

# Project Manual



Missouri University of Science and Technology  
University of Missouri

Submitted by:  
Show-Me Solar

Competition Presented by:  
U.S. Department of Energy (DOE) in partnership with DOE's National Renewable Energy Laboratory



# SHOW-ME SOLAR HOUSE TEAM

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## Summary of Changes

### Construction Drawings

- Total Drawing Formatting Changes
  - Title Blocks: Revised to comply with National CAD Standard
  - Note Blocks: Revised to comply with National CAD Standard
  - Margins: Revised to comply with National CAD Standard
  - Coordinates: Revised to comply with National CAD Standard
  - Page Sizes: Revised to ANSI D
  - Specification Keynotes: Added to comply with National CAD Standard
- General
  - Cover Sheet G-000: Properly named to comply with National CAD Standard
  - Drawing Index G-001: Added
  - Architectural Keynotes G-002: Added
  - Renderings G-901, G-902, G-903, G-904, G-905: Added
- Civil
  - Assembly and Disassembly Plan C-401: Added
  - Solar Envelope Plan C-102: Added
  - Construction Site Plan C-105: Revised
  - Tour Path C-110: Added
  - Solar Envelope Elevations C-201: Added
  - Solar Envelope Elevations C-205: Added
  - Spill Containment C-501: Added
- Landscape
  - Landscape Plan L-101: Added
- Structural
  - Foundation Plan- House S-101: Revised
  - Foundation Plan- South Deck S-102: Added
  - Foundation Plan- East Deck S-103: Added
  - Foundation Plan S-104: Added
  - Subfloor Plan S-105: Added
  - Subfloor Sheathing Layout S-110: Added
  - Deck Plan S-115: Added
  - Deck 2x4 Substructure S-116: Added
  - Deck 2x8 Substructure S-117: Added
  - SIP Connection Details S-501: Added
  - SIP Panel Layout S-505: Added
  - SIP Panel Layout S-506: Added
  - SIP Panel Layout S-507: Added



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## Summary of Changes

- Deck Details S-510: Added
- Foundation Details S-515: Added
- Subfloor Details S-520: Added
- Hinge Detail S-545: Added
  
- Architectural
  - Floor Plan A-101: Revised
  - Roof Plan A- 105: Revised
  - Reflected Ceiling Plan A-110: Revised
  - Conditioned Space Plan A-115: Revised
  - South Elevation with Louvers A-201: Added
  - South Elevation without Louvers A-202: Revised
  - North Elevation A-205: Revised
  - East Elevation without Louvers A-210: Revised
  - East Elevation with Louvers A-211: Added
  - West Elevation A-215: Revised
  - Section Looking North A-301: Revised
  - Section Looking East at Bedroom A-310: Revised
  - Section Looking East at Bathroom A-315: Revised
  - Section Looking West A-320: Revised
  - Enlarged Kitchen Plan A-401: Added
  - Cabinetry Elevation A-405: Revised
  - Cabinetry Elevations A-410: Revised
  - Enlarged Bathroom Plan A-415: Revised
  - Bathroom Elevations A-420: Revised
  - Details A-504: Revised
  - Schedules A-601: Revised
  
- Interior
  - Furniture Plan I-101: Added
  
- Fire Protection
  - Smoke Detector Plan F-101: Added
  
- Plumbing
  - Plumbing Supply Plan P-101: Added
  - Plumbing Drainage Plan P-110: Added
  
- Mechanical
  - Ductwork Plan M-101: Revised
  - Radiant Floor Tubing Layout M-115: Added
  - Detailed Mechanical Closet Layout M-501: Revised
  - Thermal Collection Schematic M-601: Added



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## Summary of Changes

- Electrical
  - Power Plan E-101: Revised
  - Lighting Plan E-105: Revised
  - PV Layout E-110: Revised
  - 1- Line Schematic E-620: Revised
  - 3- Line Schematic E-621: Added
  - Interconnection Elevation E-225: Added
  - Interconnection Plan View E-126: Added
  - Load Calculation E-630: Added
  - Automation Layout E-130: Added
  - Automation Wiring 1 E-605: Added
  - Automation Wiring 2 E-606: Added
  - Automation Wiring 3 E-607: Added
  - Automation Wiring 4 E-608: Added
  - Schedules E-601: Added

## Project Manual

- Summary of Changes: Added
- Rules Compliance Checklist: Added
- Code Compliance Checklist: Added
- Specifications- Table of Contents: Revised
- Specifications: Revised to Comply with MasterFormat 2004
- Structural Calculations: Added to comply with U.S. Department of Energy's Solar Decathlon
- Detailed Water Budget: Revised
- Summary of Unlisted Electric Components: Revised
- Retail PV Price Quote: Added
- Summary of Reconfigurable Features: Revised
- Interconnection Form: Revised
- One- Line Schematic: Revised
- Calculations of Service/ Feeder Net Computed Loads and Neutral Load: Revised
- Plan View of the Lot Showing the House, Decks, Ramps, Tour Paths, and the Service Point
- Elevations View Showing the Terminal Box, Meter, and Other Service Equipment: Revised
- Energy Analysis Results and Discussion: Revised
- Architecture Design Narrative: Revised
- Market Viability Justification: Revised
- Engineering Design Narrative: Revised
- Lighting Design Narrative: Revised



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## Rules Compliance Checklist

See attached documents.

Rule #	Rule Description	Content Requirement(s)	Drawing Sheet(s)	Coordinates
4-2	Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site	C-401, C-103	
4-2	Construction Equipment	Specs for heavy machinery	C-103 <sup>REF</sup>	
4-3	Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	S-515, E-101, S-101	A3
4-4	Impact on the Turf	Drawing(s) showing the location, contact area, and soil bearing pressure of every component resting directly on the turf	S-515, S-104, S-101, S-102, S-103	
4-5	Generators	Specifications for generators	C-103 <sup>REF</sup>	
4-6	Spill Containment	Drawing(s) showing the locations of all equipment, tanks, and pipes that will contain fluids at any point during the event	C-103, M-115, P-101, P-110	
4-6	Spill Containment	Specifications for all equipment, tanks, and pipes that will contain fluids at any point during the event	C-103 <sup>REF</sup> , M-115 <sup>REF</sup> , P-101 <sup>REF</sup> , P-110 <sup>REF</sup>	
4-7	Lot Conditions	Calculations showing that structural design remains compliant even if 18 in. (45.7 cm) of vertical elevation change exists	S-104	
4-7	Lot Conditions	Drawing(s) showing shimming methods and materials to be used if 18 in. (45.7 cm) of vertical elevation change exists on the lot	S-515	A1, A3, C3, C5
5-2	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	C-101, C-201, C-205	
5-2	Solar Envelope Dimensions	List of solar envelope exemption requests accompanied by justifications and drawing references	C-101 <sup>REF</sup> , C-201 <sup>REF</sup> , C-205 <sup>REF</sup>	
6-1	Structural Design Approval	List of, or marking on, all sheets in the complete electronic Construction Documents that have been or will be stamped by the structural engineer in the hard-copy, stamped structural submission; the stamped submission shall consist entirely of sheets or pages that also appear in the complete electronic construction document set	S-101, S-104	
6-2	Maximum Architectural Footprint	Drawing(s) showing all information needed by the Rules Officials to measure the architectural footprint electronically	A-101, A-202, C-101, C-201, C-205	
6-2	Maximum Architectural Footprint	Drawing(s) showing all movable components that may increase the footprint if operated during contest week	N/A	
6-2	Maximum Architectural Footprint	Shading calculations and/or diagrams for components that DO NOT shade the building above its finished floor height between 9 a.m. and 5 p.m. EDT on October 1 (shading calculations and/or diagrams are not necessary for components that are either shorter than finished floor height or obviously do not shade the building)	N/A	
6-3	Minimum Conditioned Space	Drawing(s) showing space conditioning means in primary living spaces	A-115	

Rule #	Rule Description	Content Requirement(s)	Drawing Sheet(s)	Coordinates
6-4	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route and the ground surface area that will be covered by organizer-provided walkway material	C-110	
7-1	Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system	L-101	
7-2	Watering Restrictions	Drawings showing the layout and operation of greywater irrigation systems	M-510	
8-1	PV Technology Limitations	Specifications for photovoltaic components	E-110 <sub>REF</sub>	
8-1	PV Technology Limitations	Retail price quote for photovoltaic components	E-110 <sub>REF</sub>	
8-3	Thermal Energy Storage	Drawing(s) showing the location of thermal energy storage components	M-501, M-115, M-601, E-110	
8-3	Thermal Energy Storage	Specifications for thermal energy storage components	M-501 <sub>REF</sub> , M-601 <sub>REF</sub> , E-110 <sub>REF</sub>	
8-3	Thermal Energy Storage	Shading calculations and/or diagrams for thermal energy storage components (if necessary)	M-601	
8-4	Batteries	Drawing(s) showing the location(s) and quantity of stand-alone, PV-powered devices	N/A	
8-4	Batteries	Specifications for all stand-alone, PV-powered devices	N/A	
8-5	Desiccant Systems	Drawing(s) describing the operation of the desiccant system	N/A	
8-5	Desiccant Systems	Specifications for desiccant system components	N/A	
8-6	Village Grid	Completed Interconnection Application form.	E-201 <sub>REF</sub> , E-126 <sub>REF</sub> , E-130	
8-6	Village Grid	Drawing(s) showing the locations of the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	E-110, E-126, E-101, E-201	
8-6	Village Grid	Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	E-110 <sub>REF</sub> , E-126 <sub>REF</sub> , E-101 <sub>REF</sub> , E-201 <sub>REF</sub>	
8-6	Village Grid	One-line electrical diagram	E-620	
8-6	Village Grid	Calculation of service/feeder net computed load per NEC 220	E-630	
8-6	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box	C-110	
8-6	Village Grid	Elevation(s) showing the terminal box, meter housing, main utility disconnect, and other service equipment	E-201	
9-4	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems	M-510	

Rule #	Rule Description	Content Requirement(s)	Drawing Sheet(s)	Coordinates
9-6	Thermal Mass	Drawing(s) showing the locations of water-based thermal mass systems	N/A	
9-6	Thermal Mass	Specifications for components of water-based thermal mass systems	N/A	
10-2	Event Sponsor Recognition	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	X-501 – X-510	
10-3	Team Sponsor Recognition	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	X-501 – X-510	
11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route	C-110	
11-4	Public Exhibit	Drawing(s) showing the dimensions, materials, artwork, and content of the handout	X-902	
11-4	Public Exhibit	Drawing(s) showing the artwork and content of the team uniform	X-901	



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## Code Compliance Checklist

See attached documents.

Rule #	Rule Description	Content Requirement(s)	Drawing Sheet(s)
3-1	Fire Protection Plan	Drawing(s) should include Fire Protection Plan and Smoke Alarm Plan	F-101
3-2	Means of Egress	Drawing(s) should include stairs and handrails locations and path of egress	C-110
3-3	Interior Finishes	Interior finishes must comply with IRC R315	A-504
3-4	Glazing	Drawing(s) showing glazing	None
3-5	Roofing	Roofing materials must comply with IRC Chapter 9	A-105, A-504
3-6	Foam Plastic	Drawing(s) showing Gypsum covering any Foam plastics	A-301, A-310, A-315
3-7	Exterior Envelope	Drawing(s) showing exterior envelope of the building	C-101
3-8	Ceiling Height	Drawing(s) showing the ceiling height is greater than 7ft.of headroom	A-202, A-211
3-9	Skylights	Drawing(s) showing skylights	N/A
4-1	Accessible Route-Interior	Drawing(s) showing the accessible route of the interior	A-101
4-3	Accessibility- Ramps	Drawings(s) showing inclined planes	S-115, S-116, S-117
4-4	Changes in Elevation	Drawings(s) showing any changes in elevation within the structure	N/A
4-5	Door and Door Approaches	Drawing(s) showing doors that comply with ADAAG Section 4.13	A-101, A-110, A-115, A-201, A-202, C-110
5-1	Prescriptive Requirements	Drawing(s) showing appropriate prescriptive provisions of the IRC	S-505, S-101, S-105, A-101,
5-2	Design Loads	Design loads comply with SD Building Code	Project Manual Structural Drawings
5-3	Exterior Construction	Drawing(s) or detail(s) showing any exterior appurtenances according to IRC	S-115, A-201, E-201
5-4	Specific point Loads	Wind-analysis calculations for all point load and solar panel connections according to IRC	Project Manual Structural Calculations
5-5	Foundation	Foundation plan for temporary setup at competition site	S-104, S-515
5-6	Alternate Materials	Listing of all permitted alternate materials according to IRC	S-501, S-505
5-7	Structural Steel	Detail(s) for load-carrying structural steel assemblies in compliance to IRC	S-515, S-512
6-1	Governing Code	Electrical requirements in compliance to the NEC	Spec 26 27 00
6-2	Drawing Requirements	Plan(s) or detail(s) showing all appropriate needs of the IRC	E-101, E-105, E-201, E-621
6-3	Tamper-Resistant Receptacles	Tamper-resistant receptacles comply with NEC article 210.52	Spec 26 27 02
6-4	Outdoor Receptacles	Outdoor receptacles comply with IRC, Sec. E3802.3	Spec 26 27 02
6-5	Arc-Fault Circuit Protection	Arc-Fault Circuit Protection complies with IRC, Sec. 210.12	Spec 26 27 00

Rule #	Rule Description	Content Requirement(s)	Drawing Sheet(s)
6-6	Ground-Fault Circuit Protection	Ground-Fault Circuit Protection complies with IRC, Sec. 210.8	Spec 26 27 00
6-7	Equipment Listing	Listing of all electrical equipment for temporary use on National Mall approved by SD building official and electrical inspector in compliance with the IRC and the NEC	E-101, E-201, E-630
6-8	Photovoltaics	Drawing(s) comply with NEC photovoltaic standards	E-110
7-1	Drawing Requirements	Drawing(s) must have a key for all mechanical symbols complying to IRC	N/A
7-2	Return Air	Return Air follows IRC, Sec. M1602.2	M-101
7-3	Outside Air	Outside Air follows IRC, Sec. M1602.2-3	M-501
7-4	Bathroom Ventilation	Drawing(s) provided with mechanical ventilation systems complying with IRC, Sec. R303.3	A-415
8-1	Drawing Requirements	Detail(s) for proposed solar mechanical systems according to IRC	M-115, E-201
8-2	Cross Connection	Detail(s) for solar hot-water system complying IRC	M-115, M-601
8-3	Access	Access complies to IRC, Sec. M2301.1	E-110
8-4	Roof-Mounted Collectors	Roof-Mounted Collectors are compliant with IRC, Sec. 2301.2.2	E-110, E-201
8-5	Pressure and Temperature Relief	Pressure and Temperature Relief valves follow IRC, Sec. M2301.2.3	M-601
8-6	Vacuum Relief	Plan(s) indicating system that is subjected to vacuum conditions complying with the IRC	M-601
8-7	Expansion Tanks	Expansion tanks in solar systems are installed in accordance with IRC, Sec. M2301.2.6	M-601
8-8	Solar Loop Isolation	Valves should be installed according to IRC, Sec. M2301.2.8	M-601
8-9	Maximum Temperature Limitation	Limitations will comply with IRC, Sec. M2301.2.3, M2301.2.9	Spec 23 64 00
8-10	Collector and Thermal Storage Unit	Collector and Thermal units will be listed in compliance with IRC	Spec 48 14 13, M-501
8-11	Prohibited Heat-Transfer Media	Acceptable heat-transfer liquids will comply with IRC	Will comply on site
8-12	Backflow Prevention	Backflow Prevention will comply with the IRC	M-601
8-13	Pressure Test	Pressure testing should not exceed 100 psi (690 kPa)	Spec 22 11 00
9-1	Drawing Requirements	Diagram(s) of proposed plumbing system with symbols according to IRC	P-101, P-110
9-2	Water Closet Demonstration	Water closet installed for demonstration only	Spec 22 40 00

Rule #	Rule Description	Content Requirement(s)	Drawing Sheet(s)
9-3	Plumbing Wall – Structural	Recommend: Create a plumbing wall with thickness to allow pipe penetrations within studs	A-415
9-4	Shower Mixing Valves	Shower Mixing Valves comply to IRC, Sec. P2802.3 and P2708.3	P-101
9-5	Backflow Prevention	Backflow Prevention in accordance to IRC, Sec. P2902.2	P-110
9-6	Supply	No additives may be added to team's supply tank at anytime	Will comply on site
9-7	Waste	Waste products must be nontoxic and biodegradable	Will comply on site
9-8	Water Feature Safety	Not Applicable	N/A
10-1	Thermal Storage	All Thermal Storage devices must be made of stable and nontoxic materials	M-501
10-2	Paint Disposal	Teams are not permitted to dispose of paint on competition site	Spec 09 90 00
10-3	MSDS	MSDS are required for all potentially hazardous materials to be used at the event	Will be on site



# **SHOW-ME SOLAR HOUSE TEAM**

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## Construction Specifications



# SHOW-ME SOLAR HOUSE TEAM

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## SECTION 01 54 19 – TEMPORARY CRANES

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Temporary Crane will be used to lift hinged roof structure during assembly and disassembly.

### PART 2 - PRODUCTS

#### 2.01 TEMPORARY TRUCK CRANE

- A. Manitowoc, National Crane, Series 1400H.
  - 1. 127 ft. boom
  - 2. 33 ton lifting capacity

### PART 3 - EXECUTION

#### 3.01 USE

- A. Crane will be placed to best apply lift to the supported structure
- B. Operator will be trained to operate heavy machinery, and follow OSHA Safety Standards for crane operation
- C. Outriggers will be placed to prevent tripping or overloading of the ground.

END OF SECTION

## SECTION 04 22 00 - UNIT MASONRY

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Not Applicable.

### PART 2 - PRODUCTS

#### 2.1 MASONRY UNITS

- A. Concrete Masonry Units (Deck Pier Blocks): ASTM C 90; Weight Classification, Normal Weight Type I, moisture-controlled units.
  - 1. Special shape for insertion of wood deck pier.
  - 2. Size: 12 inches by 12 inches by 8 inches nominal.
  - 3. Shaped: trapezoid/truncated pyramid.
  - 4. Supplier: Midwest Products Group.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION, GENERAL

- A. Insert deck post firmly into each unit masonry deck pier block.

END OF SECTION

## SECTION 05 12 00 – STRUCTURAL STEEL FRAMING

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Engineer, fabricate, and erect Structural Steel framing to withstand design loads within the following limits:
  - 1. Floor Joists: Vertical deflection of  $L/360$ .
- B. Calculate structural characteristics of structural steel framing according to AISI's "Specification for the Design of Structural Steel Members."
- C. Comply with AWS D1.1, "Structural Welding Code--Steel," and AWS D1.3, "Structural Welding Code--Sheet Steel."

### PART 2 - PRODUCTS

#### 2.1 MATERIALS

- A. Steel Joists: Fabricate with flange width of 1-5/8 inches, uncoated steel design thickness of 0.0346 inch, and of depths indicated.
- B. Manufacturer/Product: HR 4"x7.7" HR

#### 2.2 ACCESSORIES

- A. Steel Shapes and Clips: ASTM A 36, hot-dip galvanized.
- B. Mechanical Fasteners: Corrosion-resistant coated, self-drilling, self-threading steel drill screws.

### PART 3 - EXECUTION

#### 3.1 FRAMING

- A. Install framing and accessories level, plumb, square, and true to line, and securely fasten.
- B. Fasten framing members by welding or screw fastening.
- C. Fasten reinforcement plates over web penetrations larger than standard punched openings.

END OF SECTION

## SECTION 05 20 00 – METAL JOISTS

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Engineer, fabricate, and erect Structural Steel framing to withstand design loads within the following limits:
  - 1. Floor Joists: Vertical deflection of  $L/360$ .
- B. Calculate structural characteristics of structural steel framing according to AISI's "Specification for the Design of Structural Steel Members."
- C. Comply with AWS D1.1, "Structural Welding Code--Steel," and AWS D1.3, "Structural Welding Code--Sheet Steel."

### PART 2 - PRODUCTS

#### 2.1 MATERIALS

- A. Steel Joists: Fabricate with flange width of 1-5/8 inches, uncoated steel design thickness of 0.0346 inch, and of depths indicated.
- B. Manufacturer/Product: Dietrich Metal Framing

#### 2.2 ACCESSORIES

- A. Steel Shapes and Clips: ASTM A 36, hot-dip galvanized.
- B. Mechanical Fasteners: Corrosion-resistant coated, self-drilling, self-threading steel drill screws.

### PART 3 - EXECUTION

#### 3.1 FRAMING

- A. Install framing and accessories level, plumb, square, and true to line, and securely fasten.
- B. Fasten framing members by welding or screw fastening.
- C. Fasten reinforcement plates over web penetrations larger than standard punched openings.

END OF SECTION

## SECTION 05 40 00 - COLD-FORMED METAL FRAMING

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Engineer, fabricate, and erect cold-formed metal framing to withstand design loads within the following limits:
  - 1. Floor Joists: Vertical deflection of  $L/360$ .
- B. Calculate structural characteristics of cold-formed metal framing according to AISI's "Specification for the Design of Cold-Formed Steel Structural Members."
- C. Comply with AWS D1.1, "Structural Welding Code--Steel," and AWS D1.3, "Structural Welding Code--Sheet Steel."
- D. Protect cold-formed metal framing from corrosion and other damage during delivery, storage, and handling.

### PART 2 - PRODUCTS

#### 2.1 MATERIALS

- A. Galvanized Steel Sheet: ASTM A 653, G60 (ASTM A 653M, Z180) zinc coated; structural quality; Grade 33 or Grade 50.
- B. Steel Joists: Fabricate with flange width of 1-5/8 inches, uncoated steel design thickness of 0.0346 inch, and of depths indicated.
- C. Manufacturer/Product: Dietrich Trade Ready Structural Blocking

#### 2.2 ACCESSORIES

- A. Steel Shapes and Clips: ASTM A 36, hot-dip galvanized.
- B. Cast-in-Place Anchor Bolts and Studs: ASTM A 307, Grade A; carbon-steel hex-head bolts and studs; carbon-steel nuts; and flat, unhardened-steel washers. Hot-dip galvanized.
- C. Mechanical Fasteners: Corrosion-resistant coated, self-drilling, self-threading steel drill screws.

### PART 3 - EXECUTION

#### 3.1 FRAMING

- A. Install framing and accessories level, plumb, square, and true to line, and securely fasten.
- B. Fasten framing members by welding or screw fastening.
- C. Fasten reinforcement plates over web penetrations larger than standard punched openings.
- D. Joists: Install, align, and securely anchor perimeter joist track. Install joists bearing on supporting framing, level, straight, and plumb, adjust to final position, brace, and reinforce. Fasten joists to both flanges of joist track.
  - 1. Install bridging and fasten bridging at each joist intersection.
  - 2. Install miscellaneous joist framing and connections, including web stiffeners, closure pieces, clip angles, continuous angles, hold-down angles, anchors, and fasteners.

END OF SECTION

## SECTION 06 10 00 - ROUGH CARPENTRY

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submit code evaluation reports for structural insulated panels and engineered wood products.

### PART 2 - PRODUCTS

#### 2.1 LUMBER

- A. Dressed lumber, S4S, 19 percent maximum moisture content for 2-inch thickness or less, marked with grade stamp of inspection agency, complying with the requirements of and stamped with the seal of the Forest Stewardship Council.
- B. Dimension Lumber: The following grades per inspection agency indicated.
  - 1. Interior Partitions: No. 2 grade or better: Fiber bending stress (Fb) of 1250 psi or better.
    - a. Plumbing walls: 2 x 6 nominal
    - b. Other interior partitions: 2 x 4 nominal.
  - 2. Framing Other Than Non-Load-Bearing Partitions: Construction or No. 2 grade.
- C. Miscellaneous Lumber: No. 3 or Standard grade of any species for nailers, blocking, and similar members.
- D. Wood Treatment (Exterior Wood): AWPACQ.

#### 2.2 PANEL PRODUCTS

- A. Subfloor: Warmboard structural subfloor with radiant panel by Warmboard, Inc.
  - 1. Panels with span ratings required by support spacing indicated.
  - 2. Thickness: 1-1/8 inches.
  - 3. Edges: tongue and groove.
  - 4. Aluminum sheet bonded to surface.
  - 5. Modular cut channels for radiant pipe installation.
  - 6. Span Rating: 24oc.

#### 2.3 STRUCTURAL INSULATED PANEL SYSTEM

- A. Manufacturer: Thermocore of Missouri.
  - 1. Oriented Strand Board Facing: 7/16 inch, exposure 1, APA rated, PS-2.
  - 2. Insulated Core: Class 1/A fire rated polyurethane, 2.3 lbs. minimum density.

3. Panel Thickness / R-value:
  - a. Roof: 6-1/2 inch nominal; R-value of 40.
  - b. Wall: 4 inch nominal; R-value of 24.
4. Dimensional Lumber in Core: SPF No. 2 or better.
5. Fasteners: 7/16 inch 16 gauge crown staples and 16p nails.

## 2.6 MISCELLANEOUS PRODUCTS

- A. Fasteners: Size and type indicated. Where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity, provide fasteners with a hot-dip zinc coating per ASTM A 153 or of Type 304 stainless steel.
  1. Power-Driven Fasteners: CABO NER-272.
  2. Bolts: Steel bolts complying with ASTM A 307, Grade A (ASTM F 568, Property Class 4.6); with ASTM A 563 (ASTM A 563M) hex nuts and, where required, flat washers.
- B. Metal Framing Anchors: Hot-dip galvanized steel of structural capacity, type, and size indicated.
- C. Sill-Sealer: Glass-fiber insulation, 1-inch (25-mm) thick, compressible to 1/32 inch (0.8 mm).
- D. Fasteners for Structural Insulated Panels: galvanized ring shank panel nails, or panel screws, as specified by panel manufacturer, for attachment of panel to frames, roofs, and corners. All fasteners to be sized and provided by manufacturer and installed per manufacturer's requirements.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Fit rough carpentry to other construction; scribe and cope for accurate fit. Correlate location of furring, blocking, and similar supports to allow attachment of other construction.
- B. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, and complying with applicable building codes.
- C. Use hot-dip galvanized or stainless-steel nails where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity.
- D. Install structural insulated panels according to manufacturer's installation instructions and recommendations, according to configurations and details shown on drawings.
- D. Installation of Structural-Use Panels: Comply with applicable recommendations contained in APA Form No. E30 and as follows:

1. Subflooring: Glue and screw to metal joist framing.

END OF SECTION

## SECTION 06 11 16 – MECHANICALLY GRADED LUMBER

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 LUMBER

- A. Dressed lumber, S4S, 19 percent maximum moisture content for 2-inch thickness or less, marked with grade stamp of inspection agency, complying with the requirements of and stamped with the seal of the Forest Stewardship Council.
- B. Dimension Lumber: The following grades per inspection agency indicated.
  - 1. Interior Partitions: No. 2 grade or better: Fiber bending stress (Fb) of 1250 psi or better.
    - a. Plumbing walls: 2 x 6 nominal
    - b. Other interior partitions: 2 x 4 nominal.
  - 2. Framing Other Than Non-Load-Bearing Partitions: Construction or No. 2 grade.
- C. Miscellaneous Lumber: No. 3 or Standard grade of any species for nailers, blocking, and similar members.
- D. Wood Treatment (Exterior Wood): AWPACQ.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Fit lumber to other construction; scribe and cope for accurate fit. Correlate location of furring, blocking, and similar supports to allow attachment of other construction.

END OF SECTION

## SECTION 06 14 00 – TREATED WOOD FOUNDATIONS

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 LUMBER

- A. Treated Wood Products: Scruggs Lumber

#### 2.6 MISCELLANEOUS PRODUCTS

- A. Fasteners: Size and type indicated. Where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity, provide fasteners with a hot-dip zinc coating per ASTM A 153 or of Type 304 stainless steel.
  - 1. Power-Driven Fasteners: CABO NER-272.
  - 2. Bolts: Steel bolts complying with ASTM A 307, Grade A (ASTM F 568, Property Class 4.6); with ASTM A 563 (ASTM A 563M) hex nuts and, where required, flat washers.
- B. Metal Framing Anchors: Hot-dip galvanized steel of structural capacity, type, and size indicated.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Fit rough carpentry to other construction; scribe and cope for accurate fit. Correlate location of furring, blocking, and similar supports to allow attachment of other construction.
- B. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, and complying with applicable building codes.
- C. Use hot-dip galvanized or stainless-steel nails where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity.

END OF SECTION

## SECTION 06 15 19 – TIMBER DECKING

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 LUMBER

- A. Treated Wood Products: Scruggs Lumber

#### 2.6 MISCELLANEOUS PRODUCTS

- A. Fasteners: Size and type indicated. Where decking is exposed to weather, in ground contact, or in area of high relative humidity, provide fasteners with a hot-dip zinc coating per ASTM A 153 or of Type 304 stainless steel.
  - 1. Power-Driven Fasteners: CABO NER-272.
  - 2. Bolts: Steel bolts complying with ASTM A 307, Grade A (ASTM F 568, Property Class 4.6); with ASTM A 563 (ASTM A 563M) hex nuts and, where required, flat washers.
- B. Non- exposed fasteners will be used when possible.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Fit rough carpentry to other construction; scribe and cope for accurate fit. Correlate location of furring, blocking, and similar supports to allow attachment of other construction.
- B. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, and complying with applicable building codes.
- C. Use hot-dip galvanized or stainless-steel nails where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity.

END OF SECTION

## SECTION 06 16 00 – SHEATHING SUBFLOORING

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Submit code evaluation reports for structural insulated panels and engineered wood products.

### PART 2 - PRODUCTS

#### 2.01 PANEL PRODUCTS

- A. Subfloor: Warmboard structural subfloor with radiant panel by Warmboard, Inc.  
<http://www.warmboard.com/wp-content/uploads/2008/10/0908-warmboard-brochure.pdf>
  - 1. Panels with span ratings required by support spacing indicated.
  - 2. Thickness: 1-1/8 inches.
  - 3. Edges: tongue and groove.
  - 4. Aluminum sheet bonded to surface.
  - 5. Modular cut channels for radiant pipe installation.
  - 6. Span Rating: 24oc.

#### 2.02 MISCELLANEOUS PRODUCTS

- A. Fasteners: Size and type indicated. Where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity, provide fasteners with a hot-dip zinc coating per ASTM A 153 or of Type 304 stainless steel.
  - 1. Power-Driven Fasteners: CABO NER-272.
  - 2. Bolts: Steel bolts complying with ASTM A 307, Grade A (ASTM F 568, Property Class 4.6); with ASTM A 563 (ASTM A 563M) hex nuts and, where required, flat washers.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install according to manufacturers specifications and design layout for radiant floor assembly.
- B. Use liquid nails and 2 inch hex sheet metal screws to attach to the joist system.

END OF SECTION

## SECTION 06 20 00 - FINISH CARPENTRY

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 MATERIALS, GENERAL

- A. Lumber Standards: DOC PS 20 and grading rules of inspection agencies certified by American Lumber Standards Committee Board of Review.
- B. Softwood Plywood: DOC PS 1.
- C. Provide Interior and Exterior Trim from reclaimed material from either quarter-sawn Missouri harvested oak or Elmwood Reclaimed Timber [www.elmwoodreclaimedtimber.com](http://www.elmwoodreclaimedtimber.com).
  - 1. Surface finish: Resawn or S4S.

#### 2.2 WOOD DECKING

- A. Wood Decking
  - 1. Manufacturer/Product: Quarter-sawn Missouri harvested oak or [Elmwood Reclaimed Timber](http://www.elmwoodreclaimedtimber.com) “Rustic Grade, Skimmed Barn Wood” : [www.elmwoodreclaimedtimber.com](http://www.elmwoodreclaimedtimber.com)
  - 2. Plank Size: nominal 3 inches by 3 to 12 foot random lengths.
  - 3. Plank Thickness: 3/4 inches.
  - 4. Edges: Tongue and Groove.
  - 5. Species: Mixed oak.

#### 2.3 MISCELLANEOUS MATERIALS

- A. Fasteners for Exterior Finish Carpentry: Stainless-steel or hot-dip galvanized steel nails.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Condition finish carpentry in installation areas for 24 hours before installing.
- B. Prime and backprime lumber for painted finish exposed on the exterior.

- C. Install finish carpentry level, plumb, true, and aligned with adjacent materials. Scribe and cut to fit adjoining work. Refinish and seal cuts.
- D. Install trim with minimum number of joints practical, using full-length pieces from maximum lengths of lumber available. Stagger joints in adjacent and related trim. Cope at returns and miter at corners.

END OF SECTION

## SECTION 06 22 16 - MILLWORK

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 MATERIALS, GENERAL

- A. Provide Interior millwork from reclaimed material from either quarter-sawn Missouri harvested oak or Elmwood Reclaimed Timber [www.elmwoodreclaimedtimber.com](http://www.elmwoodreclaimedtimber.com).
  - 1. Surface finish: Resawn or S4S.

#### 2.3 MISCELLANEOUS MATERIALS

- A. Fasteners for Interior Finish Carpentry: Hidden Fasteners

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Condition finish carpentry in installation areas for 24 hours before installing.
- B. Prime and backprime lumber for painted finish exposed on the exterior.
- C. Install finish carpentry level, plumb, true, and aligned with adjacent materials. Scribe and cut to fit adjoining work. Refinish and seal cuts.
- D. Install trim with minimum number of joints practical, using full-length pieces from maximum lengths of lumber available. Stagger joints in adjacent and related trim. Cope at returns and miter at corners.

END OF SECTION

## SECTION 07 21 00 - BUILDING INSULATION

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Surface-Burning Characteristics: ASTM E 84, flame-spread ratings of 75 or less and smoke-developed ratings of 450 or less.

### PART 2 - PRODUCTS

#### 2.1 INSULATION PRODUCTS

- A. Recycled Cellulosic-Fiber Loose-Fill Insulation: ASTM C 739.

#### 2.2 ACCESSORIES

- A. Vapor Retarder: 6 mil Polyethylene.
- B. Fasteners: Types and sizes as recommended by building insulation manufacturer.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install insulation in full thickness at interior bathroom walls and ceilings. Install fit tightly around obstructions and fill voids with insulation.
- B. Place loose-fill insulation to comply with ASTM C 1015.
  - 1. Comply with the Cellulose Insulation Manufacturers Association's "Special Report-Standard Practice for Installing Cellulose Insulation."
- C. Install vapor barrier at inside face of ceiling insulation. Extend vapor retarder to extremities of areas to be protected from vapor transmission. Secure in place with adhesives or other anchorage.

END OF SECTION

## SECTION 07 40 00 - METAL ROOFING SYSTEM

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 METAL ROOF PANELS

- A. Roof Panels: Steel, fabricated from structural-quality steel sheet galvanized according to ASTM A 653, G90; 0.034 inch thick minimum.
  - 1. Manufacturer/Product: [Unaclad; "UC-1"](#)
  - 2. Provide roof flashings and closures to match roof panels.
- B. Factory finish panel material by coil coating with 2-coat fluoropolymer according to ASTM A 755, composed of inhibitive primer and color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight, with a total minimum dry film thickness of 0.9 mil For steel.
  - 1. Color: White or Silver with a minimum SRI of 78.
- C. Roof Panel Assembly: batten-seam.
  - 1. Roof Panel Width: Nominal 12 inches.

#### 2.2 ACCESSORIES

- A. Underlayment: Self-adhering, polymer-modified, bituminous sheet ASTM D 1970, minimum of 40 mils thick.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Anchor panels securely in place, with provisions for thermal and structural movement. Field cutting exterior panels by torch is not permitted. Install panels with concealed fasteners, unless otherwise indicated.
- B. Install all components required for a complete and weatherproof panel assembly including trim, copings, fascia, ridge closures, clips, seam covers, battens, flashings, sealants,

gaskets, fillers, closure strips, and similar items.

- C. Separate dissimilar metals with a bituminous coating or rubberized-asphalt underlayment.

END OF SECTION

## SECTION 07 46 00 - SIDING

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submit research/evaluation reports from a model code organization acceptable to authorities having jurisdiction.

### PART 2 - PRODUCTS

#### 2.1 SIDING

- A. Wood Siding: Reclaimed, kiln-dried, Missouri oak.
  - 1. Manufacturer/Product: [Elmwood](http://www.elmwoodreclaimedtimber.com) Reclaimed Timber “Rustic Grade, Skimmed Barn Wood” : [www.elmwoodreclaimedtimber.com](http://www.elmwoodreclaimedtimber.com)
  - 2. Board Size: 6 inches by 3 to 12 foot random lengths.
  - 3. Board Thickness: 3/4 or 5/8 inches.
  - 4. Pattern: Tongue and Groove.
  - 5. Species: Mixed oak.
  - 6. Surface Finish: Rough sawn.
- B. Formed Fiber Cement Vertical Siding
  - 1. [James Hardie](http://www.jameshardie.com); “[HardiePanel Vertical Siding](http://www.jameshardie.com)” [www.jameshardie.com](http://www.jameshardie.com)
  - 2. Pattern/Texture: Smooth.
  - 3. Thickness: 5/16 inch.
  - 4. Color: Primed for painting.
- B. Accessories:
  - 1. Fiber Cement Siding Batten: Fry Reglet “FCP Vertical”. [www.fryreglet.com](http://www.fryreglet.com)
  - 2. Rain Screen: “Wall Screen” by Vaproshield, Inc. [www.vaproshield.com](http://www.vaproshield.com)
  - 3. Rain Screen Flashing: “3D Flashing” by Vaproshield, Inc.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install rain screen over all exterior walls prior to installation of siding. Install rain screen flashing at all window, door, and opening perimeters.
- B. Install siding, trim, and accessories according to manufacturer’s installation instructions and requirements.

1. Install vertical siding with accessory metal joint as shown.
- D. Install wood siding level, plumb, true, and aligned with adjacent materials. Scribe and cut to fit adjoining work. Refinish and seal cuts. Install trim with minimum number of joints practical, using full-length pieces from maximum lengths of lumber available. Stagger joints in adjacent and related trim. Cope at returns and miter at corners.

END OF SECTION

## SECTION 07 60 00 - SHEET METAL FLASHING AND TRIM

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 SHEET METAL

- A. Galvanized Steel Sheet: ASTM A 653, commercial quality, lock-forming quality, hot-dip galvanized.

#### 2.2 FLASHING AND TRIM

- A. Fabricate sheet metal flashing and trim to comply with recommendations of SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of the item indicated.
- B. Fabricated Sheet Metal Items:
  - 1. Gutters: 4 inches by 4 inches, square.
    - a. Gutter Straps: 1/8 inch by 1 inch, 3 foot spacing.
  - 2. Downspouts: 3 inches by 3 inches rectangular, non-corrugated.
    - a. Downspout attachment straps: 1/16 inch by 1 inch, 3 per downspout up to 10 feet, 4 per downspout up to 15 feet, 5 per downspout up to 20 feet.
  - 3. Drip Edge: 4 inches exposed or roofing manufacturer's standard.
- C. Coil-coat galvanized steel sheet with 2-coat finish.
  - 1. Color: White or silver, with a SRI index of 78 minimum.

#### 2.3 ACCESSORIES

- A. Solder: ASTM B 32, Grade Sn50.
- B. Asphalt Mastic: SSPC-Paint 12, asbestos free, solvent type.
- C. Roofing Cement: ASTM D 4586, Type I, asbestos free, asphalt based.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Comply with SMACNA's "Architectural Sheet Metal Manual." Allow for thermal expansion; set true to line and level. Install Work with laps, joints, and seams permanently watertight and weatherproof; conceal fasteners where possible.
- B. Sealed Joints: Form nonexpansion, but movable, joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.
- C. Fabricate nonmoving seams in sheet metal with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
  - 1. Clean surfaces to be soldered, removing oils and foreign matter. Pre-tin edges of sheets to be soldered to a width of 1-1/2 inches, unless pre-tinned surface would show in finished Work.
- D. Separations: Separate noncompatible metals or corrosive substrates with a coating of asphalt mastic or other permanent separation.

END OF SECTION

## SECTION 07 92 00 - JOINT SEALANTS

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 JOINT SEALANTS

- A. Compatibility: Provide joint sealants, joint fillers, and other related materials that are compatible with one another and with joint substrates under service and application conditions.
- B. Exterior Elastomeric Sealant: Comply with ASTM C 920.
  - 1. One-part, high-modulus, neutral-curing silicone sealant, Type S; Grade NS; Class 25; Uses NT, M, G, A, and O.
- C. Interior Acrylic-Emulsion Sealant: One-part, nonsag, mildew-resistant, paintable, acrylic-emulsion sealant complying with ASTM C 834.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Comply with ASTM C 1193.

END OF SECTION

## SECTION 08 10 00 – METAL DOORS AND FRAMES

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Comply with ANSI/SDI 100.

### PART 2 - PRODUCTS

#### 2.1 MATERIALS (Exterior Doors 100, 102)

- A. Hot-Rolled Steel Sheets: ASTM A 569.
- B. Cold-Rolled Steel Sheets: ASTM A 366, commercial quality or ASTM A 620, drawing quality.
- C. Galvanized Steel Sheets: ASTM A 653, commercial quality or ASTM A 642, drawing quality, with A60 or G60 coating designation, mill phosphatized.

#### 2.2 STEEL DOORS AND FRAMES

- A. Steel Doors: 1-3/4-inch- thick of materials and ANSI/SDI 100 grades and models specified below, and as indicated on Drawings and schedules:
  - 1. Exterior Doors: Grade II, heavy-duty, Model 2, seamless design, galvanized steel sheet faces.
    - a. Core: polystyrene and honeycomb.
  - 2. Supplier: [Triple-B Doors](#).
- B. Fabricate steel frames to be rigid, neat in appearance, and free from defects, warp, or buckle.
  - 1. For exterior frames, provide units with mitered or coped and continuously welded corners, formed from 0.0635-inch- thick, galvanized steel sheet.
- C. Prepare doors and frames to receive mortised and concealed hardware according to SDI 107.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Place steel frames to comply with provisions of SDI 105.
- B. Install steel doors accurately in frames, within clearances specified in ANSI/SDI 100.

END OF SECTION

## SECTION 08 20 00 - FLUSH WOOD DOORS

### PART 1 - GENERAL

- A. Quality Standard: NWWDA I.S.1-A.

### PART 2 - PRODUCTS

#### 2.1 FLUSH WOOD DOORS

- A. Interior Solid Core Doors for Opaque Finish: Premium Grade, 5 or 7- ply, particleboard core.
  - 1. Faces: Any closed-grain hardwood.

#### 2.2 FABRICATION AND FINISHING

- A. Factory fit doors to suit frame-opening sizes indicated and to comply with referenced quality standard.
- B. Factory machine doors for hardware that is not surface applied.
- C. Cut and trim openings to comply with referenced standards.
  - 1. Trim light openings with moldings indicated.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Align and fit doors in frames with uniform clearances and bevels. Machine doors for hardware. Seal cut surfaces after fitting and machining.
- B. Align factory-fitted doors in frames for uniform clearances.

END OF SECTION

## SECTION 08 50 00 - METAL WINDOWS

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 METAL WINDOWS

- A. Fixed, double hung, and project-out metal windows as indicated in window schedule.
- B. Quaker Windows "Brighton Series".
  - 1. Frame Depth: 2-3/8 inches.
  - 2. Glazing: 1 inch insulated, tempered with Low-E coating.
  - 3. Finish: baked on polyester, white.
  - 4. Insect screen: aluminum mesh.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Provide all hardware, operators, anchors, clips, limit devices, and other components necessary for a complete and weathertight installation.
- B. Install the panel system in accordance with the manufacturer's installation recommendations..
  - 1. Anchor component parts securely in place by permanent mechanical attachment system.
  - 2. Accommodate thermal and mechanical movements.
  - 3. Set perimeter framing in a full bed of sealant compound, or with joint fillers or gaskets to provide weather-tight construction.

END OF SECTION

## SECTION 08 71 00 - DOOR HARDWARE

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 HARDWARE

- A. Door Hardware: As indicated in the Schedule at the end of this Section.
  - 1. Nonremovable hinge pins for all exterior doors.
  - 2. Cylinders with 7-pin tumblers.
- B. Key locks to key control system.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Mount hardware in locations recommended by the Door and Hardware Institute, unless otherwise indicated.
- B. Hardware Schedule:
  - 1. Exterior Doors (100, 102)
    - a. Latchsets/Locksets: [Best 7KC](#) 626 lever handle 15D S3. [www.bestaccess.com](http://www.bestaccess.com)
    - b. Hinges: 1-1/2 pair, 626 brass. 4-1/2 x 4 x 0.134. [Hager 1191](#) [www.hagerhinge.com](http://www.hagerhinge.com)
    - c. Operation: AB (entrance).
    - d. Stops (102 only): wall mounted. [Stanley CD57-5411](#), or approved equal.
    - e. Closer: [LCN 4020](#), non-handed. Painted chrome finish.
    - f. Weatherstripping:
      - 1) [Pemko HS S2000](#), adhesive silicone gasket. [www.pemko.com](http://www.pemko.com)
      - 2) [Pemko 18041NB](#) door sweep.
    - g. Threshold: ½ inch by 4 inch ribbed aluminum. [Pemko 192](#).
  - 2. Bathroom Door (101)
    - a. Sliding Door Track and Rollers: [Stanley Hardware](#) “405843 Pocket Door Kit” [www.stanleyhardware.com](http://www.stanleyhardware.com).
    - b. Pull: [Trimco ADA pull](#), “1069L-26D”.
    - c. Operation: Sliding.

END OF SECTION

## SECTION 09 20 00 - GYPSUM BOARD ASSEMBLIES

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 GYPSUM BOARD

- A. Gypsum board products in maximum lengths available to minimize end-to-end butt joints.
  - 1. Gypsum Wallboard: ASTM C 36, 5/8 inch thickness, Type X, with manufacturer's standard edges.
  - 2. Water-Resistant Gypsum Backing Board: ASTM C 630, 5/8 inch thickness, Type X.

#### 2.2 ACCESSORIES

- A. Accessories for Interior Installation: Cornerbead, edge trim, and control joints complying with ASTM C 1047, formed from steel sheet zinc coated by hot-dip process or rolled zinc or plastic.
- B. Gypsum Board Joint Treatment Materials: Comply with ASTM C 475. Paper reinforcing tape and drying-type, ready-mixed, all-purpose compounds.
- C. Cementitious Backer Units: ANSI A118.9.
- D. Cementitious Backer Unit Joint Treatment Materials: Comply with ASTM C 475.
- E. Miscellaneous Materials: Auxiliary materials for gypsum board construction that comply with referenced standards.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install and finish gypsum panels to comply with ASTM C 840 and GA-216.
  - 1. Install cementitious backer units to comply with ANSI A108.11.
  - 2. Single-Layer Fastening Methods: Fasten gypsum panels to supports with screws.
- B. Finishing Gypsum Board Assemblies: Level 5 finish, unless otherwise indicated, except Level 2 finish where panels form substrates for tile.

END OF SECTION

## SECTION 09 30 00 - TILE

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 CERAMIC TILE

- A. Ceramic tile that complies with Standard Grade requirements of ANSI A137.1, "Specifications for Ceramic Tile."
- B. Tile Schedule: Dal-Tile [www.daltileproducts.com](http://www.daltileproducts.com)
  - 1. Bathroom Walls: "Modern Dimensions"
    - a. Size: 4-1/4 inches x 12-3/4 inches x 5/16 inches.
    - b. Color: Matte Arctic White #0790
  - 2. Bathroom Floor: "Colorbody Keystone"
    - a. Size: 1 inch x 1 inch x 1/4 inches.
    - b. Color: Artesian Brown #D144
  - 3. Bathroom Accent: "Glass Mosaics"
    - a. Size: 2 inches x 2 inches x 1/4 inches.
    - b. Color: Pearl Gray #VG 32
- C. Tile trim and cove base units that match characteristics of adjoining flat tile.
- D. Tiles mounted, by manufacturer's standard method, into sheets, unless otherwise indicated

#### 2.2 CERAMIC TILE-SETTING AND -GROUTING MATERIALS

- A. Materials complying with ANSI standards.
- B. Epoxy Adhesive: ANSI A118.3, thinset bond type.
- C. Standard Grout: Cement grout, sanded or unsanded, as specified in ANSI A118.6.
  - 1. Color: White.

#### 2.3 ACCESSORIES

- A. Setting-bed accessories complying with ANSI A108.1A.
- B. Cementitious backer units complying with ANSI A118.9, of thickness indicated.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with parts of ANSI A108 series of tile installation standards in "Specifications for Installation of Ceramic Tile" that apply to types of setting and grouting materials and to methods indicated.
- B. Comply with TCA's "Handbook for Ceramic Tile Installation."
- C. Provide cementitious backer units and treat joints to comply with ANSI A108.11.
- D. Install in accordance with TCA Handbook Method F142 and F143, with standard grout, unless otherwise indicated.
- E. Lay tile in grid pattern, unless otherwise indicated. Align joints where adjoining tiles on floor, base, walls, and trim are the same size.
- F. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

END OF SECTION

## SECTION 09 64 00 - WOOD FLOORING

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 WOOD FLOORING

- A. Site-finished wood flooring:
  - 1. Manufacturer/Product: Missouri harvested quarter-sawn oak or Elmwood Reclaimed Timber “Rustic Grade, Skimmed Barn Wood” :  
[www.elmwoodreclaimedtimber.com](http://www.elmwoodreclaimedtimber.com)
  - 2. Plank Size: 3 inches by 3 to 12 foot random lengths.
  - 3. Plank Thickness: 5/8 inches.
  - 4. Edges: Tongue and Groove.
  - 5. Species: Mixed oak.
- B. Wood reducing strips and trims: of same species, grade, cut, and finish as wood flooring.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Method: Adhesive and Nailed.
- B. Where change in laying direction is indicated, kerf ends of boards and install steel spline.
- C. After installation of wood flooring to be site-finished, machine-sand surface smooth, using coarse, medium, and fine (No. 00) paper. Sand to remove offsets or observable nonlevel conditions.

END OF SECTION

## SECTION 09 90 00 – PAINTING

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Obtain wood fillers, primers, and undercoat materials for each coating system from the same manufacturer as the finish coats.
- B. Paint all exposed surfaces of fiber cement siding, metal railings, interior gypsum board, metal door frames, unless otherwise indicated.
- C. Apply clear sealer to all exposed surfaces of exterior and interior wood trim, wood flooring, unless otherwise indicated.
- D. Do not paint prefinished items, finished metal surfaces, operating parts, labels, and materials obviously intended to be left exposed such as brick and tile. Do not paint concealed surfaces.

### PART 2 - PRODUCTS

#### 2.1 PAINT / SEALER

- A. Manufacturer's best-quality paint material of the various coating types specified.
- B. Paint Manufacturer: [Sherwin Williams. www.sherwin-williams.com](http://www.sherwin-williams.com)
  - 1. No/Low VOC and water-based products.
- C. Sealer Manufacturer: [AFM Safecoat. www.afmsafecoat.com](http://www.afmsafecoat.com)
  - 1. No/Low VOC and water-based products.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Comply with paint and sealers manufacturer's written instructions for surface preparation, environmental and substrate conditions, product mixing, and application.

#### 3.2 EXTERIOR SCHEDULE

- A. Ferrous and Galvanized Metal, Fiber Cement Siding:
  - 1. “Pro Industrial 0 VOC Acrylic”: Semi-gloss, Acrylic: 2 coats over rust-inhibitive primer.

2. Color: White.

B. Exterior Wood Siding, Decking, and Trim:

1. "Polyureseal BP": Waterborne, Satin Acrylic Polyurethane: 2 coats clear-low lustre over sealer.

3.3 INTERIOR SCHEDULE

A. Gypsum Board, Ferrous and Galvanized Metal, Interior Wood Door:

1. "Harmony Interior Latex": No VOC, Eggshell Latex: 2 coats over primer.
2. Color: Olympus White 6253.

B. Interior Wood Trim and Flooring:

1. "Polyureseal BP": Waterborne, Satin Acrylic Polyurethane: 2 coats clear-low lustre over sealer.

END OF SECTION

## SECTION 10 28 00 - TOILET AND BATH ACCESSORIES

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 TOILET AND BATH ACCESSORIES

- A. Toilet and bath accessories:
  - 1. Manufacturer: [Hewi. www.hewi.com](http://www.hewi.com)
    - a. Toilet Grab Bar: [988.65.1](#)
    - b. Shower Grab Bar: [988.68.5](#)
    - b. Toilet Paper Holder: [988.80.499](#).
    - c. Mirrors: [988.35.399](#)
    - d. Folding Shower Seat: [988.776.7](#)
  - 2. Color: 99 Pure White.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install toilet accessory units using fasteners appropriate to substrate. Install units level and plumb, firmly anchored in locations, and at heights indicated. Comply with provisions of ADAAG for installation of units required to be accessible to the disabled.

END OF SECTION

## SECTION 10 70 00 – SUNSHADE LOUVERS

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 MATERIALS

- A. Galvanized Steel Sheet: ASTM A 653, G90 zinc coating, mill phosphatized.
- B. Fasteners: Of same basic metal and alloy as fastened metal or 300 series stainless steel.

#### 2.2 SUNSHADE LOUVERS

- A. Horizontal, drainable, fixed-blade, formed-metal louvers.
  - 1. Manufacturer/Product: Hunter Douglas “Aerobrise 100”.  
[www.hunterdouglascontract.com](http://www.hunterdouglascontract.com)
  - 2. Louver Depth: 4 inches (100 mm) nominal.
  - 3. Metal and Thickness: Galvanized steel sheet, 0.020 (0.5 mm).
  - 4. Blade Profile: Bullet shape.
  - 5. Accessories: end caps, framing clips, channels, and fastenrs.
  - 6. Finish: White Fluoropolymer.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install sunshade louvers level, plumb and at indicated alignment with adjacent work.
- B. Space louvers at 6 inches on center and between supports at 3 feet maximum.
- C. Use concealed anchorages where possible.
- D. Protect metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

END OF SECTION

## SECTION 11 40 00 - APPLIANCES

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.1 RESIDENTIAL APPLIANCES

- A. Manufacturer: KitchenAid unless otherwise noted. [www.kitchenaid.com](http://www.kitchenaid.com)
- B. Cooktop / Range: "Induction Hybrid Cooktop KICU508SBL"
- C. Oven / Microwave: "Combination Microwave and Built-in Oven KEMS308SSS"
- D. Refrigerator: "KBRC36FTS"
- E. Dishwasher: "KUDS03STSS"
- F. Washer: Whirlpool "Duet Steam Washer" [www.whirlpool.com](http://www.whirlpool.com)
- G. Dryer: Whirlpool "Duet Steam Dryer"

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Securely anchor built-in appliances to supporting cabinetry or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and rough openings are completely concealed.
- B. Place freestanding appliances in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.

END OF SECTION

## SECTION 12 24 00 – WINDOW SHADES

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Window Shades will comply with manufacturer specification.

### PART 2 - PRODUCTS

#### 2.1 MOTORIZED WINDOW SHADES

- A. Window Shades, Insolroll, Elevate Motorized Lift System
  - 1. The motor will have quiet operation and reliability.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Window shades and motors will be installed according to the manufacturer's specifications and installation manuals.
- B. Fabrics and materials will be made from recycled material and have little to no off-gassing effect.

END OF SECTION

## SECTION 12 30 00 - CABINETRY

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Comply with ANSI/KCMA A161

### PART 2 - PRODUCTS

#### 2.1 CASEWORK

- A. Modular or custom casework:
  - 1. AWI Grade: Premium.
    - a. Style: Flush Overlay.
    - b. Door Material:
      - (1) Manufacturer: Kirei USA [www.kireiusa.com](http://www.kireiusa.com)
      - (2) Material: "Kirei Board" reclaimed sorghum straw, no formaldehyde or VOCs.
      - (3) Thickness: 3/4 inch nominal (20mm).
    - c. Cabinet Body Material: birch veneer plywood
      - (1) Thickness: 1/2 and 3/4 inch nominal.
    - d. Hardware:
      - (1) Pulls: none.
      - (2) Drawer Slides: 75 pounds, minimum.
      - (3) Hinges: European style, concealed.
      - (4) Catches: Magnetic with touch latch.
      - (5) Concealed adjustable shelf supports: flush pilasters and pilaster brackets.
      - (6) Folding door: size to support weight of doors.
  - 2. Cabinet Fabricator: Mark Hall Fine Cabinetry.
- B. Countertops and splashes:
  - 1. Manufacturer: EnRich Construction, Columbia, Missouri.
  - 2. Countertop Thickness: 1 inch nominal.
  - 3. Countertop Material: Recycled glass and porcelain and color-customizable resin.
  - 4. Resin Color: Alabaster White.
  - 5. Glass Color: Clear.
  - 6. Finish: Matte.
- C. Countertop configuration:
  - 1. Front Style: Square.

## SECTION 12 44 00 – BATH FURNISHINGS

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Used to facilitate contests for the US department of Energy Solar Decathlon.
- B. towels will be washed and dried to compare the appliance energy usage for a standard set of bath towels.

### PART 2 - PRODUCTS

#### 2.1 TOWELS

- A. Anvil Promotional Beach Towel, CCC Promo West, CCC #48075.

#### 2.2 SHOWER LINENS

- A. Shower Curtain, Walmart, Mod Square Shower Curtain.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Bath Furnishings will be used or installed per the manufacturer's recommendation procedure.
- B. Towels will not be used except for in the SD contest.

END OF SECTION

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install casework with no variations in flushness of adjoining surfaces by using concealed shims. Where casework abuts other finished work, scribe and cut for accurate fit. Provide filler strips, scribe strips, and moldings in finish to match casework face.
- B. Install casework without distortion so doors and drawers fit openings properly and are aligned.
- C. Install casework and countertop level and plumb to a tolerance of 1/8 inch in 8 feet.
- D. Fasten each unit of casework to adjacent unit and into structural members of wall construction.
- E. Fasten countertops by screwing through corner blocks in base units into underside of countertop. Spline and glue joints in countertops and provide concealed mechanical clamping of joints.

END OF SECTION

## SECTION 22 11 00 - WATER PIPING

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.01 PIPES AND TUBES

- A. Hard Copper Tube: ASTM B 88, Types L and M, water tube, drawn temper.
- B. Soft Copper Tube: ASTM B 88, Types K and L, water tube, annealed temper.
- C. PVC Foam Core, Water Pipe: ASTM D 1785, Schedules 40 and 80, plain ends. [PVC Foam Core](#)
- D. PEX, PEX Tube: ASTM F 876, 877. [PEX](#)
- E. PEX-AL, PEX Aluminum Tube: ASTM F 1281. [PEX-AL](#)

#### 2.02 FITTINGS

- A. Wrought-Copper, Solder-Joint Pressure Fittings: ASME B16.22.
- B. Cast-Copper-Alloy, Solder-Joint Pressure Fittings: ASME B16.18.
- C. Bronze Flanges: ASME B16.24, Classes 150 and 300.
- D. Copper Unions: ASME B16.18, cast-copper-alloy body, hexagonal stock, with ball-and-socket joint, metal-to-metal seating surfaces, and solder-joint, threaded, or solder-joint and threaded ends. Threads complying with ASME B1.20.1.
- E. PEX Press Fitting: ASTM F-1281
- F. PEX Compression Fitting: ASTM F-1281
- G. PVC Plastic, Schedule 40, Socket-Type Pipe Fittings: ASTM D 2466.

#### 2.03 JOINING MATERIALS

- A. Pipe Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

- B. Solder Filler Metal: ASTM B 32, alloys to suit system requirements.
- C. Brazing Filler Metals: AWS A5.8, alloys to suit system requirements.
- D. Solvent Cements: As recommended by manufacturer.
- E. Plastic Pipe Seals: ASTM F 477, elastomeric gasket.

## PART 3 - EXECUTION

### 3.01 PIPING APPLICATIONS

- A. Install listed pipe materials and joining methods below in the following applications:
  - 1. Aboveground: Hard copper tube, Type M; wrought-copper or cast-copper-alloy pressure fittings; copper unions; bronze flanges; and solder joints with Alloy Sn95, Sn94, or E solder.

### 3.02 VALVE APPLICATIONS

- A. Install gate valves close to main on each branch and riser serving 2 or more plumbing fixtures or equipment connections and where indicated.
- B. Install gate or ball valves on inlet to each plumbing equipment item, on each supply to each plumbing fixture not having stops on supplies, and elsewhere as indicated.
- C. Install drain valve at base of each riser, at low points of horizontal runs, and where required to drain water distribution piping system.
- D. Install swing check valve on discharge side of each pump and elsewhere as indicated.
- E. Install ball valves in each hot-water circulating loop and discharge side of each pump.

### 3.03 PIPING INSTALLATIONS

- A. Install hangers and supports at intervals indicated in the applicable Plumbing Code and as recommended by pipe manufacturer.
- B. Support vertical piping at each floor.

### 3.04 INSPECTING AND CLEANING

- A. Inspect and test piping systems following procedures of authorities having jurisdiction.

- B. Clean and disinfect water distribution piping following procedures of authorities having jurisdiction.

END OF SECTION

## SECTION 22 12 00– FACILITY GROUND-MOUNTED POTABLE WATER STORAGE TANKS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Sized according to water demand during the competition to accommodate necessary contests.

### PART 2 - PRODUCTS

#### 2.01 GROUND MOUNTED WATER TANK

- A. 800 Gallon water storage tank supply: [www.plastic-mart.com](http://www.plastic-mart.com).  
<http://www.plastic-mart.com/class.php?item=606>
- B. 800 Gallon water storage tank waste: [www.plastic-mart.com](http://www.plastic-mart.com).  
<http://www.plastic-mart.com/class.php?item=606>

### PART 3 - EXECUTION

#### 3.01 INSTALLATIONS

- A. Installation and fittings to accommodate flow from supply and to waste.
- B. Installation to comply with SD Building Code, to facilitate with ground contact rulings.
- C. No waste shall enter either the supply or waste tank.
- D. Will comply with spill containment rulings.

END OF SECTION

## SECTION 22 35 23 - DOMESTIC WATER HEAT EXCHANGERS

### PART 1 - GENERAL

Not Applicable

### PART 2 - PRODUCTS

#### 2.01 CIRCULATING HEAT EXCHANGERS

- A. Circulating, Domestic Water Heat Exchangers: UL E-113265 [Model SCC-119SB](#)

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Installation will be to manufacturer's instruction.
- B. Will be installed plumb and level.

#### 3.02 INSPECTION

- A. Connections are to be tested to ensure safe work practices

END OF SECTION

## SECTION 22 40 00 - PLUMBING FIXTURES

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Comply with requirements of Public Law 102-486, "Energy Policy Act," regarding water flow rate and water consumption of plumbing fixtures.

### PART 2 - PRODUCTS

#### 2.01 WATER CLOSET

- A. Vitreous-China Water Closet: Kohler, San Raphael™ one-piece elongated toilet - K-3466, white. [http://www.us.kohler.com/onlinecatalog/pdf/1013536\\_4.pdf](http://www.us.kohler.com/onlinecatalog/pdf/1013536_4.pdf)
- B. Toilet Seat: Kohler, Lustra K-4650, white. [http://www.us.kohler.com/onlinecatalog/pdf/1031217\\_4.pdf](http://www.us.kohler.com/onlinecatalog/pdf/1031217_4.pdf)
- C. Fixture Support: Vertically adjustable, cast-iron, water-closet carrier with combination support and waste fitting assemblies and tiling frame or setting gage. Include additional faceplate and coupling for water closet at wide pipe space. Compact-type carrier for back-to-back water-closet installation is prohibited.

### PART 3 - EXECUTION

#### 3.01 INSTALLATIONS

- A. Install fitting insulation kits on handicap-accessible fixtures.
- B. Install fixtures with flanges and gasket seals.
- C. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for handicapped people to reach.
- D. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.
- E. Fasten wall-hanging plumbing fixtures securely to supports attached to building substrate

when supports are specified, and to building wall construction where no support is indicated.

- F. Fasten floor-mounted fixtures to substrate. Fasten fixtures having holes for securing fixture to wall construction, to reinforcement built into walls.
- G. Fasten wall-mounted fittings to reinforcement built into walls.
- H. Fasten counter-mounting plumbing fixtures to casework.
- I. Secure supplies to supports or substrate within pipe space behind fixture.
- J. Set shower receptors and mop basins in leveling bed of cement grout.
- K. Install individual supply inlets, supply stops, supply risers, and tubular brass traps with cleanouts at fixture.
- L. Install water-supply stop valves in accessible locations.
- M. Install traps on fixture outlets. Omit traps on fixtures having integral traps. Omit traps on indirect wastes, unless otherwise indicated.
- N. Install disposers in sink outlets. Install switch where indicated, or in wall adjacent to sink if location is not indicated.
- O. Install hot-water dispensers in back top surface of sink or in counter with spout over sink.
- P. Install escutcheons at wall, floor, and ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons where required to conceal protruding pipe fittings.
- Q. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color.
- R. Install piping connections between plumbing fixtures and piping systems and plumbing equipment. Install insulation on supplies and drains of handicap-accessible fixtures.
- S. Ground equipment. Tighten electrical connectors and terminals according to UL 486A and UL 486B.

END OF SECTION

## SECTION 23 31 13 – METAL DUCTS

### PART 1 - GENERAL

#### 1.1 GENERAL REFERENCE

- A. The sizing and placement of the metal duct will comply with the sizing standards attributed to the industry: SMACNA Residential Duct Sizing, and ASHRAE.
- B. Connections of the duct to the air supply will be made by best practice methods within the field.

### PART 2 - PRODUCTS

#### 2.1 RECTANGULAR DUCT

- A. DUCT
  - 1. Standard Rectangular Sheet Metal Duct: 12” x 4”

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Metal Rectangular Ducts will be laid out such that there is the least amount of distance between the supply and the in-room diffuser.
- B. Finishing Gypsum Board Assemblies: Level 5 finish, unless otherwise indicated, except Level 2 finish where panels form substrates for tile.

END OF SECTION

## SECTION 23 34 23 - POWER VENTILATORS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Submit Product Data. Renewaire
- C. Bear the AMCA seal.
- D. Comply with applicable NEMA standards.
- E. Comply with UL 705.

### PART 2 - PRODUCTS

#### 2.01 VENTILATORS AND ACCESSORIES

- A. Centrifugal Wall-Mounted Ventilators: Renewaire EV70,

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Ground power ventilators.
- B. Tighten electrical connectors and terminals according to UL 486A and UL 486B.

END OF SECTION

## SECTION 23 36 16 – VARIABLE AIR VOLUME UNIT

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Specified with SMACNA.
- B. Specified to comply with ASHRAE Residential Standards.
- C. Complies with ENERGY STAR® guidelines.

### PART 2 - PRODUCTS

#### 2.01 AIR HANDLING UNIT

- A. TRANE: 2/4 TEE VARIABLE SPEED. Model 2/4 TEE 3D31.
  - 1. Specified with 2.5 tons.
  - 2. Refrigerant type: R-410A.

#### 2.02 FILTRATION UNIT

- A. TRANE CLEAN EFFECTS™.
  - 1. Removes particles to 0.1 microns

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install according to TRANE manufacturing specifications.
- B. Attached to Duct lines according to SMACNA specifications and best practice methods.

END OF SECTION

## SECTION 23 37 13 – DIFFUSERS, REGISTERS, AND GRILLS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. The diffusers and grills shall work to evenly distribute the cool air through the space.

### PART 2 - PRODUCTS

#### 2.01 REGISTER

- A. Hart and Cooley: 651 Register, White, 12" x 8", Metal

#### 2.02 GRILLES

- A. Hart and Cooley: 650 Return Air Grille, White, 12" x 8", Metal

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Fasten level and plumb.
- B. Check damper as fully functional.

### END OF SECTION

## SECTION 23 64 00 – PACKAGED WATER CHILLERS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Comply with ARI 460.
- B. Comply with ASHRAE 15.
- C. Comply with UL 303.

### PART 2 - PRODUCTS

#### 2.01 WATER TO WATER HEAT PUMP

- A. Trane: WPWD024 10C2100T, 15.20 SEER

#### 2.02 ACCESSORIES

- A. Precharged and insulated refrigerant suction and liquid tubing.
- B. Head-pressure control to modulate condenser-fan motor speed for low ambient conditions.
- C. Low-voltage control transformer.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install units level and plumb, and maintain recommended clearances.
- B. Install ground-mounted units on 4-inch- (100-mm-) thick reinforced-concrete base. Anchor unit to pad using inserts or anchor bolts. Install roof-mounted units on mechanical equipment curb. Anchor unit to structural frame with removable fasteners.
- C. Install electrical devices.

END OF SECTION

## SECTION 23 81 00 – DECENTRALIZED UNITARY HVAC EQUIPMENT

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Submit Shop Drawings, including mounting and installation details for roof curbs and coordination with roofing system.
- C. Comply with ASHRAE 15.
- D. EER: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Building, except Low-Rise Residential Buildings."

### PART 2 - PRODUCTS

#### 2.01 PACKAGED UNITS, 20 TONS (70 kW) OR LESS

- A. Factory assembled and tested, consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, filters, and dampers. Trane: 2/4TEE3D31
- B. Operating Controls: Include economizer controls, low ambient control for compressors, and remote thermostat that provides staged heating and cooling with manual or automatic changeover on a standard subbase. For units 7.5 tons (26 kW) and larger include smoke detectors and fire thermostats.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install units level and plumb and firmly anchored.
- B. Connect to supply and return hydronic piping with shutoff valve and union or flange at each connection.
- C. Install ducts to termination in roof mounting frames. Terminate return-air duct through roof structure.
- D. Connect units to wiring systems and to ground.
- E. Tighten connectors and terminals according to tightening torques specified in UL 486A

and UL 486B.

END OF SECTION

## SECTION 23 82 36 - FINNED-TUBE RADIATION

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Submit Product Data, including color charts for cabinet finishes.
- B. Test and rate according to the Hydronics Institute.

### PART 2 - PRODUCTS

#### 2.01 FACTORY-ASSEMBLED UNITS

- A. Apricus: HD 25 Heat Dissipater,
- B. Aluminum fins mechanically bonded to copper tube water and having ratings based on design tests performed by the Hydronics Institute. Furnish with wall mounting brackets and steel enclosure with extruded-aluminum discharge grille.
- C. Cabinet Finish: Bonderized, phosphatized, baked-enamel finish in manufacturer's standard color, white.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install access fitting in cabinets for access to valves and other fittings.
- B. Use manufacturer's filler pieces and end caps.
- C. Connect to supply and return hydronic piping with shutoff valve and union or flange at each connection.
- D. Connect units to wiring systems and to ground.
- E. Tighten connectors and terminals according to tightening torques specified in UL 486A and UL 486B.

END OF SECTION

## SECTION 23 83 34 – RADIANT HEATING PUMPBOARD

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Design and testing according to Watts Radiant design and layout specifications.
- B. Testing and inspection shall be done according to Watts Radiant testing and pressurization techniques.

### PART 2 - PRODUCTS

#### 2.01 PUMPBOARD

- A. Watts Radiant Pumpboard:

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install according to Watts Radiant Specifications for installation.
- B. Clamp PEX tubing to pumpboard assembly according standard practice using PEX and PEX-AL.
- C. Connect to supply and return hydronic piping with shutoff valve and union or flange at each connection.
- D. Connect units to wiring systems and to ground.

#### 3.02 INSPECTION

- A. The system will be pressurized according to the SD Building Code and best practice methods.

END OF SECTION

## SECTION 23 84 00 – HUMIDITY CONTROL EQUIPMENT

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Submit Shop Drawings, including mounting and installation details.
- C. Comply with ASHRAE 15.
- D. EER: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Building, except Low-Rise Residential Buildings."

### PART 2 - PRODUCTS

#### 2.01 HUMIDIFIER

- A. Factory assembled and tested, consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, filters, and dampers. Trane: THUMD200ABM00A
- B. Controls: Manual Control, Up to 300 ft<sup>2</sup>,

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install units level and plumb and firmly anchored.
- B. Connect units to wiring systems and to ground.
- C. Tighten connectors and terminals according to tightening torques specified in UL 486A and UL 486B.

END OF SECTION

## SECTION 25 11 00 – INTEGRATED AUTOMATION NETWORK EQUIPMENT

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Network equipment will be used to transfer data throughout the space, and is also a key component of the Chameleon Home Automation System.
- B. Any system included will comply with standards and specifications of their unique manufactures.

### PART 2 - PRODUCTS

#### 2.01 WIRELESS NETWORK ROUTER

- A. Apple Inc., Airport Express,
  - 1. Specified with audio out port.
- B. Cisco, WET200, Wireless-G Business Ethernet Bridge with built in switch
  - 1. Complies with IEEE 802.3af

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Network Equipment will be mounted level and plumb.
- B. Secure wireless networking will be established according manufacturers specifications.
- C. Audio out will be integrated within the Home Entertainment equipment to assure complete system-wide integration.

#### 3.02 TESTING

- A. Wireless networking will be tested throughout the limits of the space and protected from exterior attack.

END OF SECTION

## SECTION 25 14 13 – INTEGRATED AUTOMATION REMOTE CONTROL PANELS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Integrated Automation Control Panels will be used to develop and change user preferences and depict energy use characteristics, a key component of the Chameleon Home Automation System.

### PART 2 - PRODUCTS

#### 2.01 CONTROL PANEL

- A. [www.touchscreens.com](http://www.touchscreens.com), LCDSA121-OF, RGB color

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Screens will be wall-mounted or cabinet-mounted level and plumb.
- B. Secure modules according to manufactures' specifications.
- C. Wire modules according to layout design.

#### 3.02 TESTING

- A. Test according to NEC and standard of practice.

END OF SECTION

## SECTION 25 14 19 – INTEGRATED AUTOMATION TERMINAL CONTROL UNITS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Integrate Automation Units will be used to evaluate data and control process automation, a key component of the Chameleon Home Automation System.

### PART 2 - PRODUCTS

#### 2.01 AUTOMATION CONTROLLER

- A. National Instruments, CompactRIO Automation Controller,

#### 2.02 INTEGRATED INPUT/ OUTPUT MODULES

- A. Modules developed through evaluation of environmental cause and effect relationships
  - 1. Module layout in E-608 Automation Wiring 4.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Chassis will be mounted level.
- B. Secure modules according to manufactures' specifications.
- C. Place modules according to layout E-608.
- D. Wire modules according to layout design.

#### 3.02 TESTING

- A. Test according to NEC and standard of practice.

END OF SECTION

## SECTION 25 15 00 – INTEGRATED AUTOMATION SOFTWARE

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Integrated Automation Software will be used to program energy-responsible tasks for daily use, the most thorough issue the Chameleon Home Automation System contends against.

### PART 2 - PRODUCTS

#### 2.01 PROGRAMMING SOFTWARE

- A. National Instruments, LABVIEW,

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. LABVIEW will be installed on the CompactRIO and programming will consist of develop through the entire module input/ output sequence.
- B. Programming will be done by a registered Certified LABVIEW Associate Developer (CLAD)

#### 3.02 TESTING

- A. Testing to control errors in programming to ensure safe practices and energy-responsible

END OF SECTION

## SECTION 25 35 13 – INTEGRATED AUTOMATION ACTUATORS AND OPERATORS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Integrated Automation Actuators and Operators will be used to develop process based change with the environment of the space.
- B. Actuators and Operators will comply with UL listing for their discrete operation.

### PART 2 - PRODUCTS

#### 2.01 ACTUATORS

- A. Truth Hardware, Marvel Power Window System.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Motor will be mounted level and plumb.
- B. Models will be secured according to manufactures' specifications based on window type.
- C. Wire models according to manufacturer's specification and NEC guidleines.

#### 3.02 TESTING

- A. Test according to NEC and standard of practice.

END OF SECTION

## SECTION 25 35 16 – INTEGRATED AUTOMATION SENSORS AND TRANSMITTERS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Integrated Automation Sensors and Transmitters will be used to monitor environmental changes and limitations with the environment of the space.
- B. Sensors and Transmitters will comply with manufacturers specification.

### PART 2 - PRODUCTS

#### 2.01 SENSORS

- A. Interior Sensors
  - 1. Interior Temperature and Humidity, Siemens, QFA 2060.
  - 2. Indoor Air Quality Sensor, Siemens, QPA 2002.
  - 3. Flow Meter, Omega, FTB 4605.
  - 4. Occupancy, Lutron, LOS-WDT.
  - 5. Ambient Light, LICOR, LI- 210SZ.
  - 6. Soil Moisture, Vegetronix, VG400.
- B. Exterior Sensors
  - 1. Exterior Temperature, Siemens, QAC 3161.
  - 2. Exterior Humidity, Siemens, QFA 4160.
  - 3. Pyranometer, LICOR, LI-200SZ-50.
  - 4. Wind Speed, Inspeed, Vortex Wind Sensor.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Sensors will be mounted according to manufacturers diagrams.
- B. Sensors will be wired to allow for proper wiring technique.
- C. Sensors will be wired according to manufacturer's specification and NEC guidelines.
- D. Sensors' terminal ends will be wired according to automation layout schematics.

#### 3.02 TESTING

- A. Test according to NEC and standard of practice.
- B. Ensure connection to Chameleon Home Automation System.

END OF SECTION

## SECTION 25 36 00 – INTEGRATED AUTOMATION INSTRUMENTATION AND TERMINAL DEVICES FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Integrated Automation instrumentation and terminal devices for electrical will be used to monitor electrical available and use within the space.
- B. Instrumentation will comply with manufacturer's specification.

### PART 2 - PRODUCTS

#### 2.01 POWER METER

- A. Power Monitoring, Continental Control Systems LLC, WattNode

#### 2.02 Current Sensors

- A. Current Monitoring, Continental Control Systems LLC, Current Transducer

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Meters and sensors will be mounted according to manufacturers diagrams.
- B. Meters and sensors will be wired to allow for proper wiring technique.
- C. Power meter and current sensors will be wired according to manufacturer's specification and NEC guidelines.
- D. Sensors' terminal ends will be wired according to automation layout schematics.

#### 3.02 TESTING

- A. Test according to NEC and standard of practice.
- B. Ensure connection to Chameleon Home Automation System.

END OF SECTION

## SECTION 25 36 26 – INTEGRATED AUTOMATION LIGHTING RELAYS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Integrated Automation Lighting Relays will be used to affect the lighting within the space to reduce any necessary waste of energy.
- B. Lighting Relays will comply with manufacturer's specification.

### PART 2 - PRODUCTS

#### 2.01 CONTROLS AND RELAYS

- A. Lighting Relays: Lite Touch, Compact CCU

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Lighting control relays will be mounted according to manufacturer's diagrams.
- B. Relays and control boards will be wired to allow for proper wiring techniques.
- C. Relays will be wired according to manufacturer's specification and NEC guidelines.
- D. Relays will be wired according to automation layout schematics.

#### 3.02 TESTING

- A. Test according to NEC and standard of practice.
- B. Ensure connection to Chameleon Home Automation System.

END OF SECTION

## SECTION 26 05 00 – GROUNDING ROD

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Grounding of electrical system complies with NEC standard for grounding.

### PART 2 - PRODUCTS

#### 2.01 GROUNDING ROD

- A. Grounding Rod: Standard Grounding Rod Assembly 3/4" Copper.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Hammer into ground at 45 degrees to ground plane. No more than 18" below ground surface.

END OF SECTION

## SECTION 26 27 00 - WIRING METHODS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Summary: Building wires and cables and associated splices, connectors, and terminations for wiring systems rated 600 V and less, and twisted-pair cable; and raceways and boxes.

### PART 2 - PRODUCTS

#### 2.01 WIRES AND CABLES

- A. Building Wires and Cables: Type XHWN/THWN copper conductor.
- B. Connectors and Splices: Wiring connectors of size, ampacity rating, material, and type and class for application and for service indicated.
- C. Single Conductor Plenum Coaxial: 75-ohm characteristic impedance, solid bare copper central conductor, foamed Teflon dielectric, 100 percent coverage tinned-copper, double-braid shield, Teflon jacket, suitable for installation in air-handling spaces.
- D. Twisted Pair: No. 22 AWG tinned-copper conductors; PVC insulation; overall aluminum/polyester shield and No. 22 AWG tinned-copper drain wire; PVC jacket.
- E. Twisted-Pair Plenum: No. 24 AWG, 7-strand, tinned-copper conductors; Teflon insulation; overall aluminum/polyester shield and No. 22 AWG tinned-copper drain wire; Teflon jacket; suitable for use in air-handling spaces.

#### 2.02 RACEWAYS

- A. Conduit: Comply with the following:
  - 1. Rigid Steel Conduit: ANSI C80.1.
  - 2. Intermediate Metal Conduit: ANSI C80.6.
  - 3. Electrical metallic Tubing: ANSI C80.3.
  - 4. Rigid Nonmetallic Conduit: NEMA TC 2, Schedule 40.
- B. Wireways: Hinged type, with manufacturer's standard finish.
- C. Surface Metal Raceway: Galvanized steel with snap-on covers. Finish with manufacturer's standard prime coating suitable for painting.

- D. Surface Nonmetallic Raceway: 2-piece construction, manufactured of rigid PVC compound with matte texture and manufacturer's standard color.
- E. Outlet and Device Boxes: UL listed and labeled nonmetallic boxes.
- F. Floor Boxes: Cast metal, fully adjustable, rectangular.
- G. Pull and Junction Boxes: Small nonmetallic boxes.

## 2.03 ENCLOSURES

- A. Hinged-Cover Enclosures: NEMA 250, steel enclosure with continuous hinge cover and flush latch. Finish inside and out with manufacturer's standard enamel.
- B. Cabinets: NEMA 250, Type 1, except where another Type is indicated.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install wires and cables according to the NECA's "Standard of Installation."
- B. Remove existing wire from raceway before pulling in new wire and cable.
- C. Wiring at Outlets: Install with at least 12 inches (300 mm) of slack conductor at each outlet.
- D. Outdoors Wiring Methods: As follows:
  - 1. Exposed: Rigid or intermediate metal conduit.
  - 2. Concealed: Rigid or intermediate metal conduit.
  - 3. Underground, Single Run: Rigid nonmetallic conduit.
  - 4. Underground, Grouped: Rigid nonmetallic conduit.
- E. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid or Motor-Driven Equipment): Liquidtight flexible metal conduit.
- F. Indoors Wiring Methods: As follows:
  - 1. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid or Motor-Driven Equipment): Flexible metal conduit, except in wet or damp locations use liquidtight flexible metal conduit.
  - 2. Use armored cable and nonmetallic sheathed cable in applications allowed by NFPA 70.
  - 3. Damp or Wet Locations: Rigid steel conduit.

4. Exposed: Electrical metallic tubing or rigid nonmetallic conduit.
  5. Concealed: Electrical metallic tubing, electrical nonmetallic tubing, or rigid nonmetallic conduit.
  6. Boxes and Enclosures: NEMA 250, Type 1, except in damp or wet locations use NEMA 250, Type 4, stainless steel.
  7. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.
  8. Conceal conduit and electrical metallic tubing, unless otherwise indicated, within finished walls, ceilings, and floors.
- G. Use raceway fittings compatible with raceway and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, unless otherwise indicated.
- H. Raceways Embedded in Slabs: Install in middle third of the slab thickness where practical, and leave at least 1-inch (25-mm) concrete cover.
- I. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
- J. Join raceways with fittings designed and approved for the purpose and make joints tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight. Use insulating bushings to protect conductors.
- K. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb (90-kg) tensile strength. Leave not less than 12 inches (300 mm) of slack at each end of the pull wire.
- L. Install raceway sealing fittings and locate at suitable, approved, accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings where required by the NEC.
- M. Stub-up Connections: Extend conductors to equipment with rigid steel conduit; flexible metal conduit may be used 6 inches (150 mm) above the floor.
- N. Flexible Connections: Use maximum of 72 inches (1800 mm) of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across flexible connections.
- O. Install a separate green ground conductor in surface metal raceway from the junction box supplying the raceway to receptacle or fixture ground terminals.

END OF SECTION

## SECTION 26 27 02 – JUDGES OUTLET

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Summary: Receptacle used in the competition judging.

### PART 2 - PRODUCTS

#### 2.01 RECEPTACLE

- A. Receptacles will be GFCI receptacles.

#### 2.03 ENCLOSURES

- A. Hinged-Cover Enclosures: NEMA 250, steel enclosure with continuous hinge cover and flush latch. Finish inside and out with manufacturer's standard enamel.
- B. Cabinets: NEMA 250, Type 1, except where another Type is indicated.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install wires and cables according to the NECA's "Standard of Installation."
- B. Receptacles and wiring will be installed according to the NEC 2009 and best practice methods.

END OF SECTION

## SECTION 26 31 00 – PHOTOVOLTAIC COLLECTORS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. The roof-mounted photovoltaic collectors shall be wired and installed according to manufacturer's specifications. Incident angle of the photovoltaic will be based on roof angle and efficiency according to geographic area.

### PART 2 - PRODUCTS

#### 2.01 PHOTOVOLTAIC COLLECTORS

- A. Silicon Cell: BP SX 3200, 200 Watt, Voltage: 25.4 V.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install wires and cables according to the NECA's "Standard of Installation."
- B. Outdoors Wiring Methods: As follows:
  - 1. Exposed: Rigid or intermediate metal conduit.
  - 2. Concealed: Rigid or intermediate metal conduit.
- G. Use raceway fittings compatible with raceway and suitable for use and location.
- J. Join raceways with fittings designed and approved for the purpose and make joints tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight. Use insulating bushings to protect conductors.
- L. Install raceway sealing fittings and locate at suitable, approved, accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings where required by the NEC.

END OF SECTION

## SECTION 26 32 13 – ENGINE GENERATORS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Engine Generator will be used to facilitate power demands throughout the course of the assembly and disassembly processes.
- B. Generator will be placed atop spill protection to protect the US National Mall grounds.

### PART 2 - PRODUCTS

#### 2.01 ENGINE GENERATOR

- A. Gas Generator, Honda, EU 3000iSA
  - 1. 3000 watts, 120Volts
  - 2. 20 Amp, 30 Amp Receptacles

### PART 3 - EXECUTION

#### 3.01 USE

- A. Generator will be used to operate electrical machinery necessary for construction.
- B. Generator will never be electrically overdrawn.

END OF SECTION

## SECTION 26 50 00 - LIGHTING

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Submit Product Data for each luminaire, including lamps.
- B. Coordinate ceiling-mounted luminaires with ceiling construction.

### PART 2 - PRODUCTS

#### 2.01 LUMINAIRES

- A. Lighting Schedule sited in construction drawings: E-601 Schedules
  - 1. (A): CREE: LR6
  - 2. (B): Custom Luminaire by Green Light
  - 3. (C): Custom Luminaire by Green Light
  - 4. (D): Custom Luminaire by Green Light
  - 5. (E): NEXXUS: Hyperion Accent
  - 6. (F): TECH LIGHTING: Kable Light
  - 7. (G): DABMAR: LV-LED311
  - 8. (H): Custom Luminaire

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Set units plumb, square, and level with ceiling and walls, and secure.
- B. Support for Recessed and Semirecessed Grid-Type Fluorescent Fixtures: Install ceiling support system rods or wires at a minimum of 4 rods or wires for each fixture, located not more than 6 inches (150 mm) from fixture corners.
- C. Support for Suspended Fixtures: Brace pendants and rods over 48 inches (1220 mm) long to limit swinging. Support stem-mounted, single-unit, suspended fluorescent fixtures with twin-stem hangers. For continuous rows, use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of chassis, including one at each end.
- D. Lamping: Where specific lamp designations are not indicated, lamp units according to manufacturer's written instructions.

END OF SECTION

## SECTION 26 60 00 – COMPETITION SPECIFIC ELECTRICAL EQUIPMENT

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Electrical equipment specified by the Solar Decathlon building codes and rules.
- B. This equipment is used to accurately judge and distribute points to competition contestants.

### PART 2 - PRODUCTS

#### 2.01 UTILITY DISCONNECT

#### 2.02 A/C DISCONNECT

#### 2.03 JUNCTION BOX

#### 2.04 DATALOGGER ENCLOSURE

#### 2.05 INVERTER

#### 2.06 BREAKER PANEL

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. All competition specific electrical equipment is wired according to the NEC 2009 building code.
- B. Orientation and placement will be decided based on competition needs according to the Solar Decathlon 2009 rules.

END OF SECTION

## SECTION 27 41 13 – ARCHITECTURAL INTEGRATED AUDIO-VIDEO EQUIPMENT

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Audio Equipment will be used to reduce the amount of peripheral communications appliances within the space to reduce any necessary waste of energy.
- B. Audio equipment will have seamless integration into the space via the Chameleon Home Automation System.

### PART 2 - PRODUCTS

#### 2.01 AUDIO EQUIPMENT

- A. Audio Drivers, Home Automation Inc., Hi-Fi.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Hi-Fi will be mounted according to manufacturer's diagrams.
- B. Control boards will be wired to allow for proper wiring techniques.
- C. Control Board and Input/ Output Modules will be wired according to manufacturer's specification and NEC guidelines.
- D. Modules will be wired according to automation layout schematics.

#### 3.02 TESTING

- A. Test according to NEC and standard of practice.
- B. Ensure connection to Chameleon Home Automation System.

END OF SECTION

## SECTION 31 48 23 – JACKED PIER

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Piers will be built to comply with the Solar Decathlon building codes, such that, the load on the National Mall is less than specified.

### PART 2 - PRODUCTS

#### 2.01 PIER

- A. 2' x 2' x 18" recycled wood block.
- B. Central Piers Inc. 6" Pier stands.  
<http://www.centralpiers.com/CP%20Catalog%20%20110dpi%209.2M%20.pdf>
- C. Item number 238, Saddle Top Pier Top.  
<http://www.centralpiers.com/CP%20Catalog%20%20110dpi%209.2M%20.pdf>

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Piers will be built to equally distribute the applied load on the National Mall.
- B. They will be placed under the jack stands that support the house.

END OF SECTION

## SECTION 31 62 19 – PIER

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Piers will be built to comply with the Solar Decathlon building codes, such that, the load on the National Mall is less than specified.

### PART 2 - PRODUCTS

#### 2.01 PIER

- A. 2' x 2' x 18" recycled wood block.
- B. Central Piers Inc. 6" Pier stands.  
<http://www.centralpiers.com/CP%20Catalog%20%20110dpi%209.2M%20.pdf>
- C. Item number 238, Saddle Top Pier Top.  
<http://www.centralpiers.com/CP%20Catalog%20%20110dpi%209.2M%20.pdf>
- D. Mobile Home Parts Store: 20" x 20" Pier Pad, ABS Plastic
- E. Custom Built Leveling Sandbox: 3' x 3' Sandbox to allow for temporary proper leveling of the structure at the decathlon site. Geotextile fabric to contain sand.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Piers will be built to equally distribute the applied load on the National Mall.
- B. They will be placed under the jack stands that support the house.

END OF SECTION

## SECTION 31 68 00 – FOUNDATION ANCHORS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Anchors tie downs will be used to secure the foundation to the ground.

### PART 2 - PRODUCTS

#### 2.01 ANCHOR

- A. Auger Anchoring Bolts [www.centralpiers.com](http://www.centralpiers.com), EZ Auger (32”),

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Auger will be attached at spacing similar to the foundation piers.
- B. Auger will be drilled into the ground at a 45 degree angle, going no farther than 18” beneath the ground level into the National Mall.
- C. Anchor Straps will be connected and tightened to foundation spaces within the joists.
- D. A ratchet will be used to turn strapping bolt to anchor.

END OF SECTION

## SECTION 32 90 00 - PLANTS

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Not Applicable.

### PART 2 - PRODUCTS

#### 2.1 PLANTS (Missouri Natives)

- A. Missouri Bluestem
- B. Coneflowers
- C. Coreopsis
- D. Black-Eyed Susans
- E. Buffalo Grass
- F. Sumac
- G. Primrose

### PART 3 - EXECUTION

#### 3.1 Not Applicable

END OF SECTION

## SECTION 33 71 73- ELECTRIC METERS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Meter housing for electric utility will be UL listed and NEMA rated.
- B. Meter will comply with NEC 2009.

### PART 2 - PRODUCTS

#### 2.01 ELECTRICAL UTILITY METER

- A. Schneider Electric, Square D, UTRS101B, 125A, 600 VAC, Single Phase.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install level and plumb.
- B. Ensure electric connection according to NEC standard and best practice methods.
- C. Comply with US Department of Energy Solar Decathlon, Show-Me Solar Health and Safety Plan, and LOTO status before energizing the system.

END OF SECTION

## SECTION 48 14 13 – SOLAR ENERGY COLLECTORS

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Solar energy collection through circulating hot water evacuated tube system.
- B. Design of system will comply with manufacturing specifications.

### PART 2 - PRODUCTS

#### 2.01 EVACUATED TUBE ASSEMBLY

- A. Evacuated tube: Six foot long dual glass wall, heat pipe style, Apricus Manufacturer.  
[http://www.apricus.com/html/evacuated\\_tubes.htm](http://www.apricus.com/html/evacuated_tubes.htm)

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install according to manufacturers installation specifications for standing seam metal roof.
- B. The manifold assembly shall be constructed in accordance with the Apricus specifications, and the copper will be sweated to ensure a good seal.

#### 3.02 INSPECTION

- A. System shall be pressurized and tested to comply with US Department of Energy Solar Decathlon Rules and Regulations and manufacturers specifications.

END OF SECTION

## SECTION 48 19 00 – ELECTRICAL POWER CONTROL EQUIPMENT

### PART 1 - GENERAL

#### 1.01 SECTION REQUIREMENTS

- A. Comply with NFPA
- B. Comply with NEC 2009
- C. Comply with IRC 2006

### PART 2 - PRODUCTS

#### 2.01 INVERTERS

- A. Solar DC to AC Inverter. Fronius IG Plus 7.5-1 UNI 7500W GT 240 V.  
[http://www.fronius.com/cps/rde/xchg/SID-E624A552-DAE5C618/fronius\\_usa/hs.xsl/2714\\_1481.htm](http://www.fronius.com/cps/rde/xchg/SID-E624A552-DAE5C618/fronius_usa/hs.xsl/2714_1481.htm)

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install systems according to NFPA standards.
- B. Install according to manufacturing specifications.
- C. Install level and plumb

END OF SECTION



# **SHOW-ME SOLAR HOUSE TEAM**

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## Structural Calculations

See following pages.

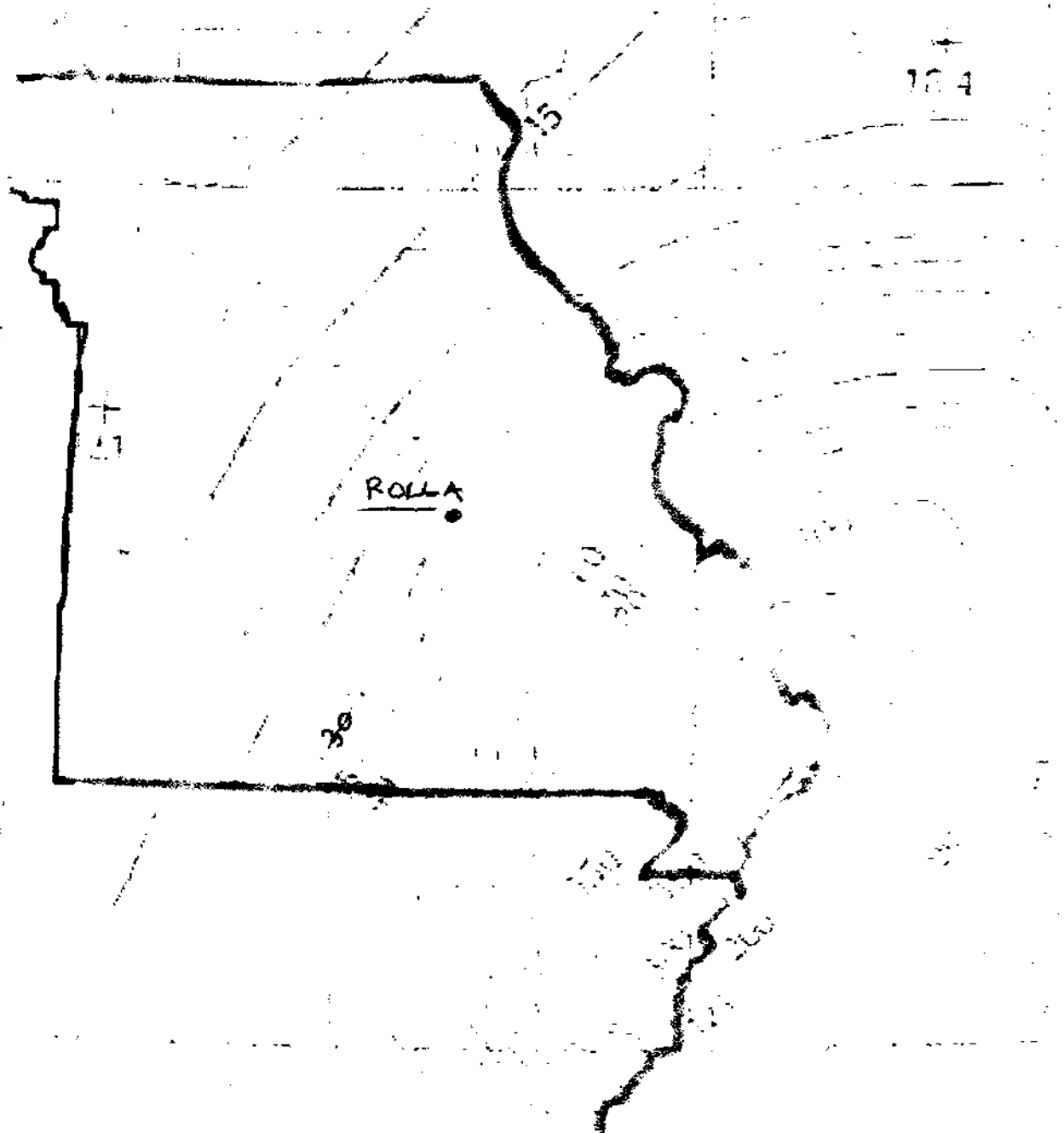
**Fred Severud Consulting Engineer**

Sheet No. 1

Project Solar Bldg. UMR Rolla, MO

FSCE # 090102, S&V #

Date



Fred Severud Consulting Engineer

Sheet No. 2

Project Solar Bldg. UMR Rolla, MO

FSCE # 090102, S&amp;V #

Date JAN '09

SEISMIC LOADS FROM IBC 2003 FIG 1615.1.1  $V \leq 30\%$ 

ASSUME SITE CLASS "D"

SIMPLIFIED ANALYSIS (1617.5)

$$V = \frac{1.2 S_{DS} W}{R}; R = 6\frac{1}{2}; S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} (1.5)(0.3) = 0.30$$

$$\therefore V = 0.055W$$

SIP PANELS = 3 psf ±

$$\text{ROOF } 49' \times (14.27' + 4.74') = 931.3 \text{ \#}$$

$$\text{WALLS } \frac{2 \times 49' \times 9' + 2 \times 15' \times 9' + 2 \times 15' \times 4.74'}{2} = 1223.1 \text{ \#}$$

$$\text{INT. WALLS } 2 \times 14.33 \times 9 + 8 \times 9 = 815.9 \text{ \#}$$

$$W = 8.9 \text{ K} \Rightarrow \underline{\underline{V = 0.49 \text{ K}}} \text{ BASE SHEAR}$$

WIND LOADS  $V = 90 \text{ mph}$  (FIG 1609)SIMPLIFIED METHOD (1609.6);  $I = 1.0$ ;  $H/E = 1$ 

TRANSVERSE DIR. CONTROLS

$$\text{END ZONE} = 2 \times 10 \times 49 = 9.8 \text{ K} \text{ ROOF SLOPE} = 18^\circ (4/12)$$

ZONE	P	V	
A	16.1	$9.8 \times 9$	$= 1.42$
B	-5.4	$9.8 \times 4.74$	$= -0.25$
C	10.7	$39.2 \times 9$	$= 3.77$
D	-3.0	$39.2 \times 4.74$	$= -0.56$

$$\underline{\underline{E = 5.50 \text{ K}}} \text{ BASE SHEAR}$$

(CONTROLS)

ASSUME LD SHARED EQUALLY BY 2 END WALLS &amp; 2 INT. WLS.

$$\therefore \text{EACH WALL TAKES } 1.38 \text{ K} \therefore V = \frac{1.38}{15} = 0.092 \text{ K/F}$$

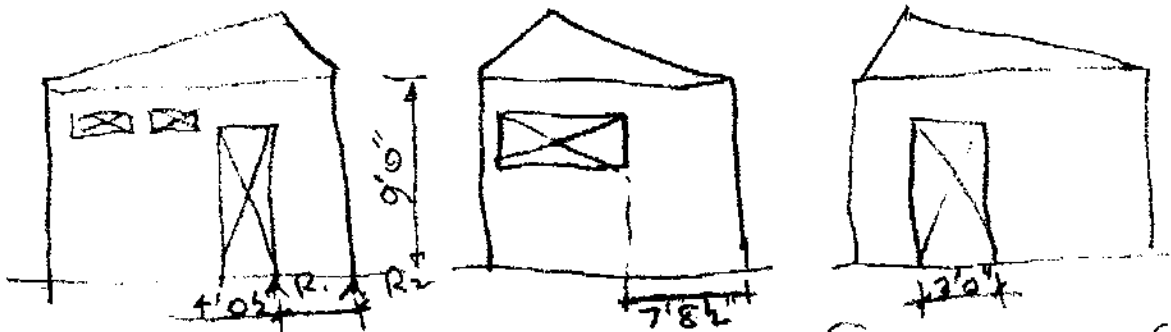
 $\Rightarrow 8d @ 6" \text{ EDGE NAILING (TABLE 2306.4.1)}$

Fred Severud Consulting Engineer

Sheet No. 3

Project Solar Bldg. UMR Rolla, MO

FSCE # 090102, S&amp;V #

Date FEB '09

① EASE WALL    ② W. WALL    ③ INT. WALL (x2)

$$① C_o = \frac{4.04}{14.33} = 0.282 ; R_1 = R_2 = \frac{1.38 \times 9.0}{0.282 \times 14.33} = 2.97 \text{ K UPLIFT}$$

$$② C_o = \frac{7.71}{14.33} = 0.538 ; R_1 = R_2 = \frac{1.38 \times 9}{0.538 \times 14.33} = 1.61 \text{ K UPLIFT}$$

$$③ C_o = \frac{11.33}{14.33} = 0.791 ; R_1 = R_2 = \frac{1.38 \times 9}{0.791 \times 14.33} = 1.10 \text{ K UPLIFT}$$

$$\text{DL REACTION} = \frac{8.9 \text{ K}}{8} = 1.11 \text{ K} \therefore \text{MAX TIEDOWN} = 1.86 \text{ K}$$

$\therefore$  USE SIMPSON STRONGTIE 1212 HL STRAP TIES OR EQUIV.  
AT EACH END OF TRANSVERSE WALLS,  
& PROVIDE ANCHORS TO FDN. AT ENDS OF TRANS.  
WALLS FOR 1.86 K UPLIFT (MIN)

Fred Severud Consulting Engineer

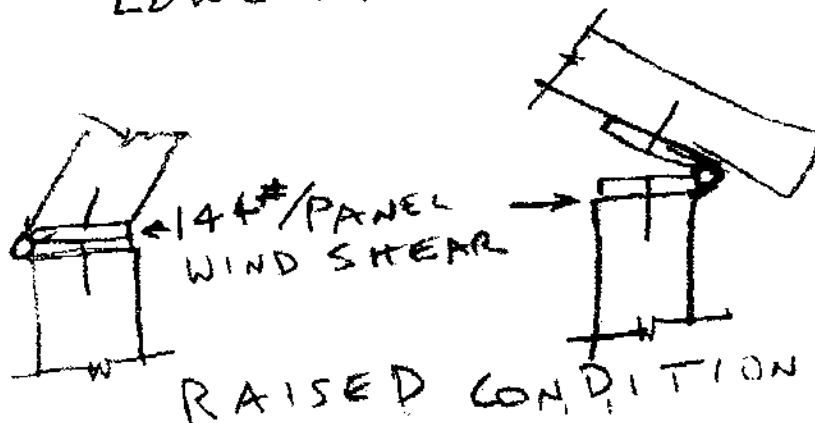
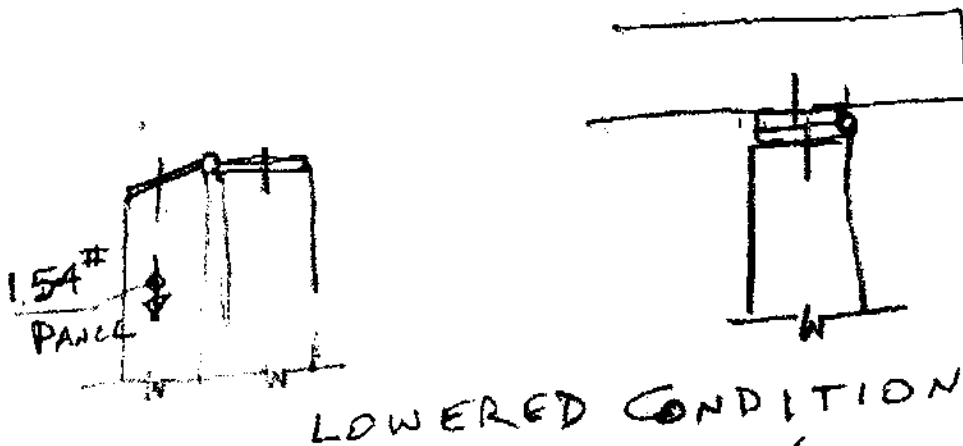
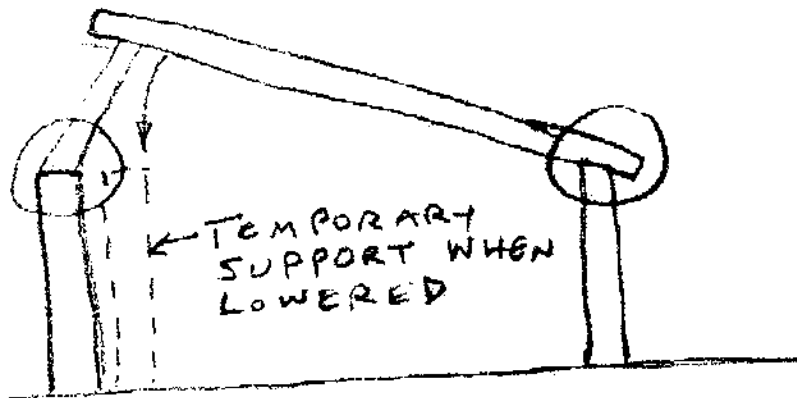
Sheet No. 4

Project Solar Bldg. UMR Rolla, MO

FSCE # 090102, S&amp;V #

Date FEB '09

PANEL WTS.

LARGE R.F. PANEL =  $16' \times 8' \times 3 \text{ pcf} = 384^{\#}$  EACHSMALL R.F. PANEL =  $6.4' \times 8' \times 3 \text{ pcf} = 154^{\#}$  EACHWIND LD =  $0.25 + 0.56 = 0.81^{\text{K}}$ EACH PANEL TAKES  $(8/45) \times 0.81 = .144^{\text{K}} = 144^{\#}$  WIND SHEAR

**Fred Severud Consulting Engineer**Sheet No. 1Project Education Bldg. Jackson Cty. MO FSCE # 090101, S&V #Date Jan '09

The enclosed calculations were prepared by myself or under my direct supervision.



Fred Severud





2009 SOLAR  
DECATHLON  
ENTRY

[illegible]

S-100

## SHEET KEYNOTES

① HOUSE FOUNDATION:  
(60000 LB)/(14 PIERS)/  
(2.95 FT<sup>2</sup>/PIER) = 1450  
LB/FT<sup>2</sup>

5

4.

3

---

2

1

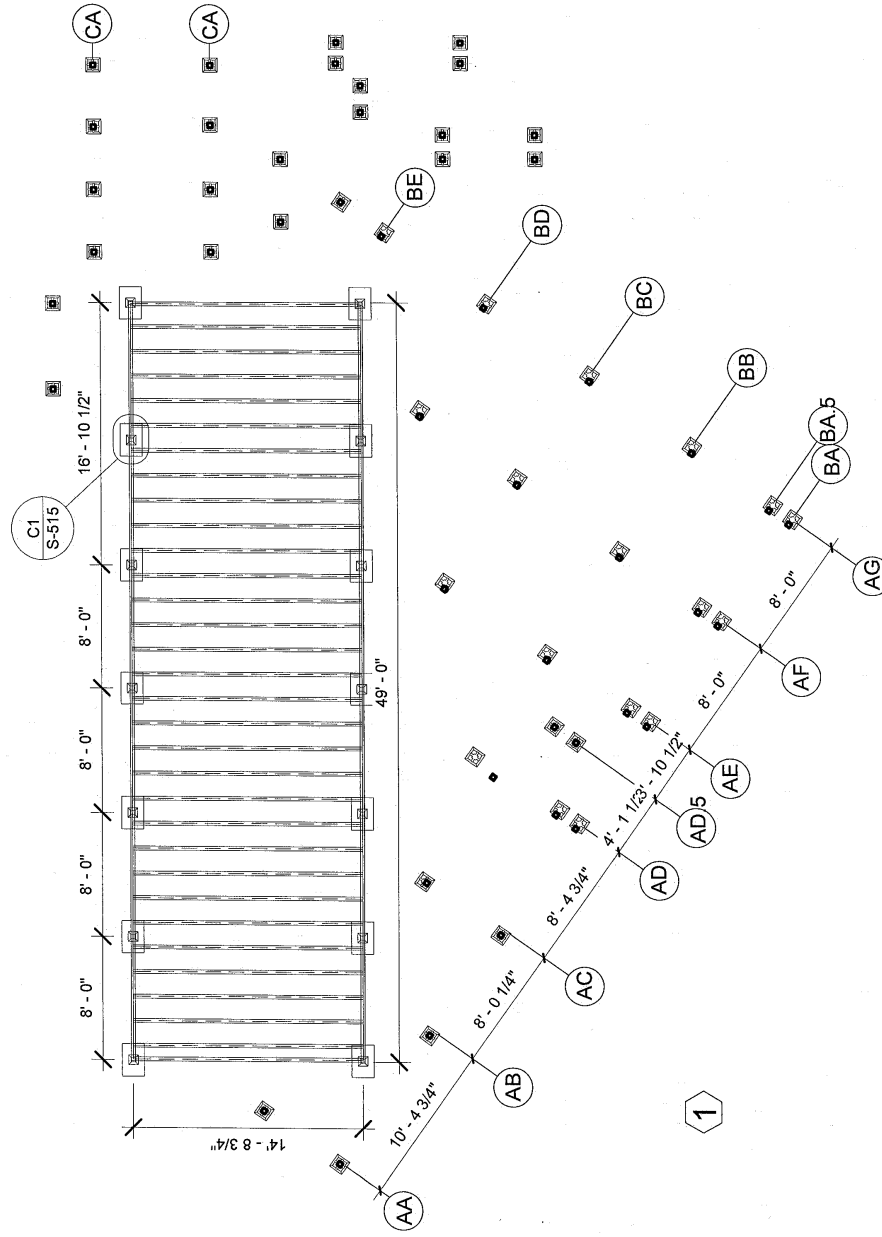
5

4

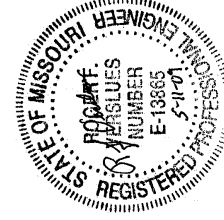
3

2

1



**A1** FOUNDATION PLAN  
1/8" = 1'-0"





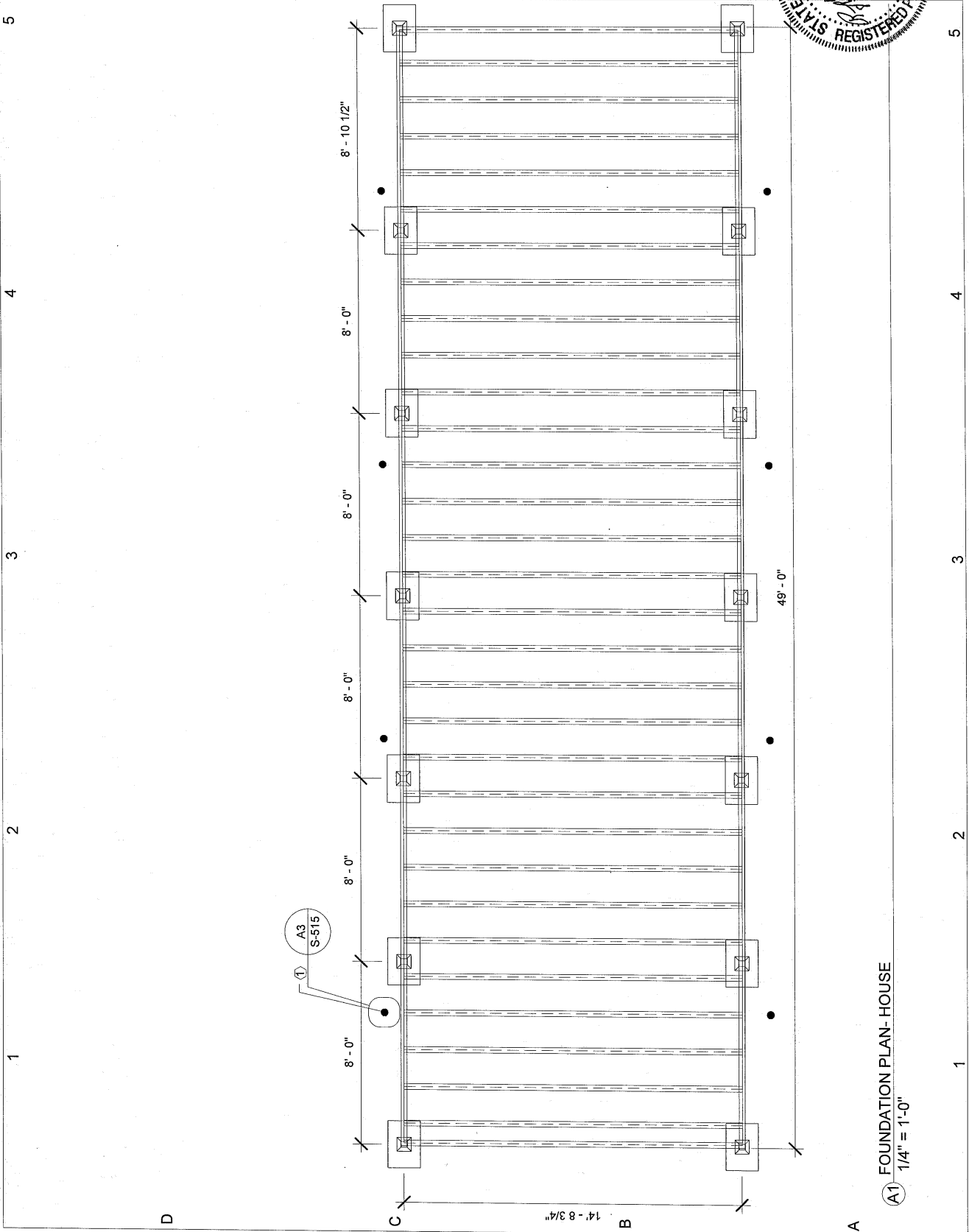
2009 SOLAR  
DECATHLON  
ENTRY

[illegible]

S-101

## SHEET KEYNOTES

- ① SCREW TYPE SOIL ANCHOR

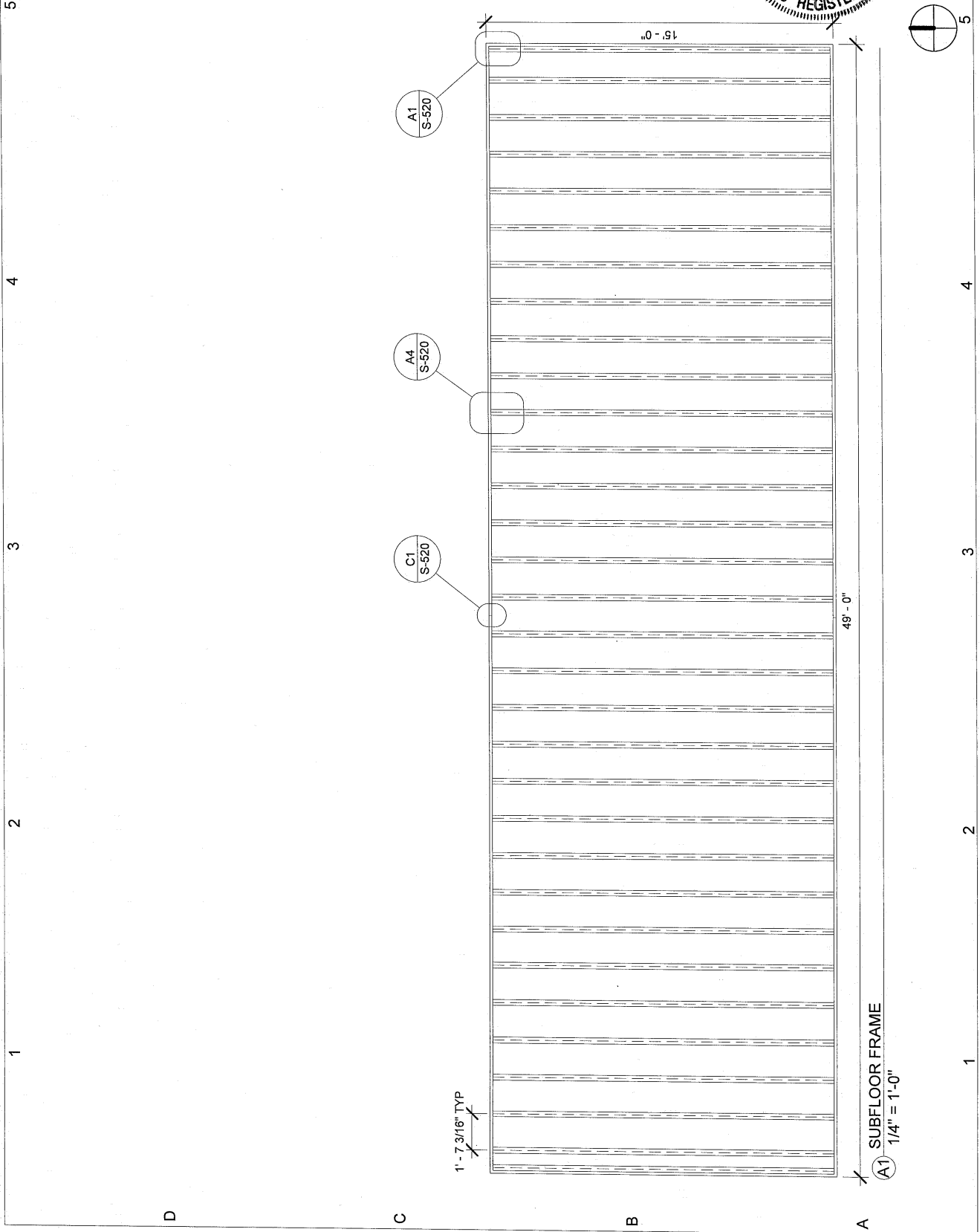
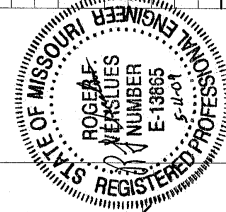




**2009 SOLAR  
DECATHLON  
ENTRY**

[illegible]

S-105

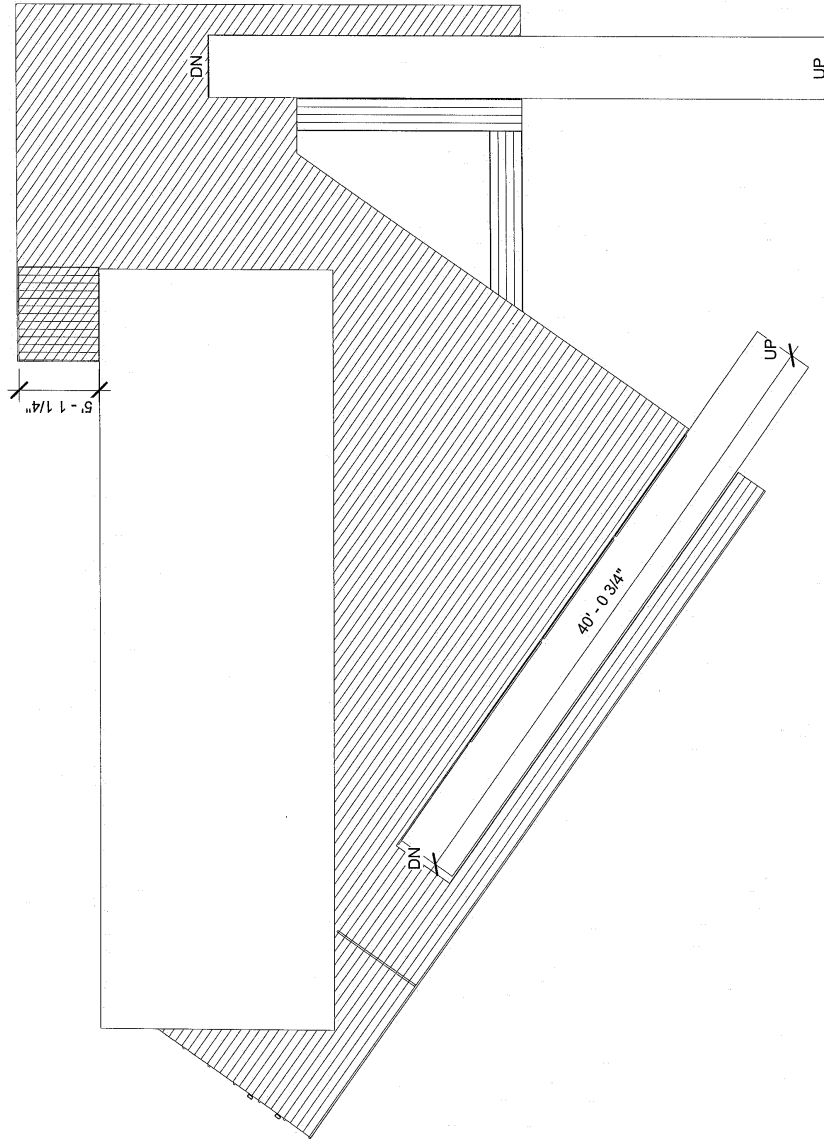
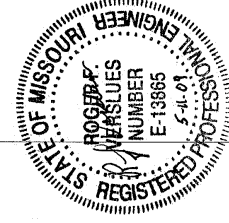




**2009 SOLAR  
DECATHLON  
ENTRY**

MARK	DATE	DESCRIPTION			
ISSUE:					
DATE:	06/02/2009		DRAWN BY:	CAL	
			CHECKED BY:	LAS	
SHEET TITLE					
DECK					

S-115



DECK  
A1  $1/8" = 1'-0"$

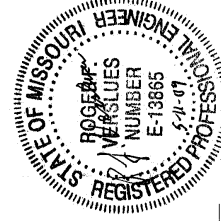
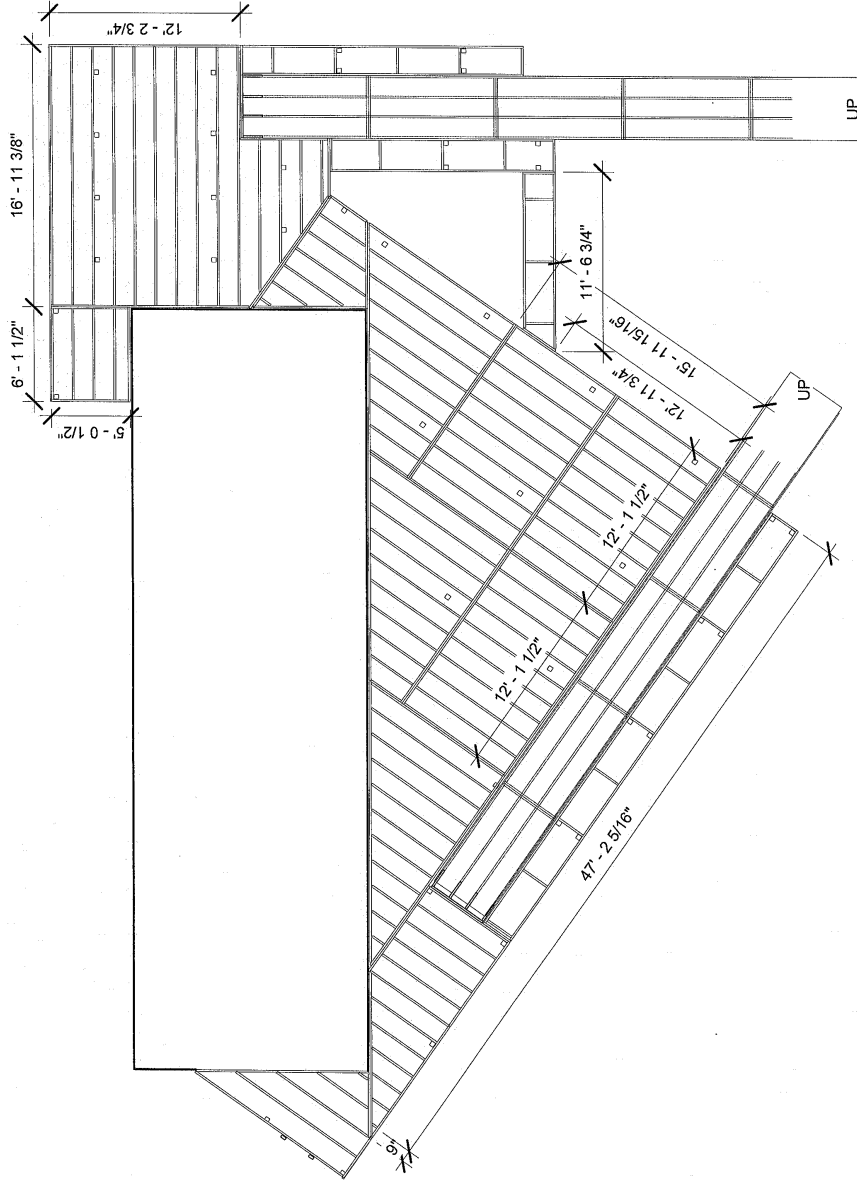
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4

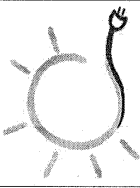
3

2

1



A1 2x4 DECK SUBSTRUCTURE  
1/8" = 1'-0"

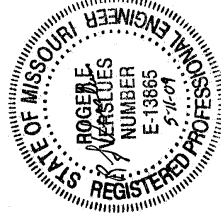


# Show-Me Solar

Missouri S&T  
University of Missouri

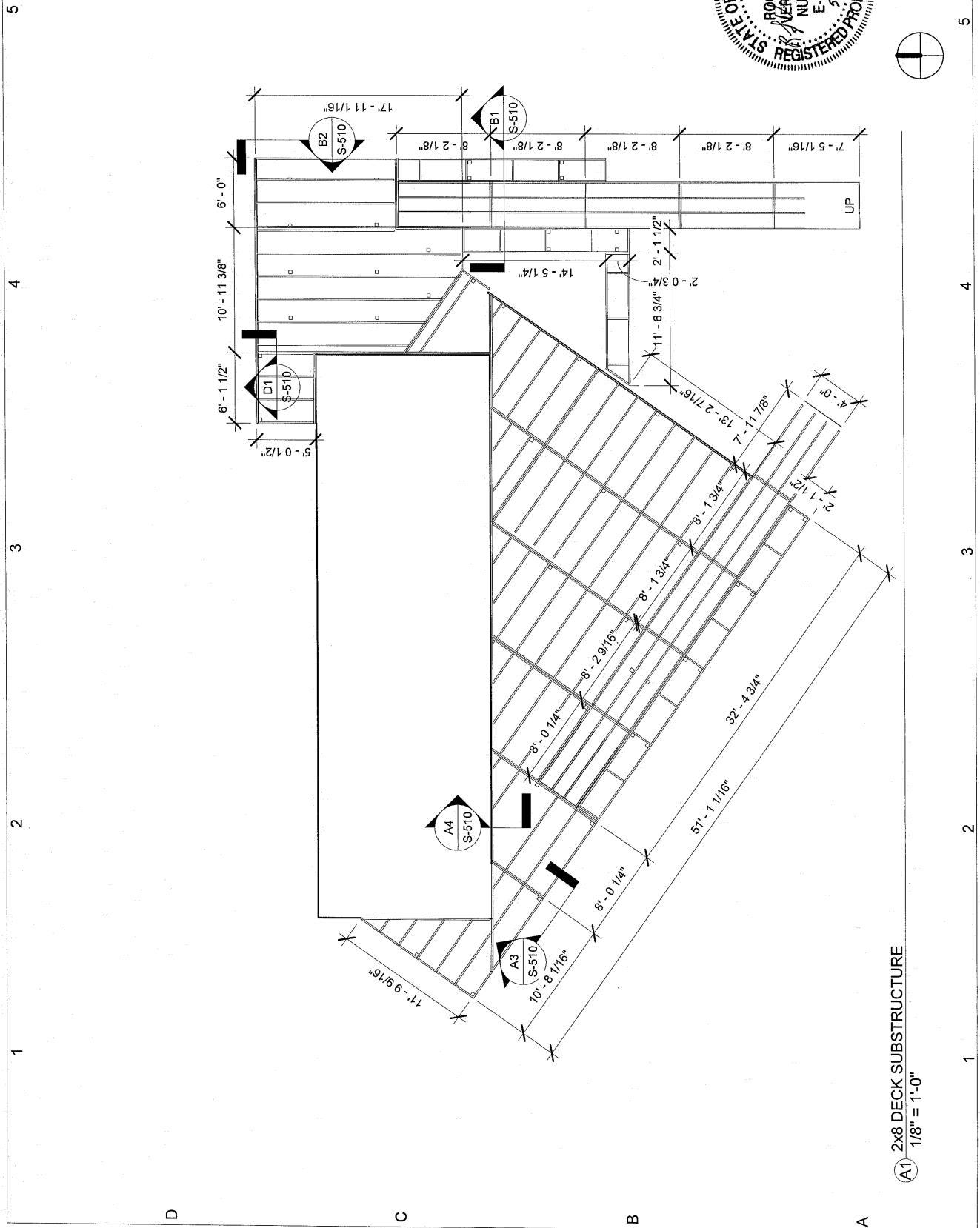


2009 SOLAR  
DECATHLON  
ENTRY  
NATIONAL MALL,  
WASHINGTON D.C.



MARK DATE DESCRIPTION  
ISSUE:  
DATE: 06/02/2009  
DRAWN BY: CAK  
CHECKED BY: Checker  
SHEET TITLE  
DECK 2X8  
SUBSTRUCTURE

S-117



(A1) 2x8 DECK SUBSTRUCTURE  
1/8" = 1'-0"



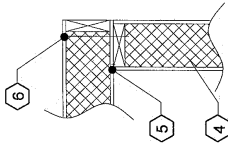
**2009 SOLAR  
DECATHLON  
ENTRY**

[illegible]

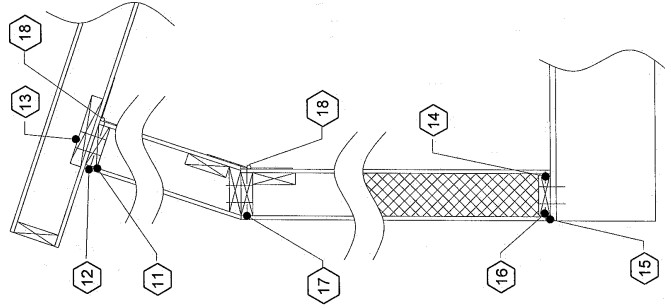
S-500

## SHEET KEYNOTES

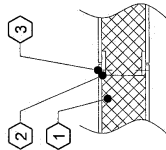
- |    |                  |    |                  |    |                 |    |              |     |             |
|----|------------------|----|------------------|----|-----------------|----|--------------|-----|-------------|
| 1  | 6-1/2" SIP       | 2  | 12" X 12" GASKET | 3  | 2X PLINE FASTED | 4  | 1-1/2" SCREW | 5   | 2X BLOCKING |
| 6  | 12" X 12" GASKET | 7  | 12" X 12" GASKET | 8  | 2X PLINE FASTED | 9  | 1-1/2" SCREW | 10  | 2X BLOCKING |
| 11 | 12" X 12" GASKET | 12 | 12" X 12" GASKET | 13 | 2X PLINE FASTED | 14 | 1-1/2" SCREW | 15  | 2X BLOCKING |
| 16 | 12" X 12" GASKET | 17 | 12" X 12" GASKET | 18 | 2X PLINE FASTED | 19 | 1-1/2" SCREW | 20  | 2X BLOCKING |
| 21 | 12" X 12" GASKET | 22 | 12" X 12" GASKET | 23 | 2X PLINE FASTED | 24 | 1-1/2" SCREW | 25  | 2X BLOCKING |
| 26 | 12" X 12" GASKET | 27 | 12" X 12" GASKET | 28 | 2X PLINE FASTED | 29 | 1-1/2" SCREW | 30  | 2X BLOCKING |
| 31 | 12" X 12" GASKET | 32 | 12" X 12" GASKET | 33 | 2X PLINE FASTED | 34 | 1-1/2" SCREW | 35  | 2X BLOCKING |
| 36 | 12" X 12" GASKET | 37 | 12" X 12" GASKET | 38 | 2X PLINE FASTED | 39 | 1-1/2" SCREW | 40  | 2X BLOCKING |
| 41 | 12" X 12" GASKET | 42 | 12" X 12" GASKET | 43 | 2X PLINE FASTED | 44 | 1-1/2" SCREW | 45  | 2X BLOCKING |
| 46 | 12" X 12" GASKET | 47 | 12" X 12" GASKET | 48 | 2X PLINE FASTED | 49 | 1-1/2" SCREW | 50  | 2X BLOCKING |
| 51 | 12" X 12" GASKET | 52 | 12" X 12" GASKET | 53 | 2X PLINE FASTED | 54 | 1-1/2" SCREW | 55  | 2X BLOCKING |
| 56 | 12" X 12" GASKET | 57 | 12" X 12" GASKET | 58 | 2X PLINE FASTED | 59 | 1-1/2" SCREW | 60  | 2X BLOCKING |
| 61 | 12" X 12" GASKET | 62 | 12" X 12" GASKET | 63 | 2X PLINE FASTED | 64 | 1-1/2" SCREW | 65  | 2X BLOCKING |
| 66 | 12" X 12" GASKET | 67 | 12" X 12" GASKET | 68 | 2X PLINE FASTED | 69 | 1-1/2" SCREW | 70  | 2X BLOCKING |
| 71 | 12" X 12" GASKET | 72 | 12" X 12" GASKET | 73 | 2X PLINE FASTED | 74 | 1-1/2" SCREW | 75  | 2X BLOCKING |
| 76 | 12" X 12" GASKET | 77 | 12" X 12" GASKET | 78 | 2X PLINE FASTED | 79 | 1-1/2" SCREW | 80  | 2X BLOCKING |
| 81 | 12" X 12" GASKET | 82 | 12" X 12" GASKET | 83 | 2X PLINE FASTED | 84 | 1-1/2" SCREW | 85  | 2X BLOCKING |
| 86 | 12" X 12" GASKET | 87 | 12" X 12" GASKET | 88 | 2X PLINE FASTED | 89 | 1-1/2" SCREW | 90  | 2X BLOCKING |
| 91 | 12" X 12" GASKET | 92 | 12" X 12" GASKET | 93 | 2X PLINE FASTED | 94 | 1-1/2" SCREW | 95  | 2X BLOCKING |
| 96 | 12" X 12" GASKET | 97 | 12" X 12" GASKET | 98 | 2X PLINE FASTED | 99 | 1-1/2" SCREW | 100 | 2X BLOCKING |



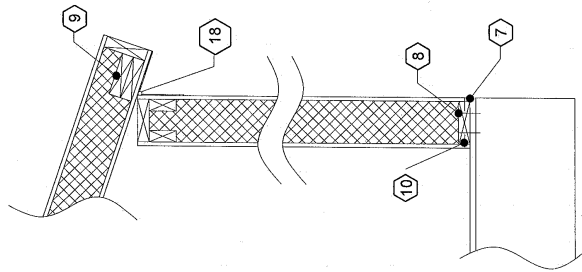
**C3** SIP DETAIL - CORNER  
3/4" = 1'-0"



**A3** SIP DETAIL - NORTH WALL  
3/4" = 1'-0"



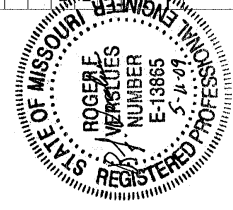
**C1** SIP DETAIL - TONGUE AND GROOVE  
3/4" = 1'-0"



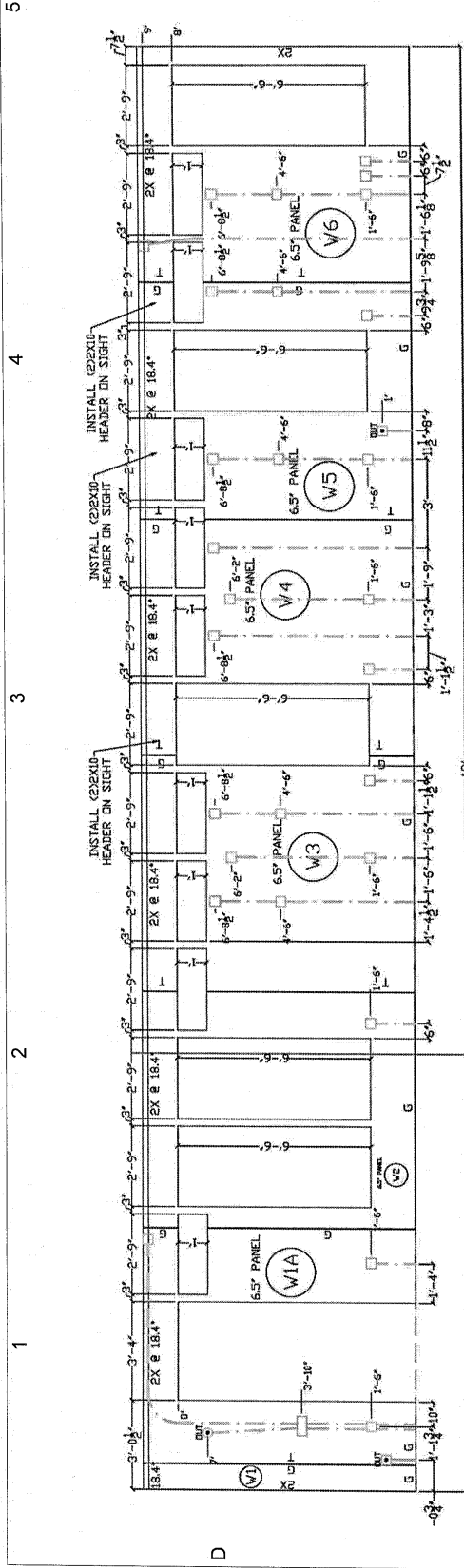
**A1** SIP DETAIL - SOUTH WALL  
3/4" = 1'-0"



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ENTRY**  
NATIONAL MALL,  
WASHINGTON D.C.

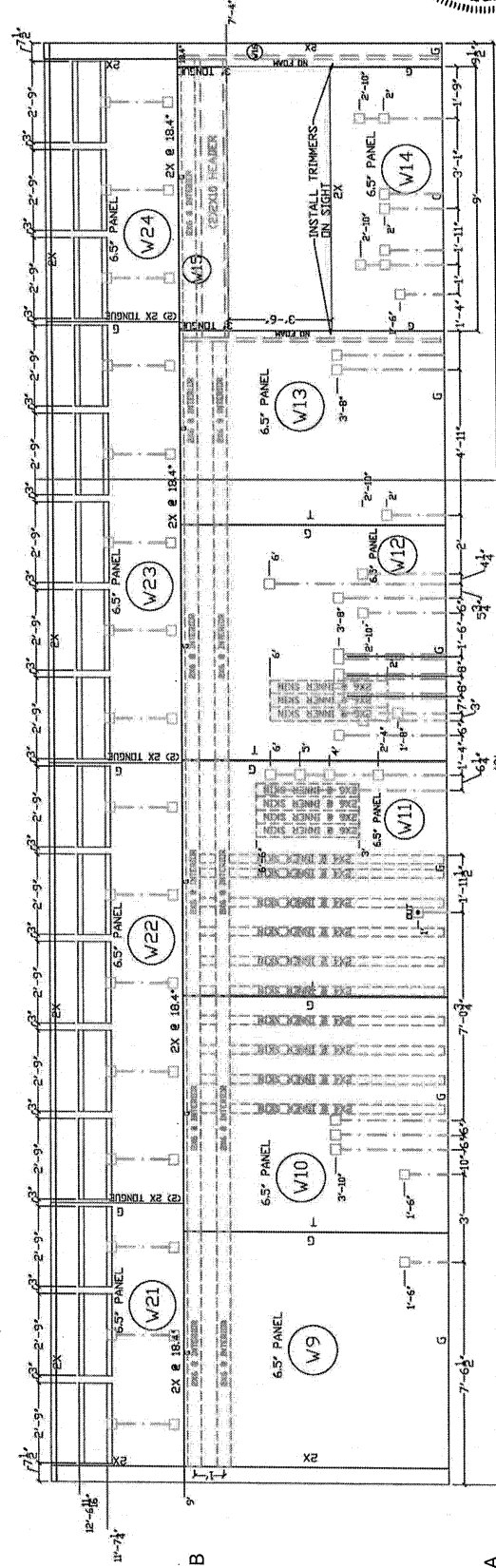
[illegible]

S-505



C

B2	SIP- SOUTH 2
	1/4" = 1'-0"



A1

 SIP- NORTH 2  
 1/4" = 1'-0"

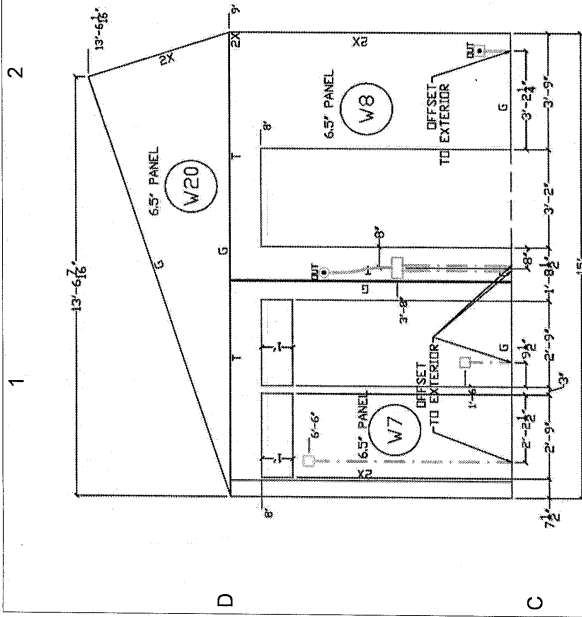


2009 SOLAR  
DECATHLON  
ENTRY

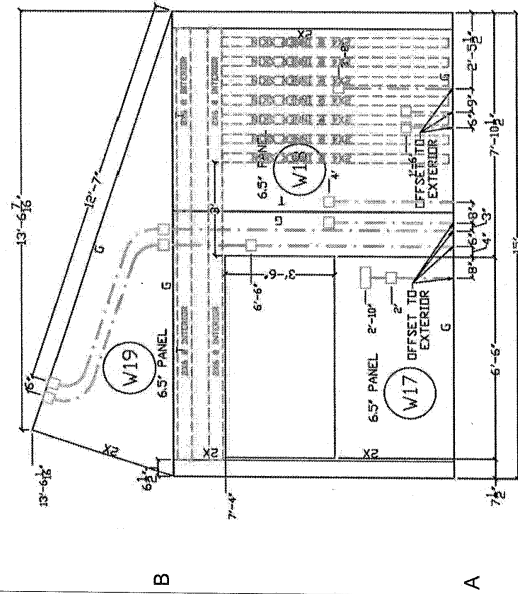
NATIONAL MALL,  
WASHINGTON D.C.

[illegible]

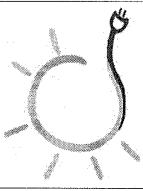
S-506



C1 SIP- EAST 2  
1/4" = 1'-0"



A1 SIP- WEST 2  
1/4" = 1'-0"



# Show-Me Solar

Missouri S&T  
University of Missouri

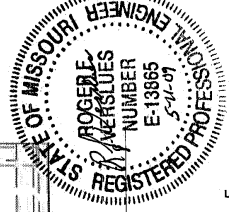


2009 SOLAR  
DECATHLON  
ENTRY  
NATIONAL MALL,  
WASHINGTON D.C.

MARK	DATE	DESCRIPTION

DATE: 06/02/2009  
DRAWN BY: Author  
CHECKED BY: Checker  
SHEET TITLE  
SIP PANEL LAYOUT

S-507



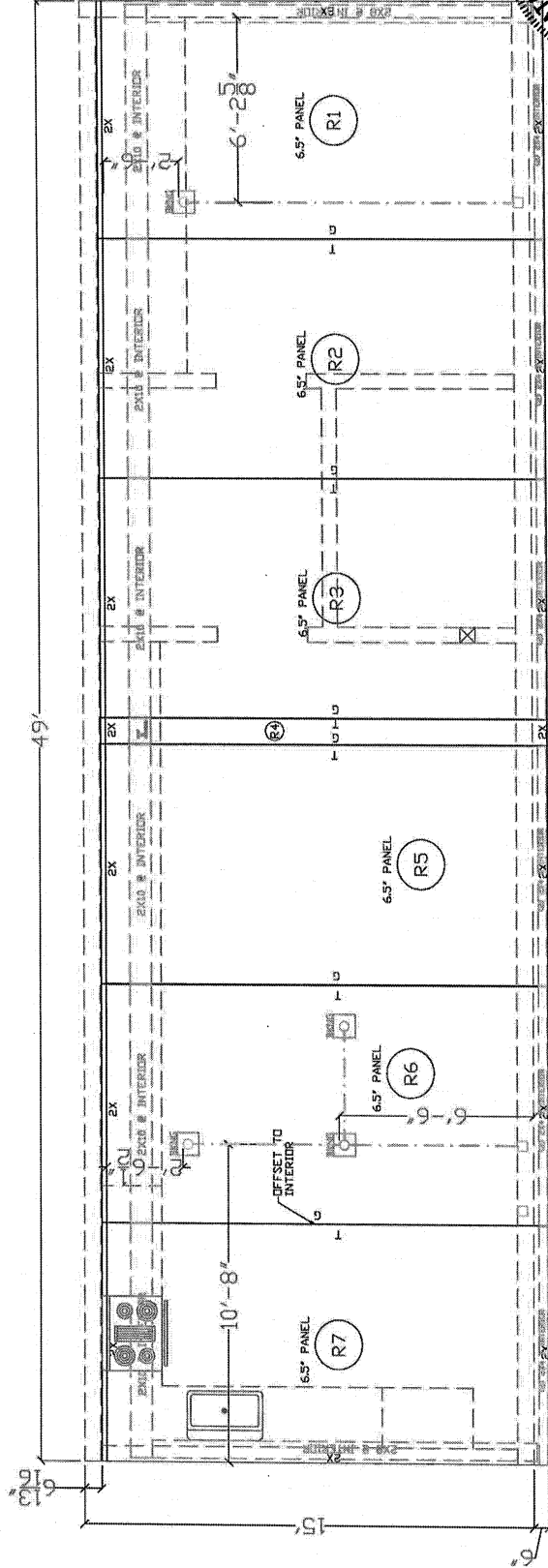
5

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2

1



A1 SIP- ROOF  
1/4" = 1'-0"

5

4

3

2

1



2009 SOLAR  
DECATHLON  
ENTRY


ISSUE:

DATE: 06/02/2009

DRAWN BY: CAK

CHECKED BY: Checker

SHEET TITLE

DECK DETAILS

S-510

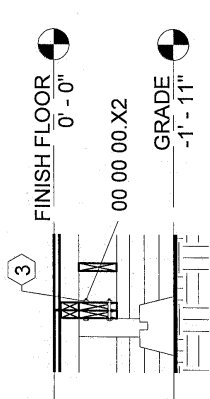
S-510

## SHEET KEYNOTES

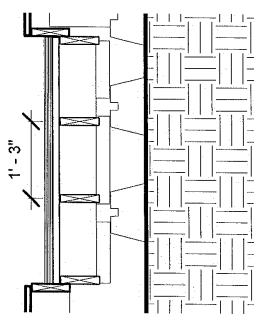
- ① 1/2" GALVANIZED LAGBOLTS, STAGGERED TOP TO BOTTOM EVERY 1'
- ② FIELD CUT TO FIT ELEVATION
- ③ 1/2" GALVANIZED BOLTS

## REF KEYNOTES

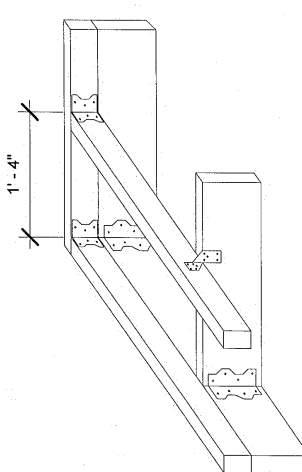
- 06 11 11 B.2 2"x4" TREATED BEAMS  
SPACED 16" O.C.
- 06 11 11 B.2 2"x4" TREATED  
LEDGER BOARD
- 40 00 00 X.2 1' FOOT SQUARE  
CONCRETE DECK PIER
- 06 22 11 B.2 2"x8" TREATED BEAMS  
SPACED 24" O.C.
- 06 15 19 A.2 1 1/4" RECLAIMED  
DECKING WITH 1"  
OVERHANG
- 16 14 00 A.2 4"x4" TREATED POST.  
ADJUST TO HEIGHT OF  
POST TO ELEVATION  
OF LAND



**D1** **MODULE CONNECTION DETAIL**  
1/2" = 1'-0" 6" 1'



**B1** SLOPED WALKWAY DETAIL  
1/2" = 1'-0"  
6" 1' 2'

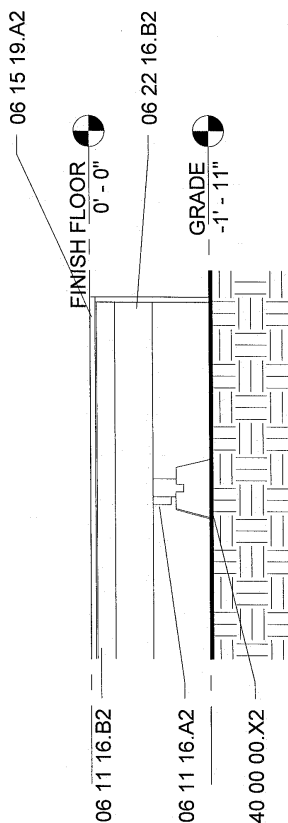


DECK JOIST DETAIL

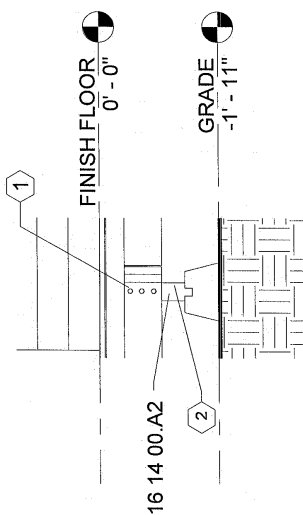
A1

3/4" = 1'-0"

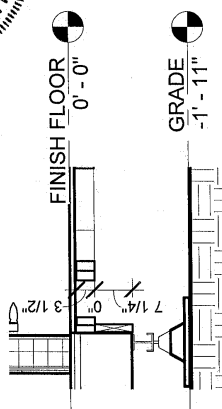
6" 1' 2'



**B2** LEDGER BOARD DETAIL  
1 1/2" = 1'-0"



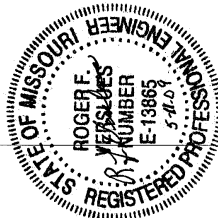
A3 TYPICAL PIER TO COLUMN TO 2"x8" JOIST DETAILS  
1/2" = 1'-0"



**DECK TO SUBFLOOR CONNECTION**

**DETAIL**

**A4**  $1\frac{1}{2}" = 1'-0"$  6" 1' 2'



**2009 SOLAR  
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ENTRY**  
NATIONAL MALL,  
WASHINGTON D.C.



2009 SOLAR  
DECATHLON  
ENTRY

MARK	DATE	DESCRIPTION
<b>ISSUE:</b>		
<b>DATE:</b>	<b>06/02/2009</b>	
<b>DRAWN BY:</b>	<b>LAS</b>	
<b>CHECKED BY:</b>	<b>Checker</b>	
<b>SHEET TITLE</b>		
<b>FOUNDATION DETAILS</b>		

S-515

## SHEET KEYNOTES

- 1 TIE DOWN ANCHOR WITH 3' DEPTH, 2" STRAPPING
- 2 ATTACH AT 45DEG SLOPE

## REF KEYNOTES

05 12 23  
S4X7.7 BEAM  
31 48 23  
JACKED PIERS  
31 62 19  
PIER PAD

5

4

3

2

5

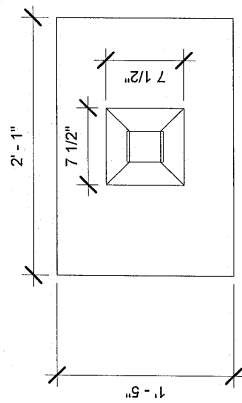
4

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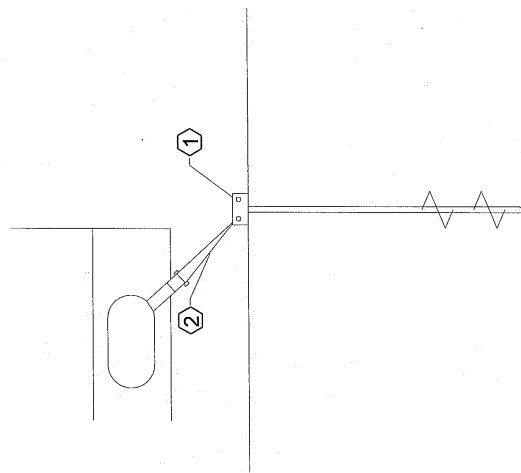
9

ANCHOR DETAIL  
3/4" = 1'-0"

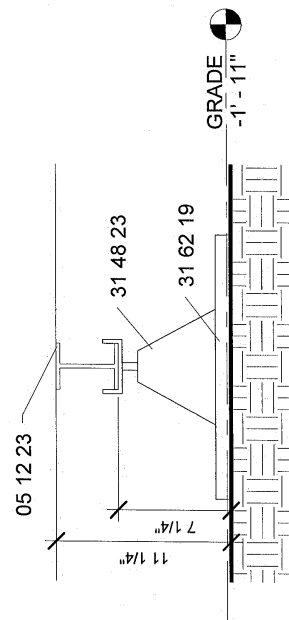
**JACK STAND DETAIL**  
1 1/2" = 1'-0"



PIER DETAIL  
1" = 1'-0"



ANCHOR DETAIL  
3/4" = 1'-0"



**JACK STAND DETAIL**  
1 1/2" = 1'-0"



2009 SOLAR  
DECATHLON  
ENTRY

[illegible]

S-520

## SHEET KEYNOTES

- 1 MUST EXTEND TO WITHIN 1/8" OF TOP AND BOTTOM FLANGE OF JOIST
- 2 DOUBLE WEB STIFFENER FOR ATTACHMENT TO RIM JOIST. SPACED 3" O.C. SAME SCREW PATTERN AS JOIST.
- 3 CENTER AND 1" FROM EDGE ON BOTH SIDES OF JOIST.
- 4 18" SPACING. CENTER OF FLANGE
- 5 2" X 2" SCREW PATTERN 2" FROM EDGE
- 6 3/4" #10 WAFER-HEAD

## REF KEYNOTES

- 05 12 00.A1  
TCS 12G 10" X 2"  
05 20 00.A1  
DW5 12G 10" X 2"  
05 41 00.A1  
TCS 12G 4-1/4" X 2"

5

4

3

2

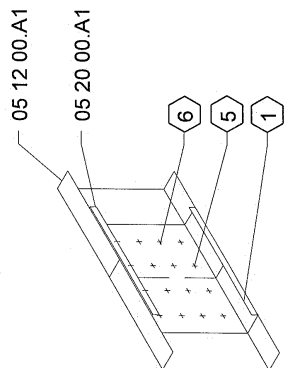
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4

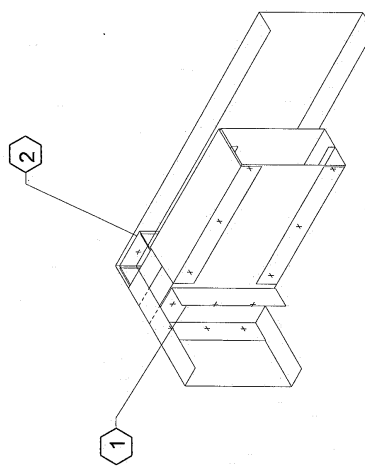
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5

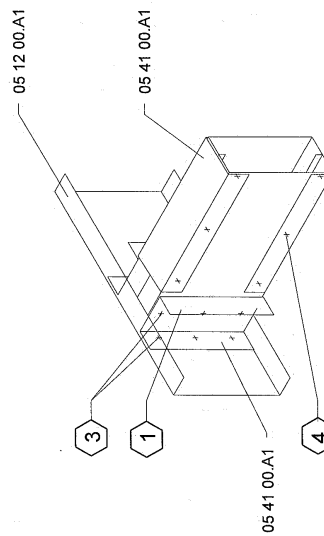
→



C1 SUBFLOOR SPLICE DETAIL  
 1" = 1'-0"

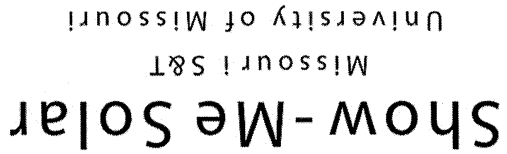


**(A1) SUBFLOOR CORNER DETAIL**  
1" = 1'-0"



**A4** SUBFLOOR JOIST DETAIL  
1" = 1'-0"





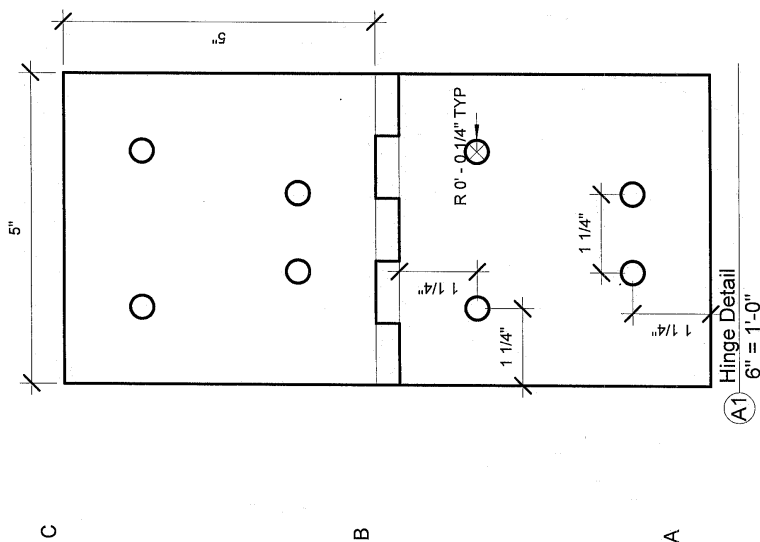
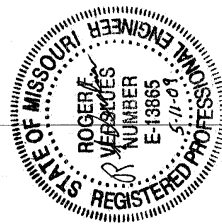
Missouri S&T  
University of Missouri



2009 SOLAR  
DECATHLON  
ENTRY

DATE: 06/02/2009  
DRAWN BY: Author  
CHECKED BY: Checker  
SHEET TITLE  
HINGE DETAIL

S-545





## SHOW-ME SOLAR HOUSE TEAM

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### Detailed Water Budget

Activity	Gallons/Activity	Number of Activities	Total (Gallons)
Water Heater			120
Shower	15	20	300
Dishwasher	7.8	5	39
Washing Machine	13.4	10	134
Solar Thermal Collection			5
Radiant Floor			20
Irrigation	5	3	15
Testing			50
Total			683
Total + 20% (Gallons)			819.6



# SHOW-ME SOLAR HOUSE TEAM

---

## Summary of Unlisted Electrical Components

### Custom Lighting- Drawing E-105

Sconces and Chandelier

Brushed aluminum frame with stacked glass and light diffusing cloth lit by Cree

XR-E chips

Soffit Uplighting

LED strip lighting

### Sensors- Drawing E-130

The following are the sensors used which are not listed.

AQF 3100

Radiation Shield

QFA 2060

Indoor Temp and Humid

QPA 2002

Air Quality

Li-200SZ-50

Pyranometer

FTB4605

Flow Meter

Wind Speed Sensor

Wind Speed

Li-210SZ

Ambient Light

VG400

Soil Moisture

### Appliances- Drawing A-405, A-410

The following Kitchen Aid Appliances have been modified by Whirlpool with a “Wide Box” which is a circuit that allows external control of the appliance via a serial port.

Whirlpool WFW9700VW

Washer

Whirlpool WED9600TW

Dryer

Kitchen Aid KUDS03ST

Dishwasher



# **SHOW-ME SOLAR HOUSE TEAM**

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## Retail PV Price Quote

See attached documents.



## PROFORMA INVOICE

DATE OF EXPORTATION 3/12/2009	EXPORT REFERENCE HGR-059886
SHIPPER/EXPORTER  BP Solar International, LLC. 630 Solarex Court Frederick, Maryland 21703 USA	CONSIGNEE  Bob Phelan Project Manager Student Design & Experiential Learning Center 112 Engineering Research Laboratory Missouri University of Science and Technology 500 W. 16th Street Rolla, MO 65409-1410
COUNTRY OF EXPORT  United States	METHOD OF SHIPMENT  Truck
COUNTRY OF ULTIMATE DESTINATION  United States	PAYMENT TERMS  Net 30

QTY.	ITEM NUMBER AND DESCRIPTION	UNIT VALUE	TOTAL VALUE USD.
40	SX 3200B – 5213.0123 Freight Charges	\$674.00	\$26,960.00 \$223.00

TOTAL INVOICE VALUE : \$27,183.00

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN. DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.  
I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT.  
SIGNATURE OF SHIPPER/EXPORTER

AUTHORIZED SIGNATURE  
BP SOLAR INTERNATIONAL, INC.



# **SHOW-ME SOLAR HOUSE TEAM**

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## Summary of Reconfigurable Features

There are no components of the home that are considered reconfigurable features according to Appendix B-2b of the Rules and Regulations.



# **SHOW-ME SOLAR HOUSE TEAM**

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## Interconnection Application Form

See attached for Interconnection Application and the associated documents.

Solar Decathlon 2009  
**INTERCONNECTION APPLICATION FORM**

Show-Me Solar #103

**team name and lot number**

**PV SYSTEMS**

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)
BP	4 strings in parallel	308
	each string with 10 in series	

Total DC power of all arrays is 8 kW (in tenths).

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

**INVERTERS**

Inverter Manufacturer	Model Number	Voltage	Rating (kVA or kW)	Quantity
Fronius	16 Plus 7.5-1	208/240/277	7.5 nominal	1

Total AC power of all inverters is 7.5 kVA or kW (in whole numbers).

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

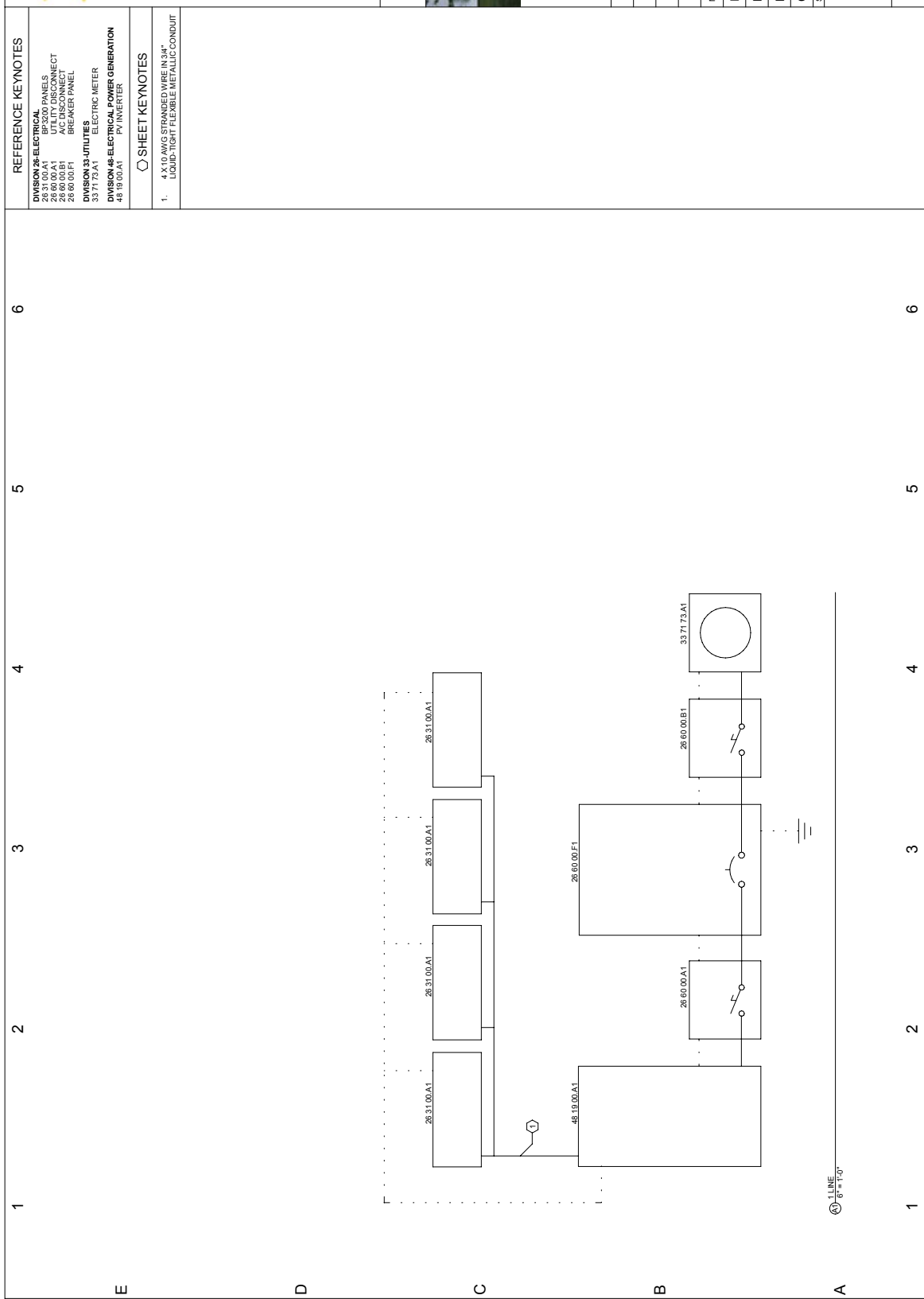
Please include the following in the Project Manual:

- 1) One-line electrical schematic – the loads do not have to be detailed.
- 2) Calculations of service/feeder net computed load and neutral load (NEC 220)
- 3) Plan view of the lot showing the house, decks, ramps, tour paths and the service point.
- 4) Elevation view(s) showing the terminal box (contains the service point), meter, and other service equipment (such as the distribution panel or load center).

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

Provide the Team's "Electrical Engineer" contact info in the "Team Officer Contact Info" database on the Yahoo Group. See Rule 3-2.

Please see the "Grid Interconnection Process for Teams" file on the Yahoo Group for more details on the interconnection process and the Terminal Box Mounting Panel.



REFERENCE KEYNOTES	
<b>DIVISION 26-ELECTRICAL</b> 26 31 00 A1 EP-3000 PANELS 26 31 00 B1 EP-3000 CONNECT 26 60 00 F1 A/C DISCONNECT 26 60 00 F1 BREAKER PANEL	
<b>DIVISION 33-UTILITIES</b> 33 71 73 A1 ELECTRIC METER 48 19 00 A1 P.V. INVERTER	
○ SHEET KEYNOTES 1. 4 X 10 AWG STRANDED WIRE IN 3/4" LIQUID-TIGHT FLEXIBLE METALLIC CONDUIT	

University of Missouri  
Missouri S&T  
Show-Me Solar

500 W. 16TH STREET  
ROLLA, MO 65401  
573-341-6794



**U.S. DEPARTMENT  
OF ENERGY 2009  
SOLAR DECATHLON  
ENTRY**



REFERENCE KEYNOTES

DIVISION 26-ELECTRICAL  
26 27 02 A1 JUNCTION BOX  
26 60 00 A1 UTILITY DISCONNECT  
26 60 00 B1 JUNCTION BOX  
26 60 00 C1 JUNCTION BOX  
26 60 00 D1 DATA/GENERATOR ENCLOSURE  
DIVISION 33-UTILITIES  
33 05 00 A1 ELECTRIC METER  
33 05 00 B1 ELECTRIC METER  
DIVISION 48-ELECTRICAL POWER GENERATION  
48 19 00 A1 PV INVERTER



500 W. 16TH STREET  
ROLLA, MO 65401  
573-341-6794



U.S. DEPARTMENT  
OF ENERGY 2009  
SOLAR DECATHLON  
ENTRY

NATIONAL WALL  
WASHINGTON D.C.

MARK	DATE	DESCRIPTION

ISSUE:

DATE: 06/02/2009

DRAWN BY: BTB

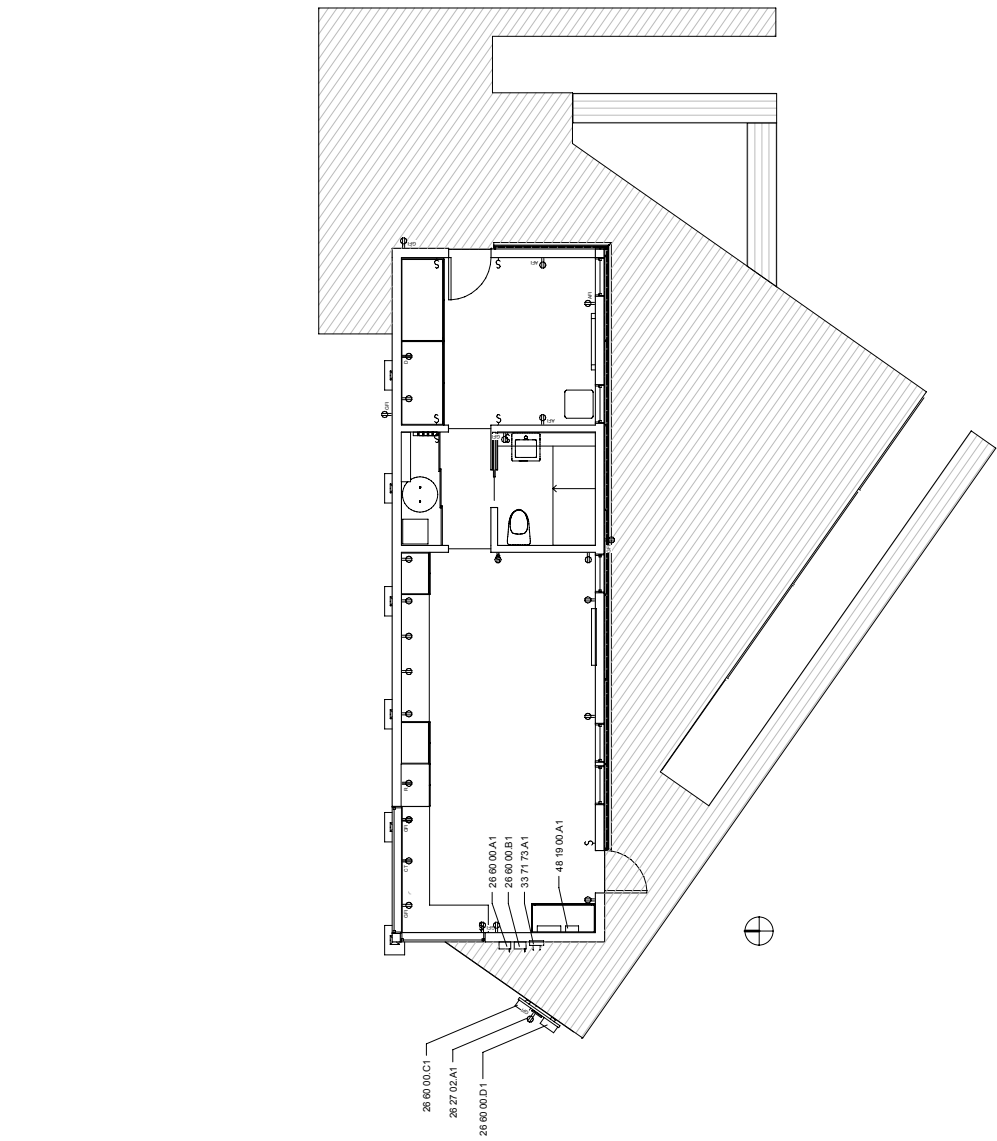
CHECKED BY: AMA

SHEET TITLE

INTERCON.

E-126

1 2 3 4 5 6



INTERCONNECTION  
SHEET 1 OF 2

1 2 3 4 5 6





# SHOW-ME SOLAR HOUSE TEAM

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## Energy Analysis Results and Discussion

The energy analysis of the Show-Me Solar House is presented in this document. The particular analyses highlighted include the solar thermal collection system, the solar panel angle, exterior wall construction, lighting, louver design, and the home automation system. Architectural items such as the solar panel angle, the louver layout, and window ratios were chosen to optimize building efficiency and maintain aesthetic integrity of the home.

### **Solar Thermal Collection**

A solar thermal energy collection system is being used due to the added efficiency of heating water directly from the sun rather than converting collected electrical energy to hot water. Further, this method of energy collection is more efficient than photovoltaics when properly implemented. Several studies have confirmed that evacuated tubes range from ten to sixty percent more efficient than flat plate collectors depending upon ambient temperature<sup>1</sup>. Reflective tubes are able to achieve Incidence Angle Modifier (IAM) of over 1.0 in certain situations which greatly increases their ability to collect energy<sup>2</sup>. For these reasons, the team has chosen to use evacuated tubes for solar thermal energy collection in conjunction with a reflective roof surface

Through the use of energy simulations, it was determined that an angle of approximately 70 degrees is optimal to create an energy output with the least variance across seasons. However to unite engineering and architecture, as well as to stay within the required solar envelope, a flatter angle of about 30 degrees has been chosen. While not optimal, the 30 degree angle still provides more uniformity and less waste heat than if the tubes were installed with no incline.

### **Solar Panel Angle**

The roof angle (i.e. the solar panel angle) chosen for the house design is 18.5 degrees, a typical 4 to 12 roof construction, and was obtained through an analysis of the energy production of the solar array. Roof angles of 18.5 degrees, 25 degrees, and 35 degrees were chosen for analysis to determine which would meet the energy needs of the home. Due to solar envelope of the building, roofs of the same size have different south facing area when pitched at different angles. The 18.5 degree roof could fit 39 solar panels, the 25 degree roof could fit 27, and the 35 degree roof could fit 15 solar panels due to the solar envelope provided by contest regulations. An analysis of these arrays at the respective angles using Maui Solar software showed that only the 18.5 degree angle with its 39 solar panels satisfies the estimated energy demand of the house. For example, during months 6-9 on Figure 1 (which correspond to June through September) the 18.5 degree solar panel system is the only one that produces enough power to meet the estimated demand.

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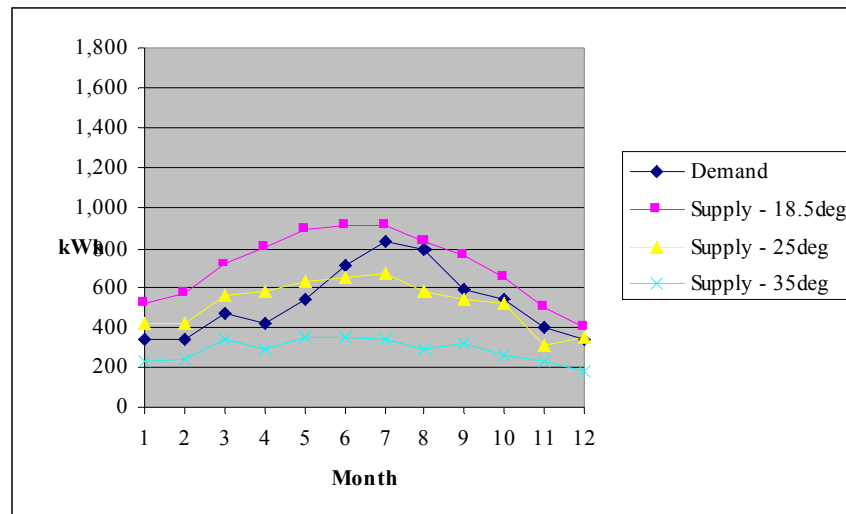
<sup>1</sup> [http://www.apricus.com/html/solar\\_collector\\_efficiency\\_compare.htm](http://www.apricus.com/html/solar_collector_efficiency_compare.htm)

<sup>2</sup> [http://www.apricus.com/html/solar\\_collector\\_efficiency\\_iam.htm](http://www.apricus.com/html/solar_collector_efficiency_iam.htm)



# SHOW-ME SOLAR HOUSE TEAM

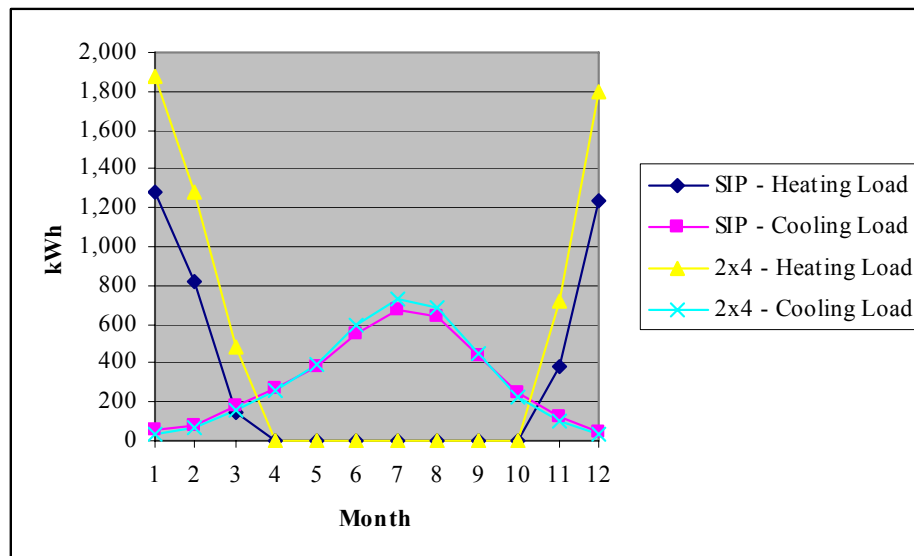
## Energy Analysis Results and Discussion



**Figure 1. Energy Demand vs. Energy Output of Potential Solar Panel Angles**

### Exterior Wall Construction

Structurally Insulated Panels (SIPs) were chosen early in the design process due to their superior thermal resistivity (R-value) and modularity. The SIPs have an R-value of 40 whereas a typical stud wall of the same thickness is nearer to 20<sup>3</sup>. Energy-10 simulations based upon these values support the assumption that this difference will reduce the wall heat transmittance by half, diminishing energy consumption noticeably. As is evident in figure 2, while savings are significant year round, more energy is saved in the winter months.



**Figure 2. Energy Demand by Construction Method**

<sup>3</sup> <http://thermocoremo.com/forms/agervalue.aspx>



# SHOW-ME SOLAR HOUSE TEAM

## Energy Analysis Results and Discussion

### Lighting

The primary lighting for the house will be provided solely by LEDs due to their high efficiency. While incandescent bulbs average 11 lumens/watt, the LEDs chosen are 54 lumens/watt<sup>4</sup>. While some CFL's achieve an efficiency of 65 lumens/watt, the use of custom fixtures requires the use of LED's small form factor<sup>5</sup>. Additionally, the lifetime of LEDs adds convenience and supports sustainable living practices. By using LEDs in wall sconces, can lights, and hanging fixtures as well as reflecting uplighting off of the ceiling, the 50 lumens/ft<sup>2</sup> for task lighting and the 30 lumens/ft<sup>2</sup> for ambient lighting recommended by the Illuminating Engineering Society of North America can be provided. Using solely LEDs will allow all primary, task, and accent lighting to be provided at a maximum average of .7 Watts per square foot. This number will be further enhanced by the passive lighting design that was considered when designing windows.

### Louver Design

Louvers were chosen as both an aesthetic and energy saving feature of the home's exterior. The spacing and depth of the louvers were chosen with regard for annual energy consumption. During warm months, nearly all direct sunlight is blocked by the louvers, thus reducing passive heating. During cooler months, as much as eighty percent of sunlight is allowed to pass through to passively heat the home and reduce energy demands. This can be seen by the low shading percentages from November to February.

	MORNING										AFTERNOON								
	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00		
Jan					20%	30%	30%	30%	30%	30%	30%	30%	20%					Jan	
Feb				10%	30%	40%	40%	40%	50%	40%	40%	40%	30%	10%				Feb	
Mar				50%	60%	60%	60%	60%	60%	60%	60%	60%	60%	50%				Mar	
Apr				100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%				Apr	
May					100%	100%	100%	100%	100%	100%	100%	100%	100%					May	
Jun						100%	100%	100%	100%	100%	100%	100%						Jun	
Jul						100%	100%	100%	100%	100%	100%	100%						Jul	
Aug					100%	100%	100%	100%	100%	100%	100%	100%	100%					Aug	
Sep				100%	80%	80%	80%	80%	80%	80%	80%	80%	80%	100%				Sep	
Oct				20%	40%	50%	50%	50%	50%	50%	50%	50%	40%	20%				Oct	
Nov					20%	30%	30%	40%	40%	40%	30%	30%	20%					Nov	
Dec					10%	20%	30%	30%	30%	30%	30%	20%	10%					Dec	
	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00		
	MORNING										AFTERNOON								

Figure 3. Percentage of Shading by Month and Time of Day<sup>6</sup>

### Home Automation System

A hybrid automation and energy management system has been designed for implementation into the house. It has optimized control logic to minimize the amount of time that heating and

<sup>4</sup> [http://www.creelighting.com/downloads/LR4\\_spec\\_072908.pdf](http://www.creelighting.com/downloads/LR4_spec_072908.pdf)

<sup>5</sup> <http://www.prismaecat.lighting.philips.com/ecat/Light/ApplicationRouter.aspx>

<sup>6</sup> [http://susdesign.com/louver\\_shading/index.php](http://susdesign.com/louver_shading/index.php)



## **SHOW-ME SOLAR HOUSE TEAM**

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### **Energy Analysis Results and Discussion**

cooling systems need to run by opening windows and ensuring that separate systems do not run concurrently. It can also reduce the number of lights that need to be on by automatically adjusting shades, and will turn lights off when vacant. Standby power can also be terminated based upon vacancy by relays that have been installed. Further, the appliances can be triggered through the automation system to run when there is an abundance of energy, thus reducing the usage time of supplemental water heaters.

Using energy simulations and blackbox testing, it has been projected that that the system will be able to save 1.39 kWh per square foot per year.



# SHOW-ME SOLAR HOUSE TEAM

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## Architecture Design Narrative

Architectural design should not only respond to its natural surroundings but also reflect cultural influences. The Show-Me Solar House exhibits traditional Missouri characteristics while incorporating technology of the 21<sup>st</sup> century. Our concept, Expanding Horizons, stresses the future of solar and other green technologies which are symbolized in the home's main axis as well as a continuing pattern of horizontal lines. These ideas are expressed in the floor plan, material selections, and integrated technology systems.

The Show-Me Solar House floor plan is very responsive to the surrounding environment. Beginning with an elongated east-to-west axis, southern exposure is maximized allowing for passive solar gain through large southern windows. To control the amount of heat gain, an incorporated louver system blocks the sun's summer rays and allows for light in the winter to penetrate and heat the home. The elongated axis also provides for maximum cross ventilation cooling the house in the summer months. All heat-producing appliances and cabinetry rest along the north wall to protect the interior from harsh winter winds.

The design of the floor plan separates the public and private spaces with the more public areas on the west side, by the main entrance, and the private areas on the east side. The bedroom is greeted in the morning by the rising sun and the dining and living areas experience the sun set in the evening. This design allows for the sun to follow the spaces that have the most activity, leaving little need for artificial lighting. The plan has a wide, unobstructed circulation path for easy access to the home's amenities for all residents.

Also incorporated into the design is a modular three-foot grid which helps to connect all features of the house and simplify construction. The grid creates a pattern of measurements which are similar throughout the entire house, thereby creating less construction waste and making the possibility of mass production much easier. The simple, repeated pattern also helps to make the resident more comfortable by contrasting the complex systems and advanced features. In addition, this grid helps to line up views across the house, such as the cross-section taken from the east door in which the walls of the hallway line up perfectly with the west window of the kitchen providing a view outdoors. A view of the main seating section of the deck is also directly visible through the living room windows from the kitchen work triangle. These views cause the house to seem larger than it is by providing exterior perspectives from nearly all rooms of the house.

The material selections for the home reflect Missouri's culture complemented with new products. For the exterior, reclaimed barn wood was selected for siding from a Missouri barn paired with a cement fiberboard accent. The main interior materials combine traditional oak flooring, which is native to Missouri, with Kirei Board cabinets that are produced from sorghum straw – an agricultural waste product.



# **SHOW-ME SOLAR HOUSE TEAM**

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## *Architecture Design Narrative*

In the end, the house provides a very comfortable feel while providing very modern amenities and showcasing Missouri native materials. Altogether the house symbolizes the future of solar technologies coupled with energy saving features and the benefits of using local products that will soon become the norm.



# SHOW-ME SOLAR HOUSE TEAM

## Market Viability Justification Report

### Abstract

#### Brief Target Market Description of Show-Me Solar House Team

Location of Permanent Site	Housing Type	Number of Occupants	Occupant Demographic	Homeowner Annual Income	Number of bedrooms
St. Charles, MO	Retirement residence	2	Retiring couple. Dual-income with no kids (DINK) Ages 55-to-60	\$125,000	1

#### Notes:

1. Homeowner annual income may not be relevant once the homeowner is retired. In that case, the target market will have a net worth of greater than or equal to \$600,000.

### Livability

The design of the Show-Me Solar home offers the occupants a safe, functional, convenient, comfortable and enjoyable place to live. To accomplish these qualifications, we are using the ADA as a framework for all design decisions. Designing accessible, adaptable homes leaves bright, open and clean interiors that can host a number of activities.

This design meets the unique needs and desires of retiring dual-income couples with no kids through the adaptability of the spaces, the ability for the house to take care of itself while left alone for long periods of time, and timeless and durable materials.

### Marketability

The use of local, ecological and durable exterior materials demonstrates curb appeal for this Missouri home. Materials of this style are throughout the interior for the enjoyment of retiring professionals who have a love of natural Missouri. The use of local and durable materials shows the team's investment to quality craftsmanship and design.

Because of our chosen target market, the house's sustainability features and strategies make a positive contribution to its marketability. Retiring professionals understand investing in materials that last more than their lifetime. Using sustainable materials such as reclaimed barn siding and recycled glass countertops, expresses this interest by reusing materials, rather than producing new ones. The Show-Me Solar home offers potential homebuyers within this target market a good value by providing a unique, timeless place for them to appreciate nature and all that Missouri has to offer.



# SHOW-ME SOLAR HOUSE TEAM

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## Market Viability Justification Report

### **Introduction**

The Show-Me Solar House Team designed and developed a home to be adaptable and simple to live in, within a deliberate goal to efficiently use local Missouri products and workers to reduce the consequences on the environment. The team's target market consists of couples who are near retirement or are retired. These couples have a dual income and no kids (DINK) and love the natural surroundings of Missouri. While employed, these residents earned an income of approximately \$125,000 per year and when retired have amassed a net worth of over \$600,000. The desired housing market is concentrated in eastern Missouri, more specifically in St. Charles because of the local Universities and proximity to St. Louis.

The interest on lessening the impact on the environment is an increasing trend in the real estate market. This same section of the market is also motivated to find alternative ways of obtaining power and lowering household energy bills because of the current economic crisis. Although the last aspects are concerns for the majority of the U.S., the Show-Me Solar team focused on the desires of retiring DINK Missourians. Retiring individuals want a home tailored to their unique traits and lifestyle, ideally a safe environment, which will ease the transition from busy professionals to active adults. The Show-Me Solar House Team designed a house to meet the requirements of their chosen target market. This report will describe the choices the team made in regarding a design for this demographic.



# SHOW-ME SOLAR HOUSE TEAM

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## Market Viability Justification Report

### **Livability**

The house was designed to maximize safety and adaptability while not sacrificing aesthetics and comfort. The whole home illustrates this feature by the fact that it was designed using the American with Disabilities Act (ADA) as a resource. Certain incorporated features accommodate the consumer without forcing a dominant change into their lifestyle. The design of this home aids the homeowner and allows them to continue living in the home despite age or health issues, such as being in a wheelchair.

Specifically, the kitchen's 34-inch ADA approved countertops allow anyone to enjoy the rolling views from the kitchen windows despite any restrictions. These terrazzo countertops were created using recycled glass and built to be easily maintained and cleaned. Each kitchen appliance was positioned to ensure ease of operation for anyone using the kitchen. Similarly, the bathroom applied many of the same techniques as the kitchen to ensure full function for the target market.

The designers chose the bathroom fixtures and coverings to provide for the safety of the consumer without sacrificing aesthetics. Specifically, the shower wand allows anyone to take a shower, while still being seamlessly integrated into the bathroom design. A seat in the shower enables the consumer to enjoy a shower safely and comfortably. An ADA-approved dual-flush toilet provides ease of use to the consumer as well as providing an environmentally friendly option. A unique, polymer ceramic flooring with slip resistance gives the consumer extra grip not found with traditional tile floors while retaining the tile's easy maintenance.

Throughout the home, the team has designed a home automation system to provide comfort, safety and entertainment for the consumer. The automation system performs many dedicated tasks to help the homeowners use the energy created in the most efficient manner. The use of ambient light, temperature, and occupancy sensors optimize the integrated core systems to allow for a reduction in artificial light, heating and cooling loads within the home. The home automation system also reduces any excessive energy uses when the homeowner is away. Home entertainment may seem extravagant, but the home automation system's control also leads to a reduction in standby power and a reduction in peripheral products. For example, the homeowner can utilize the speaker system across the entire house from a single input. The home automation system provides energy data to educate the consumer on energy consumption. This information gives the homeowner an opportunity to change his or her habits in an effort to be more energy conscious. A touch-screen interface system, conveniently located in the living room and bedroom, accesses this information and controls the actions performed by the home automation system.

The multitude of windows in the house provides a necessary connection to nature that this market has enjoyed. A series of sun-shading louvers supply a passive solar element for shade to the south side of the house and develop a dynamic lighting profile for the inside. The integrated window and shade motors in the home automation system provide natural and optimized energy efficient heating, cooling and lighting options for the home. The window and shade motors allow the consumer to open them with the touch of a button instead of risking their safety while climbing to open them.



# SHOW-ME SOLAR HOUSE TEAM

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## Market Viability Justification Report

Additional comforts in the house were provided through the active HVAC and construction of the house. A radiant floor was installed within the home to provide a warmer, more constant heat. With the evacuated tube system, the use of a radiant floor allows for the direct collection of home-warming heat from the sun without wasting energy on a forced air furnace. The active cooling and ventilation system utilize energy-efficient products and elevated ducts to disperse the conditioned air through the home. In regards to structure, the team used structurally insulated panels in the construction of the structural walls and roof of the home. They have an R-40 rating and provide the house with a stable interior environment, while reducing the losses attributed to conventional insulation and air leakage.

The majority of the house provides the consumer with flexible living arrangements to accommodate the market's active lifestyle. The living room furniture is modular; which allows the consumer to move them with ease into whatever arrangement they prefer. The defined public spaces of the home begins in the kitchen, dining and living area, then gently transition into private spaces as the eye follows the bold lines of the home's Kirei board cabinetry. The bedroom design was to create a sanctuary for the couple to retreat to at the end of the day. The bedroom lighting contributes to the relaxing mood, with built-in task lighting for reading. The bedroom closets can accommodate full-length dresses and suits while ensuring adequate storage space for the couple. The washer<sup>1</sup> and dryer<sup>2</sup>, also located in one of the bedroom closets, are the quietest on the market, but also have the added benefit of an enclosed closet space to dampen the already subtle hum of the machines. All these innovations and techniques help to meet and exceed the standards for LEED Certification of Homes.

### **Buildability**

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ encourages and accelerates global adoption of sustainable green building. This home complies with the LEED for Homes (LEED-H) requirements to provide the consumer with a green, environmentally friendly house that is nationally recognized. Local, sustainable materials such as Structurally Insulated Panels (SIPs) and recycled barn wood siding help to comply for the LEED specifications. The use of local materials will cut down on transportation costs and delay time. The homebuilder will have a better knowledge of sustainable building products and implementation techniques for these products due to familiarity and experience with regional systems and materials.

SIPs provide the exterior structure of the house further benefits other than thermal. SIP's durability and strength withstands the extremes of the Missouri's seasons. Due to fact that the SIPs are factory manufactured and assembled on site by trained SIP contractors, the use of SIPs allows for a reduction in lumber usage as well as reduced waste in the production of the home. This benefit is an added gain to the target market, which worry about their flow into the waste stream and the effect on the total environment. In addition, this reduction in waste translates into

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<sup>1</sup> Whirlpool Duet Steam Washer -

<http://www.whirlpool.com/catalog/product.jsp?src=Search&categoryId=115&productId=1436>.

<sup>2</sup> Whirlpool Duet Steam Dryer -

<http://www.whirlpool.com/catalog/product.jsp?src=Search&categoryId=119&productId=1417>.



# SHOW-ME SOLAR HOUSE TEAM

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## Market Viability Justification Report

direct savings for the consumer. Due to the nature of the competition, the home is also well suited for easy assembly and quality product.

This home is very resilient and could easily be built offsite in a controlled environment and transported to the site. The steel subfloor provides the house with extra strength and stability against the unstable loading attributed to transportation. SIPs are very durable and can withstand the extra strain of transportation of a modular home to the home site. With the benefit of offsite modular construction, the main building can be constructed in a controlled environment with a managed budget and an efficient assembly plan to expedite the construction process as well as enhance the quality of assembly. This also gives the buyers the ability to afford a more modern home that is easy to build and safe for the environment with a lessened amount of construction waste.

### **Marketability**

The design concept of Expanding Horizons rings true in the bold lines and deep angles that define this home. Though unique in appearance, the basics of Missouri's, simple, yet elegant, traits are apparent in this design. The Show-Me Solar House Team trusts the features of the house will allow it to integrate into any community.



With the push toward using sustainable and local, the inside of the house is a collection of green and environmentally friendly materials. The flooring, besides being a finished hardwood, is quarter-sawn oak from Missouri forests. Quarter-sawn hardwoods are one of the best woods for radiant heating due to the grain of the wood. The siding consists of reclaimed siding from an old hay barn that was located in Goodman, MO built in approximately 1920. The wood is predominately oak and pine because those trees populate Missouri. Another wooden aspect in our home is the Kirei board cabinet faces. The Kirei board is constructed using compressed sorghum that is not native to Missouri; however, its growth rate makes it a sustainable material.



# SHOW-ME SOLAR HOUSE TEAM

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## Market Viability Justification Report



With all the capable appliances Energy Star-rated, and intelligently controlled through the home automation, the resident has the opportunity to save energy. In addition, a dual-flush toilet in the bathroom reduces water waste while the drywall in the house is 90 percent recycled material and gypsum. With a combination of all these systems and materials with the quality artisanship, these features add a great value to this home for the target market.

The three techniques used to design this efficient home were collecting energy efficiently, storing energy usefully and using energy intelligently. The PV collects and transmits electricity to the user and eventually to the grid. The thermal mass of the house and the water storage tank store solar energy for times without sun. Finally, the educated, energy-conscious user and optimizing home automation system intelligently control what energy is being used and when.

The energy saving features of the house will provide the consumer to see immediate savings on their energy bills. Since the design is a net-zero house, it will have the ability to generate as much energy as it consumes. By grid-tying the house, the consumer can sell excess energy back to the utility company as a way to earn extra income from their house. Since the couple is retired, with limited to no income, this will help them spend money wisely and not on the rising cost of utilities.



# SHOW-ME SOLAR HOUSE TEAM

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## Engineering Design Narrative

The Show-Me Solar House Team has engineered several systems to ensure a positive energy balance, an increase in building efficiency, and a decrease in setup time.

### **Chameleon**

The Chameleon Automation System will serve as a hybrid automation and energy management system accomplishing typical tasks in the most energy efficient manner. While traditional automation systems expend energy to provide convenience, Chameleon will be able to provide both convenience and increase the building end-use efficiency. Targeted home systems include: HVAC, lighting, window and shade control, home entertainment, appliances, standby power, and customizable entry. As a quantitative measure, the system will also incorporate power monitoring. The system receives input from the user via touchscreen interfaces and a suite of sensors installed throughout the residence. Using this information, it will accomplish necessary tasks in the most energy efficient manner. For example, depending on the differential between interior and exterior temperature and humidity, the system may choose to cool the house by opening windows rather than turning on a heat pump. Another instance would include shades opening instead of turning lights on if the ambient light level outside is above a certain threshold. Lights may also be turned off if it is determined that the residence is vacant while the standby power draw will also be terminated via the use of relays. Based upon the level of solar irradiance, queued appliances will be started automatically through the automation system. Due to the availability of solar thermal heat collection, a dramatic decrease in energy attributed to supplemental hot water heaters will be realized when the appliances are run at solar noon. Additionally, upon entry, the system presets will be loaded for the given user.

### **Solar Thermal**

The solar thermal collection system utilizes evacuated tubes to collect heat from the sun. The system dimensions are compatible, so the integration will be aesthetically pleasing and roof space will not be wasted. Depending on current house demand, the system routes this energy either to a storage tank or heat pump.

### **Radiant Floor / Subfloor**

When coupled with solar thermal heating, a hydronic radiant floor system will be between 25 to 40 percent more efficient than a forced air system. This is due to the fact that the hot water being used is generated without the use of instantaneous hot water heaters. From this system, the resident can be as comfortable as they would feel from a forced air heating system, but at a house temperature of 2-3 degrees cooler.

The radiant floor is being combined with a dual purpose subfloor. The Warmboard being used serves as structure and provides reflective channels for PEX tubing. Thermal analysis has been completed to ensure proper spacing for thermal transfer to most notably affect temperature variation.

### **Air to Air Heat Pump**

A heat pump will be used to supplement the radiant floor system in times of high heating demand, and to provide cooling.



# SHOW-ME SOLAR HOUSE TEAM

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## Engineering Design Narrative

### **Heat Recovery Ventilator**

A heat recovery ventilator exchanges air in the house using registers in the bathroom, living room, dryer, and stove hood to achieve the optimal residential ventilation of 30 cfm/room (and 90 cfm for the living room).

### **Louver Design**

The south and east exterior walls of the house incorporate louvers for passive solar. Sunlight during warm months is blocked, while up to 80% is allowed during colder months.

### **Hinged Roof**

The roof of the 2009 house has hinges on both the north and south walls. Once the roof is craned, the gables can be removed allowing for the north elevated wall to be folded into the roof and the entire roof to be lowered. This allows for faster construction, disassembly, and cheaper transportation.



# SHOW-ME SOLAR HOUSE TEAM

## Lighting Design Narrative

Lighting is the conscious application of light to achieve some aesthetic or practical effect. It includes the use of both artificial light sources and natural illumination from daylight. Proper lighting can enhance task performance, aesthetics, and give health benefits.

### Day Lighting

During the day, the majority of lighting is provided from the windows on all four sides of the house. In order to utilize solar gain in the form of heat and light, the largest percentage of windows have been placed on the south side. The outer south wall is covered with a louver system which passively controls the amount of heat and light exposure based upon the sun's position.

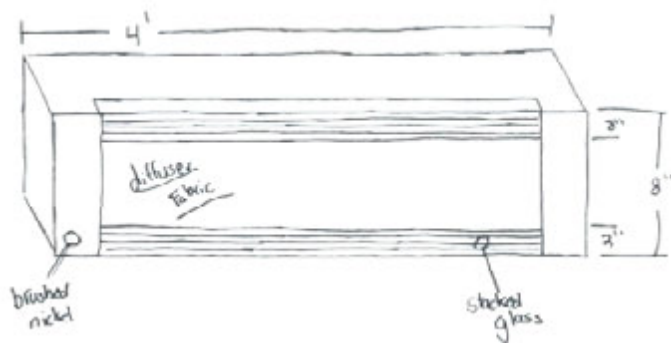
There are two large windows in the kitchen for natural task lighting. These windows provide light while allowing for a scenic view and expanding the perceived size of the room. When daytime lighting is not available, LED can-lights in the soffit will provide task lighting in the most efficient manner.

The north wall windows give the house natural lighting from above the soffit. This provides more natural daylight without as much heat gain as the southern wall while providing daylight during the winter months. This soft glow will illuminate the interior of the kitchen, living and dining area. These windows also provide lighting for the live plants on the top of the soffit.

### Artificial Lighting

The ambient lighting provides a sense of natural lighting. This is achieved by washing the ceiling with LED lighting directed upward from the soffits along the south and west walls of the house. A track system is also mounted along the side of the soffit with both spot and ambient lights to illuminate the areas of the house not covered by the task lighting.

Custom sconces are being used to provide accent and ambient lighting in the living room and bedroom. These fixtures are constructed from a brushed nickel frame, utilize stacked recycled glass, and fabric diffuser that LED lighting shines through. The sconce in the bedroom also contains adjustable reading lights in the frame.



A custom chandelier has been designed to hang above the dining table. This fixture contains the same materials as the sconces as well as fluorescent HappyLights. HappyLights are used to simulate natural sunlight and have been suggested to reduce the amount of melatonin produced by people, which is the chemical that causes sleep and drowsiness.



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## Lighting Design Narrative

### **Home Automation**

One of the main features of the Chameleon Automation System is to reduce the energy wasted by unnecessary lighting usage. Occupancy and motion sensors detect when people leave and enter rooms; which, when combined with advanced algorithms and the custom automation system, turn lights on and off when beneficial. Chameleon also controls the window shade motors, which are opened or closed depending on the time of day and the amount of solar irradiation available. In order to avoid intrusiveness, the system can be programmed with custom presets as well as temporary directions to break the algorithms.



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### **Request for Exemption of Rule 5-2**

The Show-Me Solar House Team would like to petition for an exemption of Rule 5-2. After going through the rules and drawings it has come to our attention that our decking architectural features extend 5 inches over the solar envelop.

The small amount of needed extension would not restrict a neighbor's right to the sun. The deck is 23 inches off the ground and therefore would not be in the way of any neighboring houses. The deck serves as many viable functions of the house itself. The two most important ones include: connecting a public space to nature and making the house ADA accessible through the inclined walking paths.

The small area in question can be seen in C-101 Solar Envelope, C-201 Solar Envelop 1, and C-205 Solar Envelope 2.



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## Chameleon Technical Report

### **Abstract**

Chameleon is a residential automation system dedicated to the combination of energy efficiency and convenience. The system employs a series of automated applications including lighting, HVAC, home entertainment, appliance control, and phantom load reduction. The integration of these systems influences a net energy gain.

A network of sensors will be installed throughout the residence to provide pertinent information to the control system. Chameleon will then use this data to execute the desired actions in the most energy efficient manner. The system will include all conventional controls and will be seamlessly integrated, but will also feature a dedicated user interface. The interface will allow input of the resident's preferences; the system will also be controllable via the internet.

In addition to providing convenience to the resident, the system will save a significant amount of energy. While traditional systems expend energy to provide convenience, Chameleon will have a positive impact on both aspects.

### **Subsystem Description and Logic Controls**

#### **Heating and Cooling**

The goal for the heating and cooling subsystems is to use multiple systems together in order to ensure the house maintains comfortable atmosphere.

#### **Radiant Heat and Forced Air**

Scope: Radiant heat and forced air cooling will be controlled through the automation system to ensure that only one system runs at a time, and to allow for maximum customization.

Reason: The use of two separate HVAC systems allows for overlap if not set properly. This system will allow for the sharing of temperature variables, and will allow for expansion into trend programming and analysis.

Narrative: Both the radiant heat system and the heat pump store their own control logic. Rather than recreating this logic or hardware, relays will be used to control when each system is active or inactive.

#### **Shade Control**

Scope: The automation system will allow manual and automated control of window shades.

Reason: Shade control has an effect on both internal light levels and temperature. Due to the extensive use of louvers in the current application, the temperature element will be neglected.

Narrative:

Case 1. The shades will open when the sunlight is above (SI) and Bs is false.



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## Chameleon Technical Report

Case 2. If Bs is true, shades will close.

Note: Bs will be polled every X seconds to ensure that windows close upon the Boolean being set

Sl - Sunlight level, used in shade control

Bs – Boolean shade override

X – Polling time for Bs

### Window Control

Scope: The automation system will allow manual and automated control of the upper windows.

Reason: Windows have an effect on temperature, humidity, and wind speed. The primary concern of the system will be as an alternative to conventional heating and cooling systems, though it will also account for humidity and wind speed.

Narrative:

Case 1. The windows will open when the owner is present, temperature in the house rises above (Tu), the temperature outside is below (Ou),  $H0 < Hi < Hu$ , and wind speed is between [Wl, Wu].

Case 2. The windows will open when the owner is present, temperature in the house falls below (T0), the temperature outside is above (Ol).  $H0 < Hi < Hu$ , and wind speed is between [Wl, Wu].

Case 3. The windows will close when the temperature in the house is between [Ou.Ol], wind speed is  $> Wu$  or  $< Wl$ , or humidity is  $> Hu$  or  $< H0$ .

Ol – Outdoor lower temperature limit, used in air heat pump cooling

Ou – Outdoor upper temperature limit, used in air heat pump cooling

Tu – House upper temperature limit, used in shade control

Tl – House lower temperature limit, used in shade control

H0 – Lower outdoor humidity limit

Hi – Internal humidity

Hu – Upper outdoor humidity limit

Wl – Wind speed lower limit

Wu – Wind speed upper limit

### Internal Comfort

Internal comfort refers to conveniences that are provided to the resident to increase their enjoyment.

### Audio

Scope: The automation system will feature a multi-in, multi-out whole home audio solution. Volume and zones will be controllable through the HMI.



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## Chameleon Technical Report

Reason: To allow maximum convenience and ease of use.

Narrative: As this system would not perform as expected if given predictive control, it will be solely controllable by the user.

### Energy Control

#### Lighting

Scope: To automatically adjust levels of artificial lighting to provide optimal lighting levels and minimize energy usage.

Reason: To allow full adjustment of artificial lighting so natural and artificial levels may be balanced and energy usage may be minimized.

Narrative:

If the internal lighting level ( $Li$ )  $< Pl$  (minimum lighting level):

: and the exterior lighting ( $Le$ ) level is  $> Li + X$  (the minimum threshold), then lighting will not be adjusted. Window shade logic will be executed, and lighting conditions will be rechecked.

: and the exterior lighting ( $Le$ ) level is  $< Li + X$  (the minimum threshold), then the light intensity will be increased by  $S\%$  (step size) and lighting conditions will be rechecked.

If the internal lighting level ( $Li$ )  $> Pl$  (minimum lighting level) && ( $Li$ )  $< Pu$  (maximum lighting level):

: do nothing

If the internal lighting level ( $Li$ )  $> Pu$  (maximum lighting level):

: and the exterior lighting ( $Le$ ) level is  $> Li - X$  (the minimum threshold), then lighting will not be adjusted. Window shade logic will be executed, and lighting conditions will be rechecked.

: and the exterior lighting ( $Le$ ) level is  $< Li - X$  (the minimum threshold), then the light intensity will be decreased by  $S\%$  (step size) and lighting conditions will be rechecked.

If Occupancy Timer ( $Ot$ ) reads a dormant zone:

: and lights are on, then they will be turned off until occupancy sensor detects movement in the zone

The checking process will be repeated every  $T$  seconds. Upon shade or light intensity adjustment, the process will be executed immediately so as to not delay in normalization of the lighting level. In the case of shade override ( $Bs$ ), lighting will be adjusted only through this system. In the case of dormancy override ( $Bd$ ), optimal lighting will be maintained at all times. In the case of shade, dormancy, and lighting override ( $Bs$  &&  $Bd$  &&  $Bl$ ), this system will cease function.

$Li$  – Interior Lighting Level

$Le$  – Exterior Lighting Level

$X$  – Minimum Threshold

$Pl$  – Minimum Lighting Level

$Pu$  – Maximum Lighting Level

$S$  – Step Size

$T$  – Delay Between Rerun

$Bs$  – Shade Override



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Bd – Dormancy Override

Bl – Lighting Override

Ot – Occupancy Timer

### **Phantom Loads**

Scope: The automation system will feature an array of relays in-line with the wiring to the outlets.

Reason: Toggling these relays when the connected devices are in their standby state will allow the termination of phantom loads (standby power). As toggling renders a connected device useless, the relays will only be set to off (open) when an extensive set of conditions are met.

Narrative: Predetermined outlets that are designated for non-critical objects will contain relays. If it is determined that the zone has been vacated for a preset amount of time, the relay will open. Upon reentry to the zone, all relays in that zone will be set to on (closed).

### **Power Monitoring**

Scope: The automation system will monitor the amount of power being produced, sold, bought, and the amount being consumed by the automation system itself.

Reason: To educate the user and provide data for analysis.

Narrative: The power usage/production of the indicated systems will be monitored by the use of WattNodes. This data can be logged if necessary, and can also be made available to the user so they can see the impact that their actions have on overall power usage.

### **Appliance Control / Solar Noon Programming**

Scope: To automate key heavy electric/ thermal appliances, i.e. washer, dryer, and dishwasher.

Reason: Key appliances that run heavy electric / thermal loads can be automated to run at the solar peak time (Solar Noon) for the most efficient use of solar electric / thermal energy.

Narrative: Pyranometer will set acceptable run time for optimal conditions. If an appliance has been queued and incidence of solar radiation is above a certain threshold, appliances will be run. Instantaneous appliance use can be executed through the HMI or directly from the appliance.