a net-zero home that can be self-reliant in any climate, including the harsh desert. This home will serve as a verdant refuge in our arid environment. By harnessing the sun's energy, harvesting rain and grey-water for the household and groundwater recharge and incorporating passive strategies and efficient active systems, we will minimize the energy load and achieve energy balance. The Autonomy House will be self-sufficient and highly efficient. It will respond to the unique conditions of the Mojave Desert environment and adapt to the changing needs of a modern family while creating memorable experiences through unique architectural design solutions. Our unique and fragile desert challenges designers to first respond to its environmental conditions. We are constantly reminded of the climatic challenges and draw on practical experience for our design solutions.

The house will be oriented for optimum energy performance. Screen walls, exterior shading and carefully scaled glazing will minimize undesirable heat gains and losses. Daylighting will be primarily from south and north so it can be more easily controlled. High clerestory windows will ensure evenly distributed light throughout the day and the operable windows and doors will provide cross ventilation. Evaporative cooling from wetland features will further ensure climactic comfort and humidity balance.

A sense of place that inspires memorable experiences distinguishes a home from a simple shelter. Careful detailing and attention to craftsmanship will ensure a green home that is a beautiful piece of architecture. Careful consideration of sensory experiences – sound, texture, smell, as well as visual perception will ensure a rich environment for residents. These phenomenological considerations will ensure an inspiring refuge.

Water is a rare and precious resource in the desert; the Autonomy House will respect this by featuring water conservation strategies. The home will be an oasis that thrives on captured and reclaimed water. In addition, water will provide microclimate and perceptual cooling through judicious use as an integral component of efficient native landscaping. To mitigate a heat island effect, we will use the design and orientation of the screens to create shade, and constructed wetlands along with other landscaping elements will also contribute to the evapotranspiration cooling effect.

Living in the entertainment capital of the world, a place famous for a luxurious lifestyle, Team Las Vegas will embrace a reformed culture of sustainability and renewable resources. This progressive vision responds to the unique social, economic, and environmental qualities of southern Nevada. A smaller, smarter model for living in Sin City might speak softly but most sincerely. We strive to create a design that responds to our modern standards of living and comfort while utilizing sustainable and innovative approaches to achieve these goals.

3.2 Engineering Design Narrative

Team Las Vegas' engineering goal is to combine functional durability of the engineering aspects with the architectural team's aesthetics to create systems that are not only high efficiency, high durability, and high performance, but also integrate into the architecture beautifully.

The team will design systems that harness the energy of the sun with both thermal heat transfer and photovoltaic technology to produce the thermal energy and electricity needed for the house. Plumbing, electrical and mechanical systems will be designed to offer the occupants maximum comfort and ease of use. The systems are to be efficient, reliable and sustainable, demonstrating emerging green products and control options.

Building energy simulation will be implemented throughout the design and construction phases to measure and control building performance and to ensure achieving optimization of energy efficiency. Custom programs combined with Ecotect Analysis will be used to evaluate building orientation and elevation design parameters. Monthly and yearly solar resource and exposure, monthly and yearly thermal load calculation, hourly thermal comfort analysis, indoor acoustic responses, material cost and resource consumption will all be simulated for different design alternatives.

Solar power generation by both solar thermal and photovoltaic systems will be calculated and modeled by original computational code developed by mechanical engineering team members. Measurement of performance of the actual systems will be monitored to verify performance.

4 COMPONENT DESCRIPTIONS

4.1 Temporary Foundations and Anchors

Foundations:

Our proposed temporary foundation system uses steel scissor-type leveling jacks (Figure 4.1.A), which allow for precise fine-tuning to account for possible uneven ground surfaces at the Orange County Great Park, as well as accommodating differential movement of the house during shipment and assembly at the competition. The leveling jacks will be bolted to our steel primary structure.

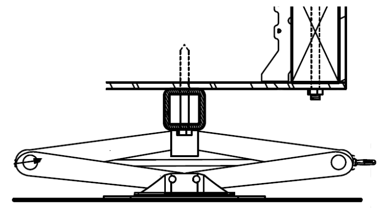


Figure 4.1.A - Leveling jack detail

Structural Systems:

The primary structural engineering challenge was to optimize the performance while providing enough stability for transportation and seismic considerations. The structural system needs to be designed to avoid thermal bridging. In order to achieve this goal, Team Las Vegas decided to design a hybrid wood and steel structural system (Figure 4.1.B). The steel members form a box frame with moment connections and lateral bracing to reduce movement during assembly and transportation. This also allows us to use more slender members for comparatively long spans and create a thin envelope construction. Wood studs will be used to frame the walls in order to receive insulation without creating thermal bridging. Wood framing also allows students to construct a substantial amount of the work, which serves UNLV's pedagogical goal of hands-on learning.

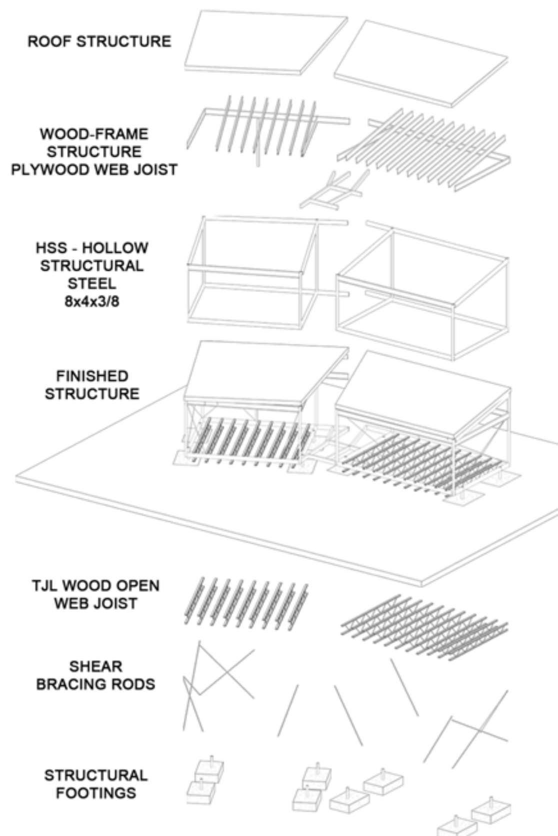


Figure 4.1.B - Exploded axonometric structure diagram

4.2 Exterior Building Structures

Cladding:

Our harsh desert environment challenges designers to think differently about building materials, as the desert affects them in unique ways. A critical component of our design approach is to recognize the passage of time, and to allow the natural environment to be a positive contributor to the design process. A key design strategy in our hot dry climate is our use of a ventilated reclaimed wood 'rainscreen,' as this shades the building's structure from the sun's heat. Nevada's earliest settle-

Figure 4.2.A - Conceptual screen design

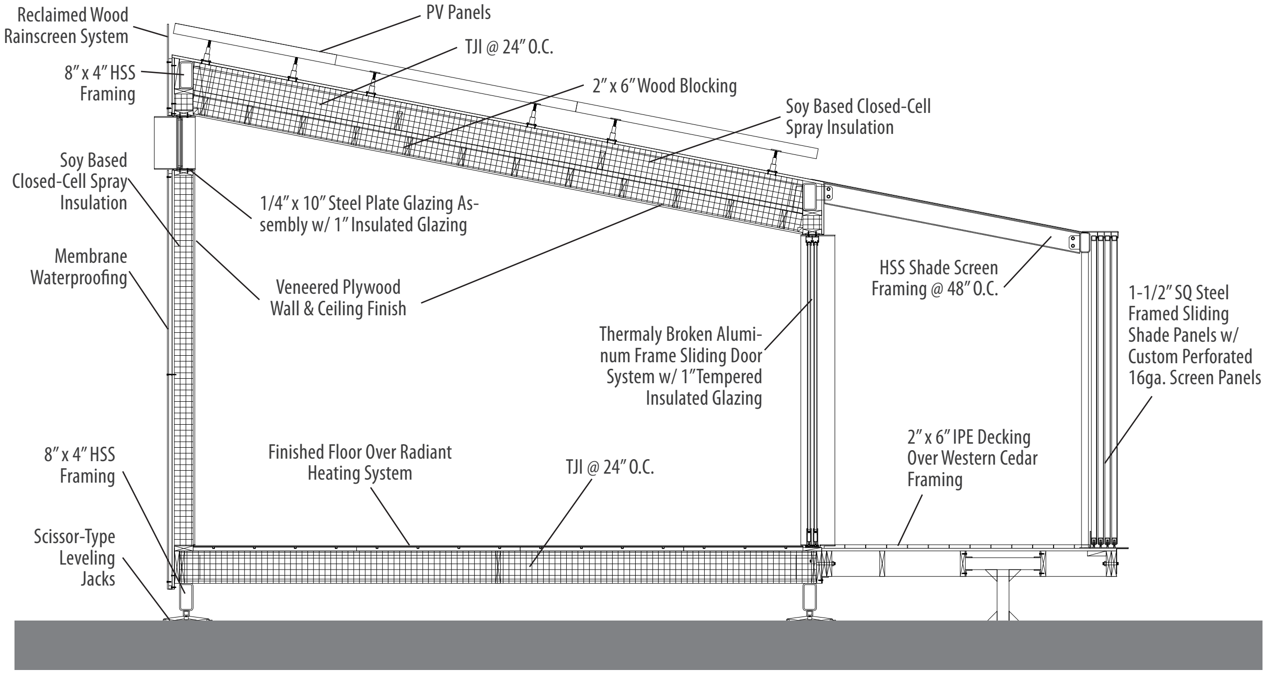


Figure 4.2.B - Building section through bedroom and deck

ments and mining structure were all built out of wood, and the many ghost towns that dot the Mojave desert are a critical part of our cultural landscape; in addition, it is a durable, highly renewable resource. Our secondary materials, such as steel deck edge trim, guardrails, and other components are intended to remain in their unfinished, 'raw' state, allowing nature to play a role in completing the house.

Shade Screen System:

The Autonomy House is encased in both fixed and operable screen systems (Figure 4.2.A). With the use of plasma and water jet cutting systems, small holes will be cut into the steel screen panels, creating the image of a mesquite tree, a species that is native to the Mojave Desert. These screens are a critical component of Team Las Vegas' response to the powerful sunshine that defines our environment. The movable screens respond to seasonal differences: in the summer, they can enclose the patio space and provide shading for the building. In the winter, the screens can be opened to allow the sun to penetrate the building, providing passive heating. The perforated screen system also extends overhead, dramatically reducing the intensity of the summer sun, while allowing heat to escape at night. The screens will provide protection to the house from the harsh desert sun as well as create comfortable, shaded spaces for residents (Figure 4.2.B).

Landscape & Decking:

The Autonomy House's landscape demonstrates how edible plants and native vegetation can readily be grown in the desert, using the available greywater from the house. Beginning with the zones farthest from the house and moving inward, the vegetation transitions from native desert plants to native river vegetation and edible plantings. A progressive filtration system purifies greywater on site for reuse as irrigation. Moreover, a small wetland will act as a biological greywater filter, and will create a microclimate that will maximize the efficiency of the HVAC system. The outdoor deck will utilize FSC-Certified Ipe hardwood because of its natural mildew and mold resistance, long lifespan, and low maintenance.

Team Las Vegas is investigating the use of a green wall for edible plantings. Green wall systems maximize the existing outdoor space, as well as potentially reducing sound transmission and stormwater run-off and enhancing air quality. The use of linear and point-source LED lighting systems are under consideration for the house's exterior. Focus will be on lighting for security and wayfinding, but also on enhancing the beauty of the house at night; the lightling will create a psychological and visual connection with the prominent lighting qualities that characterize the city of Las Vegas.

4.3 Ramps, Railings, and Guards

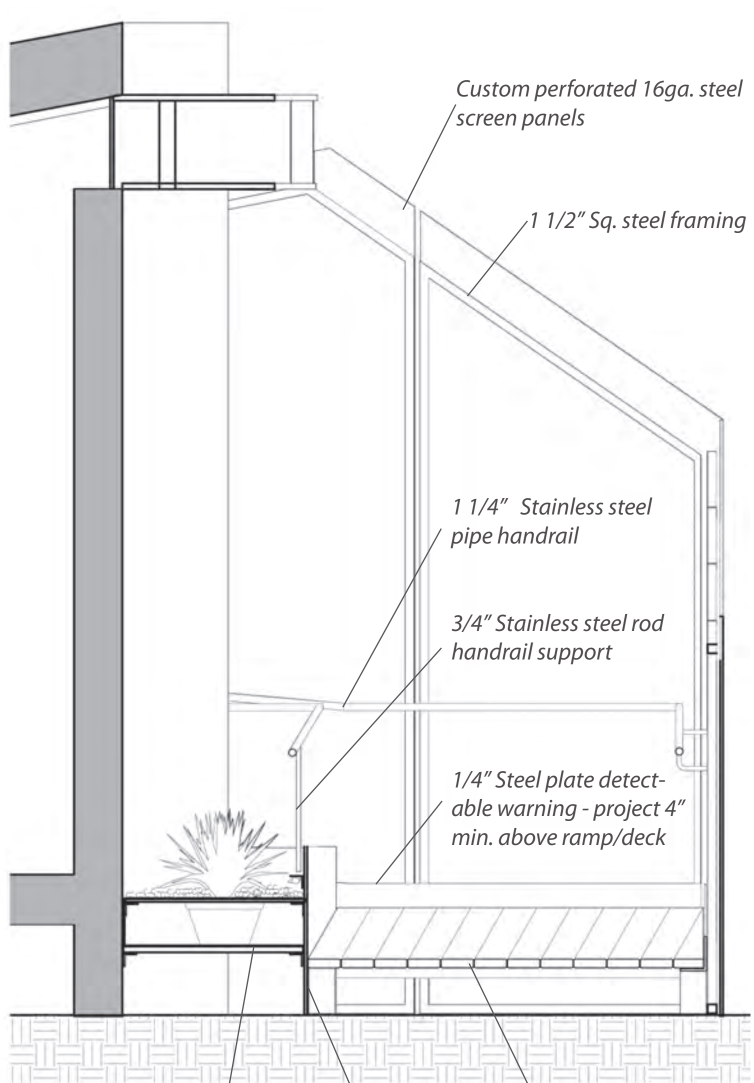


Figure 4.3.A - Guardrail integrated with shading screens

A critical component of Team Las Vegas' approach to the Autonomy House was that it be designed to allow its residents to age in place. One of the most traumatic events in a person's life is being forced to give up one's independence, due to limited mobility or other health problems. Accessibility is a central tenet of the Autonomy House, which is why our ADA-compliant ramps have been fully integrated into the experience of visiting the home. Entry to the house passes between the building and the shade screens, which serve as ramp guardrails and support for the ramp's outer handrail; the inner handrail will be a 1-1/4" O.D. stainless steel railing attached to the ramp's support structure (Figure 4.3.A). The ramp surfaces will match the Ipe decking, with steel transition plates where required.

4.4 Glazing type and location

Daylighting will be used primarily on south and north enclosures as it is most easily controlled in those locations. The east and west façade will have as little glazing as possible, to prevent excessive solar gain. Clerestory windows will be placed high to provide optimal daylight factors for all corners of the house, minimizing the use of electric lights and reducing energy loads. Operable windows will be used to help create cross ventilation. We intend to use low-e coated insulated glass units with thermally-broken clear-anodized aluminum frames, and our target U-value is .30. Fixed glazing will use the same glass units, with ¼"x 10" steel plate mullions; this allows operable window units to be inserted into the fixed glazing system.

4.5 Interior Finishes

The interior finishes of the Autonomy House respond to our desert context by utilizing different floor finishes to reference the constantly changing desert floor. Natural rock is represented by a locally-produced seamless flooring system, consisting of Portland cement and a polymer base material. This system is water and chemical resistant with low VOC coloring and sealants, making it ideal for the bathroom, kitchen, and entry space. Carpet tiles made of 100% recycled material will be installed in the bedroom space without the use of adhesives; a proprietary 'lock-dot' system eliminates VOC-producing chemicals, while also enabling residents to easily change their bedroom flooring when needed. The carpet tiles also reference the lush textures that can be found in our desert landscape, particularly in the spring. The use of mesquite end-grain wood block flooring in the living room along with stone accents originating from our surrounding mountains represents the Mohave Desert's mesquite trees in their thriving state. We intend to use veneered plywood as our wall finish, to provide a warm, inviting quality that refers back to the exterior wood finish. By bringing the exterior shade screens into the entry and adjacent corridor, this house will give visitors a sense of compression and release as they move through the space, creating both an intimate scale and expansion analogous to the desert sky as the ceiling spaces expand upward beyond the entry.

Figure 4.5.A - The guest bed is integrated within the casework, maximizing function with a minimal footprint. Image source: www.resourcefurniture.com

The Autonomy House casework is intended to minimize the need for stand-alone furnishings. Casework is to be constructed from Baltic birch, etched glass, and reclaimed wood. The casework will contain a fold out table, seating, and a guest bed, maximizing the space's flexibility, allowing its residents to live efficiently in a modest-sized space. Countertops and the bathroom vanity/sink will be cast VOC-free epoxy and recycled glass. Autonomy House will contain re-claimed materials from our region wherever possible to further enhance our desert home and maintain the goal of sustainability.

4.6 Fire Protection

Fire protection and safety are priorities in the design of the home. This includes ease of egress from each of the main rooms of the house, networked smoke detectors, fire extinguishers located in appropriate areas, and a domestic fire suppression sprinkler system.

Networked smoke detectors will be installed in the kitchen/living area, laundry/hall area, and utility closet. Suitable fire extinguishers will be installed in the kitchen, laundry closet and utility closet.

The fire protection sprinkler system is being designed to protect the home during the competition and the final installation of the home. The system will be designed per the pertinent National Fire

Protection Association (NFPA) standards: NFPA13D, and NFPA 13R.

During the competition, the fire protection sprinkler system will be supplied water from the potable water tank through the pressure pump. The system that is being considered combines the domestic potable cold-water system with the residential fire sprinkler system. As a result, one redundant piping system is eliminated, reducing material and labor costs, as well as reducing construction and coordination time on site. Traditionally, when two separate piping systems are used for the fire suppression system and the domestic cold-water, a check valve or pair of check valves or reduced pressure backflow prevention valves are used to isolate the systems on drop of supply water pressure. This is done to prevent the stagnant water in the fire suppression system from back flowing into the domestic water supply. By integrating the two systems, per NFPA 13D, we ensure that there is no stagnant water in the fire suppression system and the system does not require the backflow prevention devices or their maintenance.

To protect both the home occupants and potable water supply, all system components must be listed and/or approved by the proper authority, such as Underwriters Laboratories (UL), for fire protection service; and NSF Intl. (formerly the National Sanitation Foundation), for products that interact with the potable water system. For NFPA 13D designs, valves, hangers, tanks, pumps and many other system components are not required to carry a special fire protection service listing but will be checked for their suitability in the installation.

4.7 DC Electrical

The direct current (DC) electrical system is limited to the wiring associated with the photovoltaic system. This system has not been designed yet because the final designs for the electrical loads for equipment such as HVAC and appliances have not been made. The DC system will be designed and installed per the 2011 NEC and the recommended guidelines in the publications: *Photovoltaic Systems,* by John C. Wiles, and the *2005 National Electrical Code: Suggested Practices.*

The decision to use a single inverter, two inverters or individual micro-inverters has not been made yet. In the cases of the single inverter or two inverters, the panels will be wired in series and connected to a roof mounted disconnect. From the disconnect, the DC wiring will be run through a metallic conduit to a DC disconnect at the inverter or inverters. Maximum string voltages will be designed not to exceed 600 volts and the wire sizes will be determined to carry the calculated amperages.

If the decision to use micro-inverters is made, they will be installed directly beneath the photovoltaic panels and the DC wiring will be limited to the module leads connecting the modules to the micro-inverters. In either case, the DC wiring located behind the modules will be secured per the appropriate sections of the code.

4.8 AC Electrical

The AC electrical system will be 120/ 240 VAC, 60Hz. There will be a meter hub with smart meter and service panel located on the west side of the building adjacent to the utility room on the same side of the home as the utility corridor. Currents, wire and circuit breaker sizes are to be determined. One-line drawings of the electrical system will be provided.

Watt hour metering will be installed adjacent to the service panel with current transformers that will be installed in the service panel to monitor energy consumption of major appliances and mechanical equipment and measure energy generation of the photovoltaic system. The watt hour metering will be listed and approved for the installation and will have over current protection.

4.9 Water Storage/Service

There will be three tanks located underneath the deck; one potable water supply tank, one waste receptor, and one grey water storage tank. The potable water tank will contain water obtained on site, and a pressure controlled domestic water booster pump will be installed after the tank to pressurize the water for servicing domestic water systems. The waste receptor tank will receive waste and drainage from all the fixtures. The grey water storage tank will collect rainwater from the roof gutter system, overflow from the outdoor water feature, and air-conditioner condensate. Grey water will be used to supply landscaping irrigation. The sizes for each tank are to be determined.

4.10 Plumbing

PEX piping system is to be used for the domestic hot and cold water supply due to its flexibility and durability. Since PEX piping comes in long coils, it will eliminate many of the fittings and connections required in a traditional plumbing system and create a more efficient installation and lower cost. A manifold header with shut-off valves connected with supply piping to the kitchen, bath and laundry areas will be provided in the mechanical room.

Hot water will be generated by a solar thermal system, with a back-up on-demand instantaneous tank-less water heater at the fixtures. This design not only creates space-saving advantages, but also optimizes energy use. The on-demand water heater will only turn on to heat the water during water draws when the thermal storage tank temperature is below the set point. All hot water piping shall be insulated to save heat loss.

For the water closet, a 0.8 gallon per flush ultra-high-efficiency toilet using siphonic flushing action that pressurizes the bowl's trapway with air transfer system is being considered. In accordance with SD rules, the toilet will only be installed to showcase the type and will not be used or connected for the competition.

The shower head is to be specified with flow at 1.2gpm. A pressure-balancing, thermostatic mixing valve will be specified for the shower assembly, which provides the shower experience while still conserving water.

CPVC pipe with recycled content will be used for waste and piping. STUDOR air admittance valves (AAVs) are being considered for use in lieu of open pipe vent systems that penetrate roofs of the building. The purpose of vents is to allow air to enter the plumbing drainage waste and vent system and equalize pressure when water drains out of the system, maintaining the integrity of the water trap that prevents sewer gases from entering the building through fixture drains. When a plumbing fixture is operated, negative pressure causes the AAV to open, allowing air to enter and equalize the pressure in system. When the flow stops, gravity closes the valve preventing sewer gas from escaping through the valve into the building.

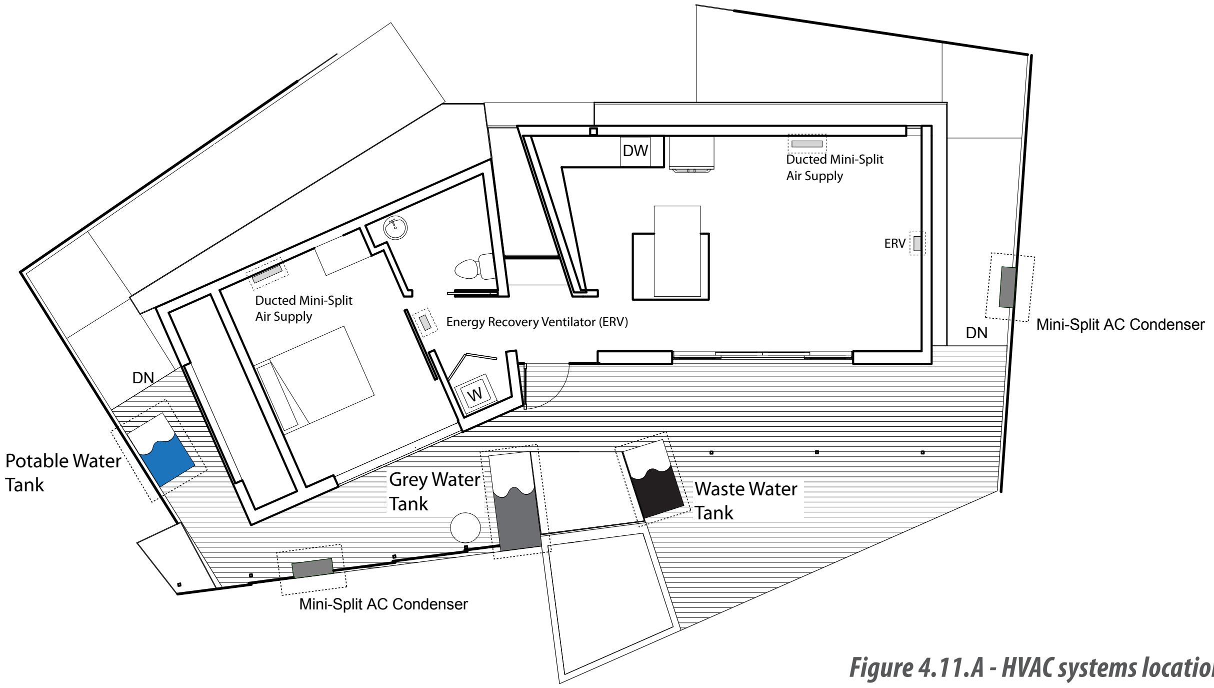


Figure 4.11.A - HVAC systems locations

4.11 Mechanical

<u>Mini-splits Heat Pump:</u>

For heating and cooling two mini-split high efficient heat pumps will be used. Equipment sizes are currently being determined by load calculations and modeling. The units will be used for direct expansion humidity control in the cooling mode (Figure 4.11.A). The units will cover two main zones; the living area which includes the kitchen, and the bedroom area which includes the bathroom and laundry closet. The use of two separate units allows system redundancy in the event of equipment failure. If one unit fails, the home will have the second unit to heat or cool the other zone for comfort until the equipment can be repaired. Having two separate zones will also allow temperature setback of the bedroom area when not being used during the day and the living area during the late night for energy savings.

The living room indoor unit will be a ducted air handler located in a custom millwork cabinet located in the center of the north wall. This location will allow centralized distribution of the conditioned air and allow the return air to be drawn from the living area away from the kitchen. Air directed towards the south wall will help with cooling loads on the south facing windows and walls. The cabinet enclosure will be lined with acoustical insulation to reduce equipment noise in the living space. The cabinet will be built to allow service and maintenance clearances for the unit.

There are two options for the location of the bedroom indoor unit. The first location is in a millwork cabinet, similar to the living area cabinet, which will be located along the north wall. A second possible location will be in the ceiling above the bathroom/ laundry area. Decisions on ceiling heights have not been determined yet for installation in this location. This location will allow ducting to be routed easily into the bathroom and laundry areas. Service for this unit would be through a return air filter grill located beneath the unit in the hallway.

Both units will be controlled by thermostats located in each zone. The outdoor units will be located on ground mounted equipment pads outside the public access walkways and decks. These will be protected by well ventilated protective barriers.

Radiant Flooring:

The home will have a radiant floor heating system that will utilize heat from the solar thermal system. The system will be designed to use this first when there is sufficient heat in the solar thermal storage tank. During periods of cloudy weather or very cold nights, the control system will allow the mini-split units to operate in heating mode. Again, having the heat pumps gives redundancy in the system in the event of a problem with the solar thermal system or a long period of cloudy days.

Energy Recovery Ventilator:

Two energy recovery ventilators will be used in the home. One will be located in the living area outside of the kitchen area, and the second in the area of the laundry/passage area. These units will be used to temper outdoor makeup air and reduce heating and cooling loads associated with makeup air. Both units will be low-sone models and will be installed to run as quietly as possible. They will be tied to the home automation system for control, to provide required air changes for the home.

Exhaust Fans:

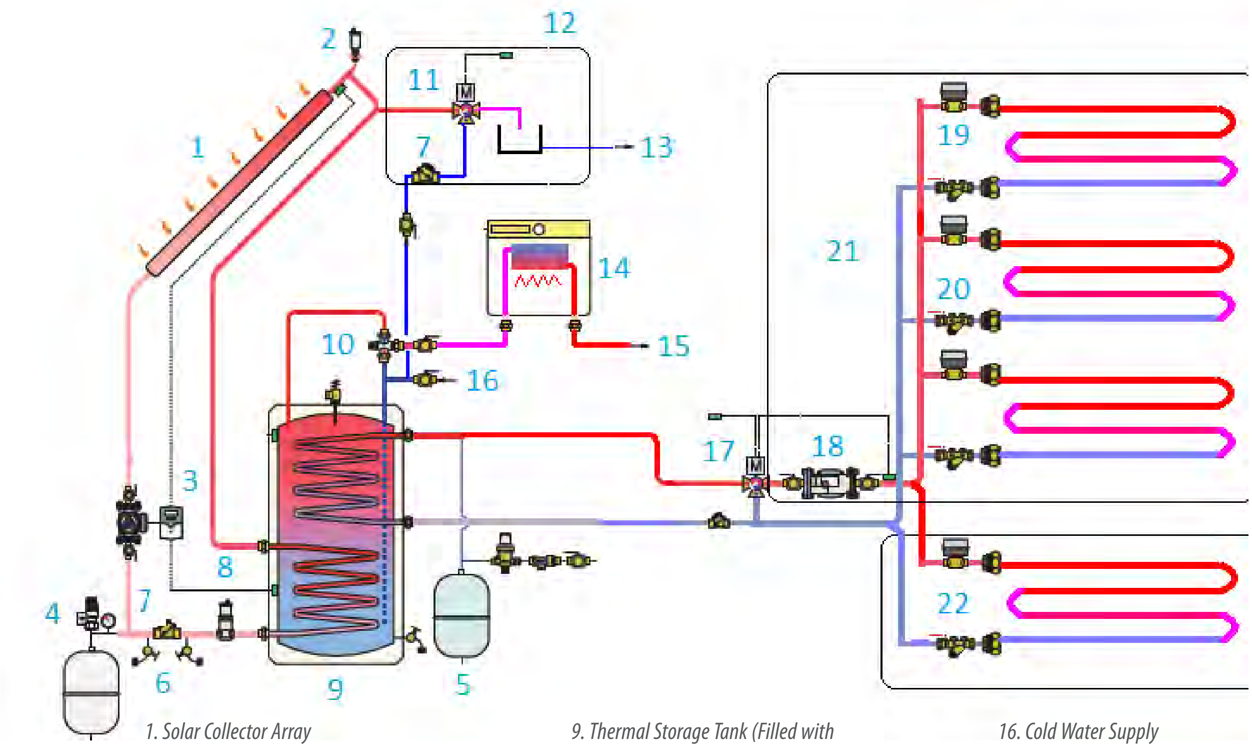
Exhaust fans will be located in both the bathroom area and in the kitchen. The bathroom fan will be used to for ventilation and to remove humidity. The kitchen exhaust will be used to remove heat, odors and humidity generated during cooking.

4.12 Solar Mechanical

Solar Thermal Array (Figure 4.12.A):

The home will use a solar thermal system for domestic hot water and radiant floor heating. Roof mounted evacuated tube collectors will be used for the solar heat source. This type of collector was selected to provide higher storage temperatures to reduce the size of the thermal storage required and reduce the space needed for the system. Water will be used as the heat transfer fluid and will be circulated by pump to a solar thermal heat storage tank which will have two integrated heat exchangers. The lower heat exchanger will be used to for the solar loop. The necessary valves, gauges, pump, and properly sized expansion tank will be installed in the solar loop. An automated solar controller will be used to control the system.

The solar collectors are being sized to provide as much of the domestic hot water as needed, and to provide heated water for the radiant floor system. Because of the high solar heat gain resource found in Las Vegas, excess heat would be collected during the summer months, which will cause a collector stagnation problem. Two methods are being considered to prevent collector stagnation. The first method is to heat a sand thermal storage decorative element that is being developed and tested for the home. The storage element consists of layers of sand with PEX tubing routed through it that allows the circulation of hot water to heat the sand. The layers of sand are visible through a glass panel on one side that resembles the Redrock sandstones found around Las Vegas. This element will be used to store or dump excess heat collected by the collectors and can be later used for the radiant floor heating or dissipate the heat. The second method being considered is to have a partial



1. Solar Collector Array
2. Air Vent with Shut-off Valve
3. Differential Temperature Controller
4. Pressure Relief Valve
5. Expansion Tank
6. Fill / Purge Valves
7. Check Valve
8. Air Separator
9. Thermal Storage Tank (Filled with domestic water)
10. 3-way Ant Scald Mixing Valve
11. 3-Way Motorized Valve
12. Possible Heat Dump System
13. To Water Feature and Grey Water Tank
14. Tank-less Water Heater
15. To Domestic Hot Water
16. Cold Water Supply
17. 3-Way Motorized Mixing Valve
18. Pressure Regulated Circulator
19. Zone Valve
20. Autoflow Valve
21. Radiant Floor Heating System
22. Thermal Mass Wall System

Figure 4.12.A - Solar thermal system schematic diagram

drain back system. This system would isolate the collectors using an electric valve when the storage temperature has reached its upper limit. A second diverter valve would open that would drain the small volume of water from the collectors into the water feature. The volume of water dumped would be kept at a minimum by placing the isolation and dump valves as close to the collectors as possible but still within the mechanical equipment room. A proper air gap would be maintained where the water dumps into the feature to prevent water from drawing back into the solar circulation loop during a low water pressure event, and also prevent scalding at the water feature. In the event the water feature is at full capacity the feature will overflow into the gray water tank and be used for landscape irrigation. An automatic air bleed valve would be used to purge air from the system when the loop is restarted and fills with water. Both methods will be modeled and tested before a decision is made.

The home will have a PEX tubing radiant floor heating system. The system will have three heating zones; the living area, the bedroom, and the bathroom. The system will use a closed loop system utilizing the top heat exchanger of the thermal storage tank. A circulation pump will be used to circulate water through the system. Zone valves will be used for each zone. The system will also have a properly sized expansion tank.

<u>Photovoltaic System:</u>

The Autonomy House will include a rooftop mounted and grid connected photovoltaic system that will be sized to provide net zero annual energy production. The system will utilize highly efficient panels that will be mounted close to the roof lines but the rack mounting will provide the important ventilation required for installation in the desert southwest. Microinverters are being considered for the PV system, which allow for more flexibility in installation, and also allow the system to maintain operation if one panel is shaded or fails. This redundancy is essential for Team Las Vegas' vacation home/empty-nester target demographic, which values a well-designed, easy-to-use, low-maintenance home. The system will be monitored by the home automation system to give the residents feedback on performance and energy generation.

Thermal Mass Wall System:

In response to climatic considerations for a hot dry climate, the Autonomy House needs thermal mass to prevent large diurnal thermal swings. The home is designed to use a chassis instead of a conventional slab-on-grade construction, and wood stud-framed walls instead of CMU or cast in place concrete. These design responses have created a need for thermal storage. We are currently testing a solution, called the Earth Wall, which may address this need.

Our exploration of venting the mass and warming it with the sun led to the idea that water, as transportation for thermal energy, could be used to heat and cool the thermal mass. The earth wall is a lightweight modular frame that is easily transportable. It is filled with layers of earth and coils of tubing running through it to transfer thermal energy from the hydronic fluid (water) to the thermal mass (earth) or vice versa (Figure 4.12.B).

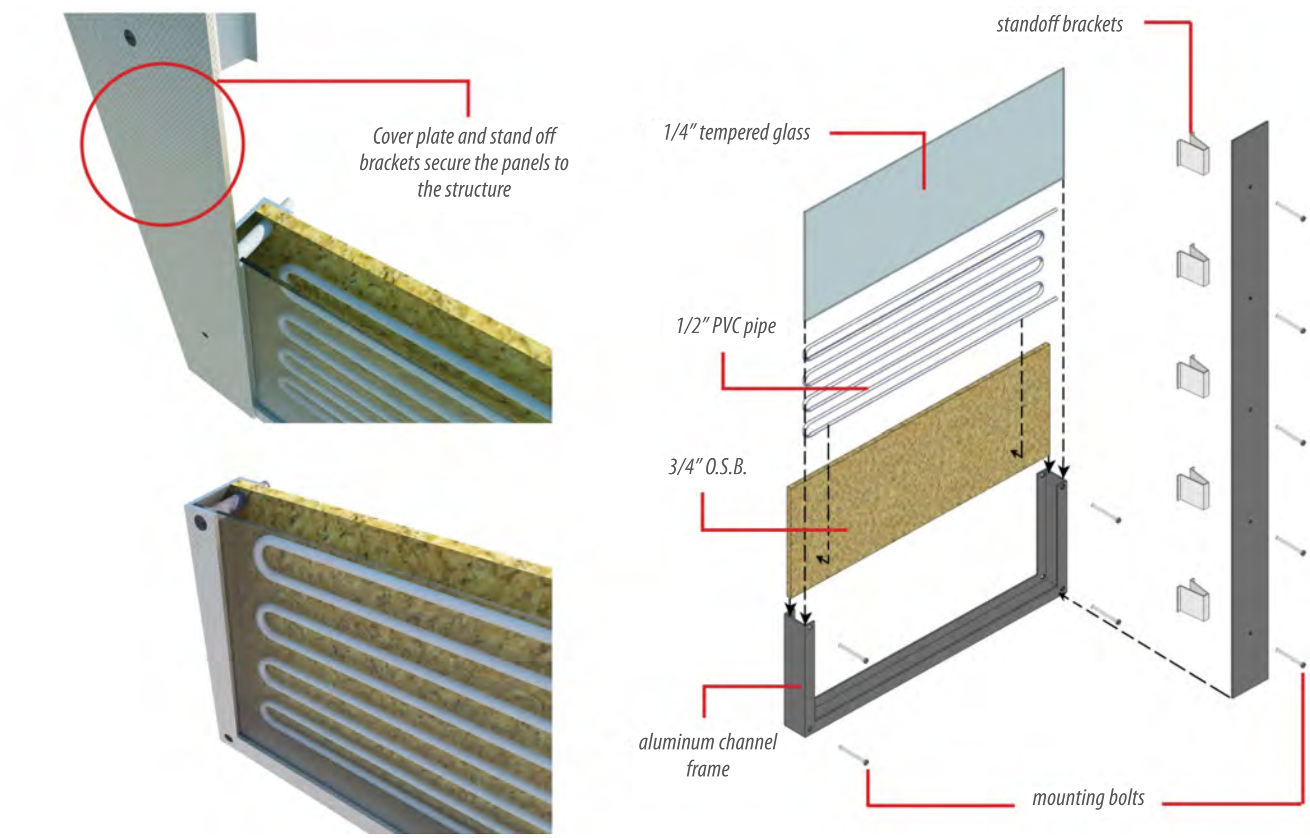


Figure 4.12.B - Thermal mass wall exploded diagram

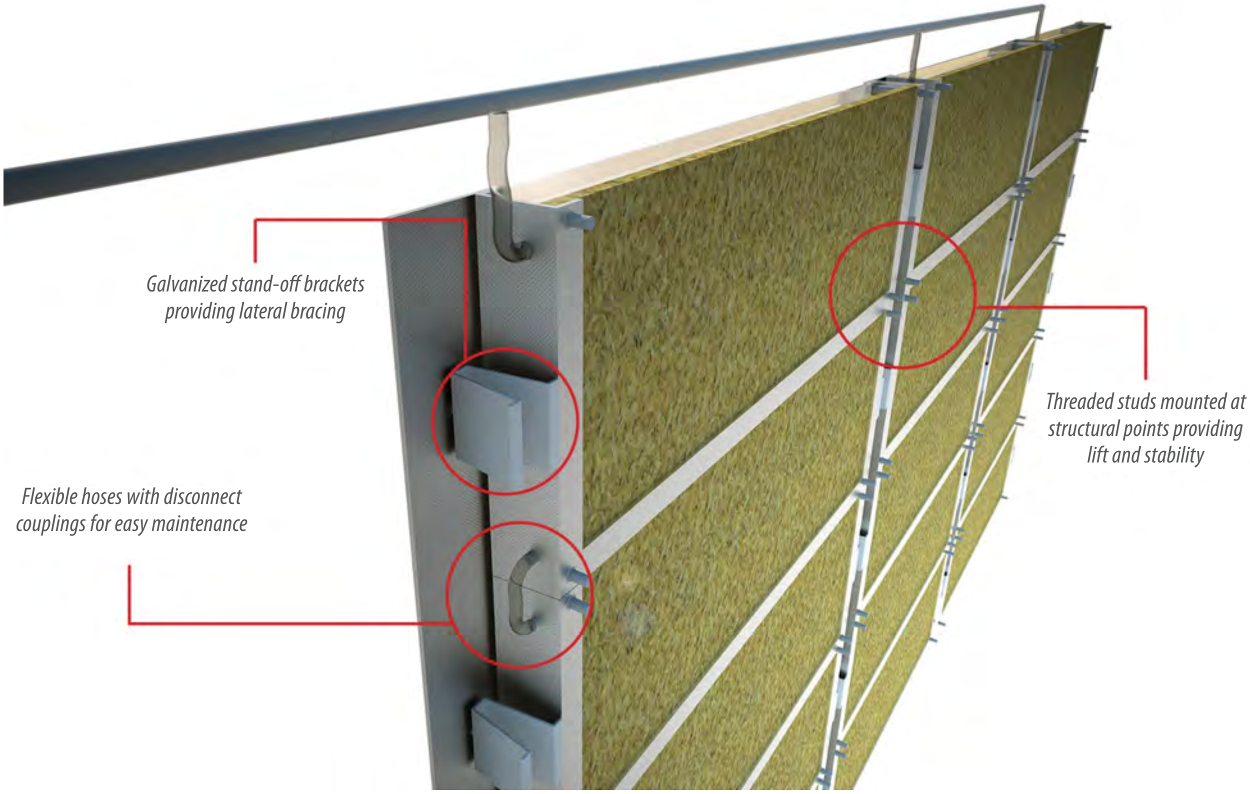


Figure 4.12.C - Thermal mass wall assembly diagram

During the summer months, water is pumped through the wall at night after exchanging thermal energy with the exterior water feature of the home. The water feature is cooled by evaporative cooling and exposure to cool evening temperatures. This lowers the temperature of the wall, which helps the earth absorb thermal radiation throughout the day. This should result in the mechanical system having less thermal heat to remove and lower energy consumption for the house.

During the winter, the wall would be warmed throughout the day by using the house's solar thermal system. The wall is massive enough to retain this heat and radiate it throughout the cold winter nights. This heating would then be supplemented by the mechanical system during the coldest nights and when the sun is blocked by cloud cover.

In addition to being a purely functional element of the home, the wall is designed to have aesthetic characteristics that are culturally and regionally appropriate. The layered earth behind glass is reminiscent of rammed earth, a traditional material common in the Mojave Desert, as well as other arid communities around the world. The Earth Wall (Figure 4.12.C) reinterprets this piece of Nevada's history and simultaneously incorporates modern technology, one of Team Las Vegas' primary goals for the Solar Decathlon.

5 UTILITY & DATA LOGGER CONNECTIONS

The utility meter and main electrical panel will be located at the northwest corner of the home, adjacent to the mechanical room (Figure 5.A). This location provides the closest access to the organizer provided utility corridor and reduces wire lengths and wire losses to some of the larger electrical loads. The location will also be proximate to the data monitoring system location for ease of wiring of energy monitoring devices.

For data monitoring, a Campbell Scientific Incorporated (CSI) model CR1000 data logger will be used. This will be housed in a data logger enclosure that will be mounted in the mechanical room. The data logger will be powered with a CSI model PS100 rechargeable power supply that will be connected to a CSI model 9591 charger. For communications, a CSI model NL120 network interface module will be connected to the data logger. This module will allow remote monitoring and also allow monitoring by the home automation system.

Temperature and humidity will be measured by a CSI model HMP60 temperature and relative humidity probe (the replacement probe for the model HMP50) that will be mounted on the roof above the mechanical room in a protective wind and rain shield. The height of the sensor will be checked so as to not cause shading on systems and to fit in the solar envelope. The sensor will be connected to the data logger.

Thermocouple extension wires will be run from the data logger to the refrigerator/freezer to allow monitoring of temperatures during the competition. These wires will be run carefully through the home during construction to prevent damage or electrical interference.

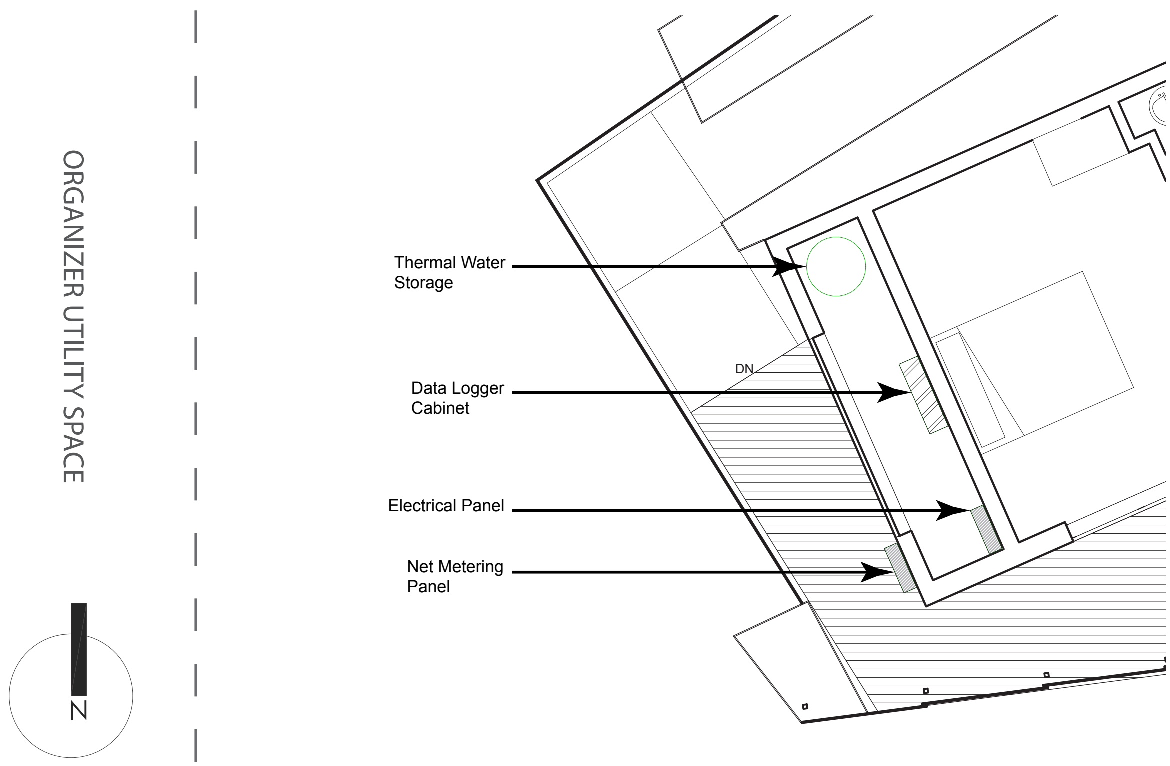


Figure 5.A - Utility connections and data logger locations

6 PUBLIC EXHIBIT, COMMUNICATIONS & OUTREACH STRATEGY

Public Exhibit:

To provide our visitors with the best viewing experience, Team Las Vegas will implement a systematic public exhibit strategy that incorporates organization, information and customer service. First, we will ensure that there is organization by designating a clear exhibit path around the Autonomy House. Complete with wayfinding signage, this path will be used by visitors to experience each part of the house. The proposed exhibit path is shown in Figure 7.A. Second, Team Las Vegas will provide information about the Autonomy House to visitors by installing information panels that describe and explain the design features and innovations in the house. We will use clear and understandable texts as well as simple graphics, photos and illustrations so that our visitors will better understand and appreciate our house's concept. Finally, designated Team Las Vegas members will assist, guide, and interact with the visitors. Team members will be ready to answer any questions from the visitors regarding the house.

Communications and Outreach:

The communications strategy (Figure 6.A) of Team Las Vegas integrates all the project's technical aspects and processes, public outreach activities, public education and exhibits, and advocacy efforts. Our strategy aims to successfully educate our audiences by delivering clear and consistent textual, verbal and graphic messages that represent our vision, experiences and results. To capture and deliver these messages, our communications strategy will include six key activities: general public relations, internal communication, website communication, media relations, and public exhibits and events.

Our general public relations will include marketing and branding of the project and the team. To make our project unique and identifiable, we will create a logo that symbolizes our team. We will use this logo in all our communication and marketing materials. Media relations will entail the communication with members of mass media including news reporters, writers and editors. The communications team will constantly share news releases on key project developments and events with local newspapers, magazines and collegiate newspapers. Similarly, we will work with a local television station to create a news feature video report about the project that would be broadcasted locally. We will simultaneously use both print and broadcast media to fully and effectively reach out to our audiences.

Internal communication will involve how team members communicate with each other in relation to the project. Constant communication among team members will facilitate successful execution of tasks and keep members updated about the project. To effectively achieve this, we will use email and Facebook.

Website communication will entail the creation and promotion of our team website, which will contain complete information about the project. Through our website, we will inform the public about the project's technical aspects, team members, developments and updates by using clear and comprehensible texts, appealing design, and accessible graphic elements such as photos and drawings.

Also, we will incorporate videos, blogs and newsfeeds to enhance usability, originality and quality of our website. Moreover, our website will feature social platform links such as Facebook and Twitter to facilitate and promote interaction with our target audience.

Understanding our audiences is a fundamental part of Team Las Vegas' strategy. We believe that the better we know our audience, the better our chances to educate and influence them. Therefore, it is imperative that our target audiences understand our project clearly and easily. We will accomplish this task by identifying our primary audiences and choosing the most effective channels of communication for each type of audience. The target audiences and modes of communications are summarized in the table below.

Target Audience	Channel of Communication
Students/academia	Social media, News media, Website, Brochures, Campus events & presentations, Videos
General public	News media, Website, Social media, Factsheets, Ads, Videos & Signage, Exhibits
Private companies & Government agencies	News media, Website, Factsheets, Emails, Videos, Fundraising events

Figure 6.A - Communications and outreach targets

To promote the Team and disseminate information about the project, the communications strategy will consist mainly of news media and social media campaigns and website promotion. For social media, we will extensively utilize Facebook and Twitter to reach out to our younger audiences. For news media, we will use local newspapers and magazines to feature any newsworthy developments related to the project and the team in the form of news articles and press releases. Moreover, we will use our team website to communicate with our audience. Our website will contain explanations and demonstrations of the technical aspects of the project that will include drawings, photos and videos.

7 ACCESSIBLE TOUR ROUTES

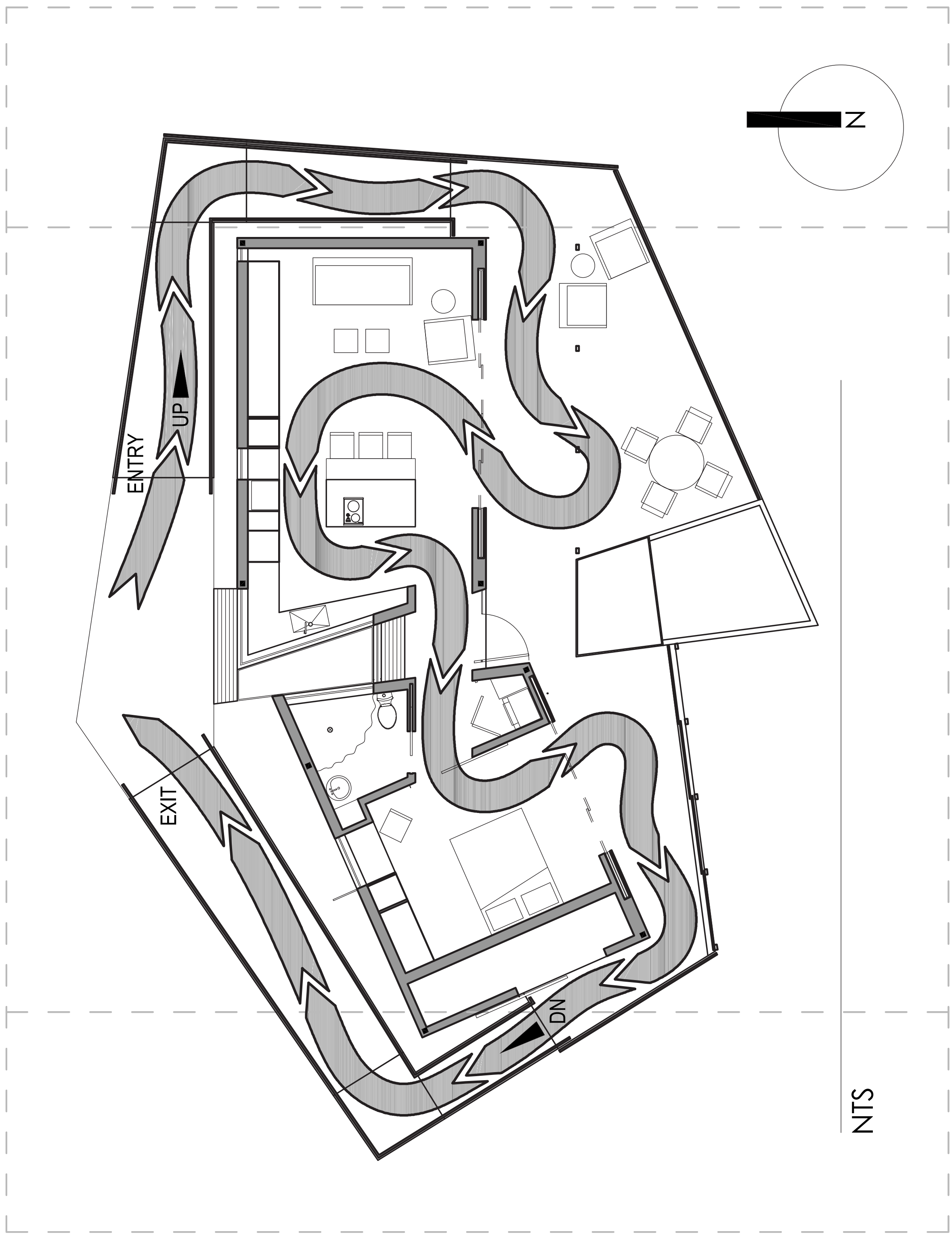


Figure 7.A - Accessible tour route plan

8 EXPERIENTIAL RENDERINGS

Figure 8.A - West elevation

Figure 8.B - Autonomy House entry court

Figure 8.C - Public deck facing west

Figure 8.D - View of the living room and kitchen

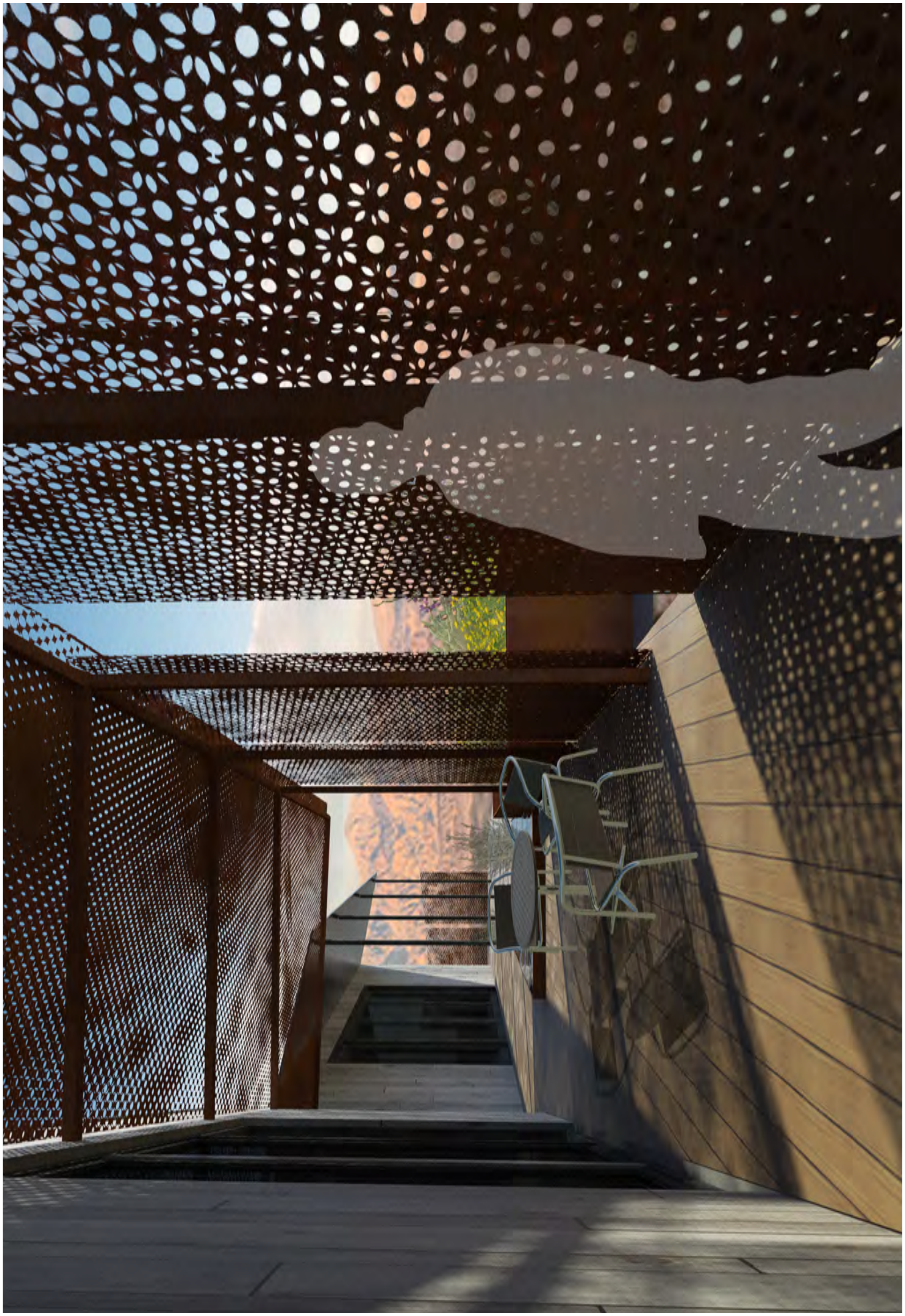


Figure 8.E - Private deck facing east

9 HEALTH & SAFETY PLAN

The Las Vegas Team will follow Occupational Safety and Health Administration (OSHA) rules and regulations during construction of the building. We will also follow the fire, electrical, and building safety codes from the National Fire Protection Association (NFPA). In addition, we will work with the University Risk Management and Safety Departments. The detailed plan will be submitted later. However, this document highlights some of the items to be considered with regard to the safety of the building and the workers involved in the Solar Decathlon Competition.

Building Construction Safety: OSHA has identified four critical areas of high accidents in construction: falls, caught-in or -between, struck-by, and electrocution. The UNLV design and construction team will try to follow the philosophy of Prevention through Design (PtD). While designing the components, the workers' safety during construction will be considered. To this end, the Las Vegas team has identified each and every component of the building that has risk factors for workers' safety. Also, we propose that the necessary training be given to the workers so that we can minimize injuries during the process of construction. The ultimate goal of Team Las Vegas during this project is Zero Accidents.

High Risk Building Components: Our team has identified the 10 most risky tasks during construction of this building, as follows:

1. Foundation installations
2. Roof and solar panel installations
3. Ceiling installations
4. Exterior and interior wall installations
5. Insulation installation
6. Heating, ventilation, and air conditioning installation
7. Electrical wires and fixtures installations
8. Plumbing and home appliances installation
9. Moving the building
10. Assembly and disassembly of the building

Our team will try to mitigate the risk by proposing non-hazardous construction materials. During the construction phase, there will be one student dedicated for the Health and Safety aspect of the project. The overall construction manager will also supervise construction safety. Both student officers will have taken the OSHA 30-hour training course, given by an OSHA-certified trainer. Pramen Shrestha, Co-PI of this project, is the OSHA-certified trainer. In addition to training the two individuals mentioned, he will give the OSHA 10- and 30-hour training to all individuals involved in this Solar Decathlon project. The training will emphasize:

- Best practices for working safely,
- How to use Personal Protective Equipment (PPE),
- Focus Four
- Understanding the Material Safety Data Sheet (MSDS), and
- Understanding OSHA rules and regulations.

Table 9.A shows some of the planned design and construction processes as well as some required

training proposed for the workers in order to achieve Zero Accidents at our site.

Fire and Electrical Safety of the Building: The building will be designed according to the NFPA codes and standards. The building will be equipped with a sprinkler system, and will follow the NFPA 13D standard. Similarly, the building will have the required number of fire extinguishers, meeting the criteria mentioned in the NFPA 10 standard. The building also will have a fire alarm system, meeting the NFPA 72 standard. All the electrical conduits and fixtures will meet the minimum standard mentioned by the NFPA70A standard. All the workers and students involved in fire and electrical work will be given Focus Four training.

S. No.	Safe Design Proposed	Safe Construction Proposed	Safety Training Proposed
1	Foundation Installation		
	The steel chassis foundation is proposed so that all the welding work of the foundation will be carried out by professional welders outside the UNLV campus.	The foundation will be built as a roller so that it will be easy to transport to the site without performing welding work at the site.	OSHA 10-hour training will be given to students involved in the movement of the foundation. This training will include Focus Four training.
2	Roof and Solar Panel Installation		
	A prefabricated roof will be designed so that workers do not have to be exposed to heights for a long time.	The roof will be built on the ground, and will be lifted by crane to put on the top of the wall.	All the workers involved in the installation of roof and solar panel will be given OSHA 10-hour training. The training will focus on Fall Prevention.
3	Ceiling Installation		
	A prefabricated ceiling frame will be proposed.	The ceiling frame will be built on the ground and lifted to install.	Students and workers involved in this work will be given OSHA 10-hour training, focusing on Fall Prevention.
4	Exterior and Interior Wall		
	The wall frame will be made of lumber, and the exterior wall sidings will be installed by professionals.	During the construction of exterior and interior wall sidings, the workers will use scaffolds.	Students and workers involved in this work will be given OSHA 10-hour training, focusing on Fall Prevention.
5	Insulation Installation		
	The insulation will be designed and installed by the professional workers.	During the installation of insulation, the workers are required to wear PPE.	The workers involved in this work will have OSHA 10-hour training.
6	HVAC Installation		
	HVAC will be designed and installed by professionals.	During HVAC installation, the workers will be required to follow OSHA safety rules.	HVAC workers will have OSHA 10-hour training covering, Fall Hazards, PPE, and Focus Four.
7	Electrical Wires and Fixtures Installation		
	All the electrical circuit and fixtures will be designed by professionals.	During the electrical conduits and fixtures installation, all the workers should follow the OSHA rules.	These workers should have general training about electrical hazards and use of PPE during electrical work.
8	Plumbing and Home Appliances		
	Plumbing will be designed by professionals.	During installation of the plumbing and home appliances, the workers should know about OSHA rules.	These workers will have training regarding Fall and Focus Four.
9	Moving of the Building		
	This will be done by professional movers.	During the transportation of the home, the mover will make sure all safety rules are followed.	The movers will have knowledge about risks in transporting mobile homes.
10	Assembly and Disassembly of the building		
	The assembly and disassembly of the building will be done by the students and workers.	During this time, all the workers and students will be informed about the health and safety risks.	All the workers and students involved will have OSHA 10-hour training.

Table 9.A Planned Safety Training and Processes

10 STRUCTURAL ENGINEER

Kirsten E. Nalley, PE, SE

Kirsten has been designing structures in Las Vegas since 1992. She joined Mendenhall Smith in 1999 and was named principal in 2001. In addition to her design and engineering responsibilities, she is responsible for managing and training new employees.

Kirsten has designed structures constructed of steel, masonry, concrete and wood and has been involved in commercial, municipal and residential projects. Her recent projects include the McCarran International Airport consolidated car rental facility, car dealerships, education facilities and recreation centers in Las Vegas and the surrounding communities.

Kirsten maintains structural engineering licenses in Nevada and California. She is an alumnus of California Polytechnic State University at San Luis Obispo.

California Board of Professional Engineers, Land Surveyors and Geologists

Licensee Name: NALLEY, KIRSTEN ELISE

License Type: CIVIL ENGINEER

License Number: 55924

Nevada State Board of Professional Engineers and Land Surveyors

Licensee Name: NALLEY, KIRSTEN E.

License Type: CIVIL ENGINEER / STRUCTURAL ENGINEER

License Number: 012577