RISE

UC BERKELEY / UNIVERSITY OF DENVER

University of California, Berkeley / University of Denver
U.S. Department of Energy Solar Decathlon 2017
Jury Narrative Submission
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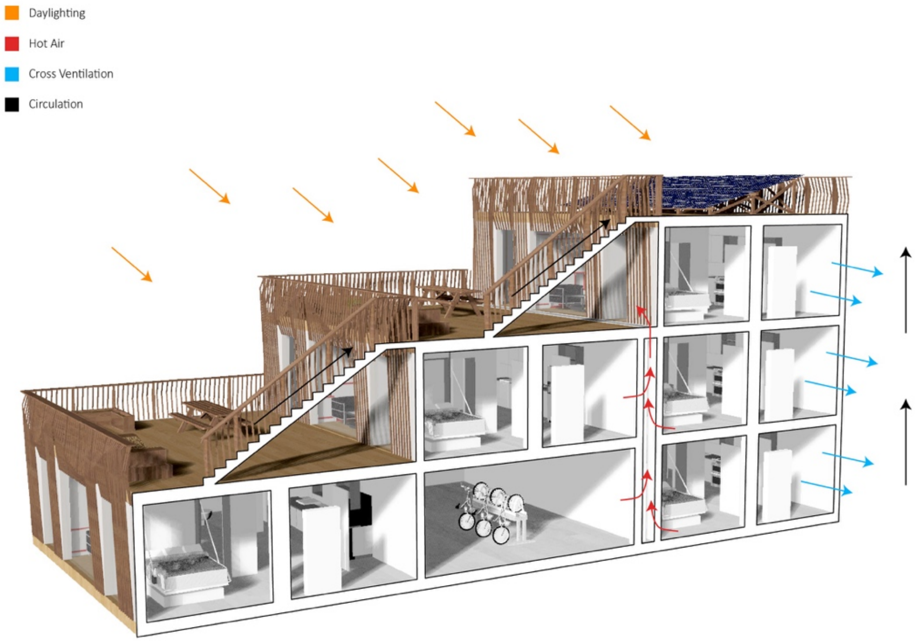
Engineering Narrative

Concept Development

The RISE team not only solved individual challenges with unique approaches, but our entire design concept differs from the status quo established in the past 15 years of Solar Decathlon competitions. Our team strived to create a practical, realistic product that solved the challenges of transitioning San Francisco Bay Area suburbs into urbanized communities. We explored the streets of a particular suburb, Richmond, consulted with city council members, and evaluated the city's newly adopted building code to gain perspective on the future direction of this community. From here, we took a unique first step and imposed the city's pressing challenges of urban infill lots on our design philosophy: tall surrounding buildings in close proximity, limited facade exposure, and limited green spaces. Finally, we were ready to establish our engineering design philosophy: to establish net-zero through no-frills systems and simple geometry, minimize pipe runs, and let detailing provide beauty and sew the home together. Distinctively, our driving concept was based on providing what the inhabitant would need versus what the inhabitant would want in the most efficient and sustainable manner possible.



Source – Team Renderings

Another unique piece of the process was our collaborative, "spiral" design approach. Instead of assigning conventional roles, we chose a charrette meeting style until our concept was solidified. We gathered energy modeling experts, undecided freshmen, professional architects, business administration majors, and everyone in between in the same room fighting for their ideas. The weekly process included teams researching and compiling fact-based arguments for their design and eventually presenting to a jury of their peers. Exploration in the target community, such as working at Richmond High School and consulting multiple neighborhood councils, drove our decision-making process. We used market standard technology with local, available materials to avoid special manufacturing and skilled labor. In the future, this is a home created to be built by community members, for community members. Instead of emphasizing smart technology, we highlighted simplicity for the reason of cost-effective products and low-budget maintenance. Every angle was analyzed with an engineering perspective, looking for efficiency, practicality, and realistic solutions. After extensive research, the nearly square form was used to reduce exposed surface area for heat transfer, the thick walls are only penetrated on the south facade as the other three walls would theoretically border other buildings, and the post-and-beam structure can handle large vertical loads from up to three-story stacked configurations while the individual floor and roof assemblies remain separate. While this may bring up the problem of an "over-engineered" top unit when the bottom unit can handle to loads of up to three stories, because of our post-and-beam structure the columns can be scaled to fit their final purpose. However, overall the columns as a whole account for less than 1% of the total cost, making their contribution almost negligible.

Structural Narrative II An Overview

The structural system is a product of collaboration through an integrated design process, and includes considerations of the architectural concepts, competition requirements, and affordability. Transportation to the competition site in Denver, Colorado from Berkeley, California governed the size and construction methods associated with our design. Ultimately, the home will be constructed as two pre-fabricated units before loading onto two separate trucks for transport. Service loads were obtained from five different codes (City of Richmond Building Code, City of Denver Building Code, IRC, IBC, and the 2017 Solar Decathlon Building Code) in which the limiting case governed. The following calculations were done under ASCE 7-10 and NDS 2012 procedures and used to demonstrate the safety and resilience of the design.

Design Intent

For the competition, the one-story project is designed to sit on temporary piers with Denver location wind and seismic load origins. In an applied setting, the home will rest on a concrete slab and is designed with Richmond location wind and seismic load origins.

However, in order to remain a safe and successful structure in Denver, the design presented in this analysis takes the limiting case of all applicable codes. Overall, the intent of our unit is to be a piece of the puzzle in a stackable structure. The concept is outlined further in other sections, but the RISE home unit can be placed on site as a one, two, or three story configuration, and this will be demonstrated through the structural engineering. The gravity and lateral load resisting systems are designed to take the loads associated with a bottom unit in the three story stacked formation.

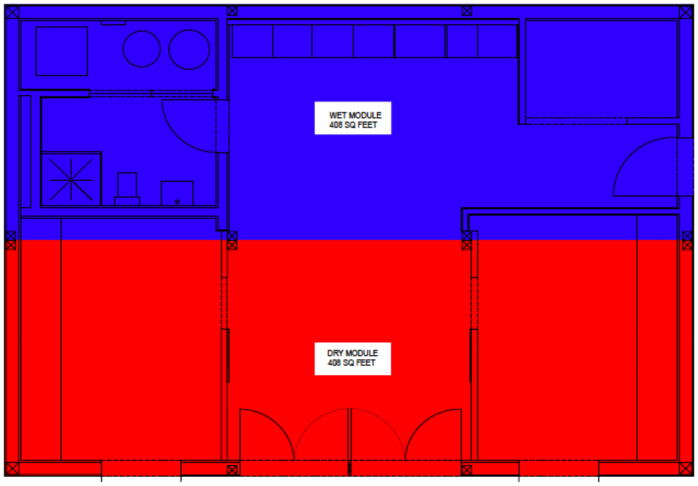
The gravity forces applied on our structure will be resisted with a wood post and beam system. This allows for simple vertical stacking, and at each level local forces flow from the spanning beams into nearby columns. Columns will line the exterior of each 12x34 module with beams and joists spanning the interior. From here, load is transferred down into the foundation. Vertical circulation will take place via a staircase and landing structure extending 6 feet outward and running along the perimeter. For the competition, the foundation will consist of 3 different pier types to accommodate for uplift, lateral, and vertical loads from the house and deck. The lateral forces will be resisted by sections of shear walls on all four corners. The shear walls are sized for the 3 story configuration due to the wind and seismic loads at Richmond and also simultaneously provide enough resistance for our one story competition house. The pier and tie down system are sized for competition values of wind and seismic because our 3 story configuration will not be placed on temporary piers.

Step 1 ll Seal it Up

Our first step in a simple, sustainable design is to seal up our home. This, in addition to removing any unnecessary shapes and edges (aka reducing our surface area of exterior contact), creates an extremely effective engineered wall assembly. In order to use our insulation efficiently, we made sure to caulk every bay both inside and out as well as install a Pro Clima interior air barrier. All large gaps between the individually transportable modules are foamed and sealed quickly and easily, something that will be replaced after the move to competition site.

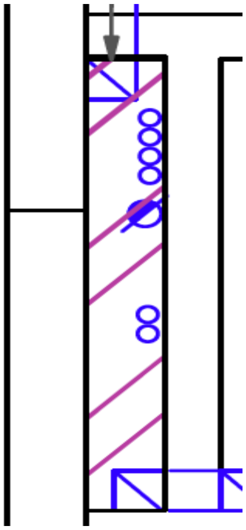
Step 2 ll Smart Design

After ensuring our home is tightly sealed, we can re-visit a slew of design decisions leading up to that point that make sure our tightly sealed thermal envelope is using energy both efficiently and sustainably. With a wet and dry module separating the home, our plumbing and HVAC are compacted into one 408 sqft. module.



Source – Team Drawings

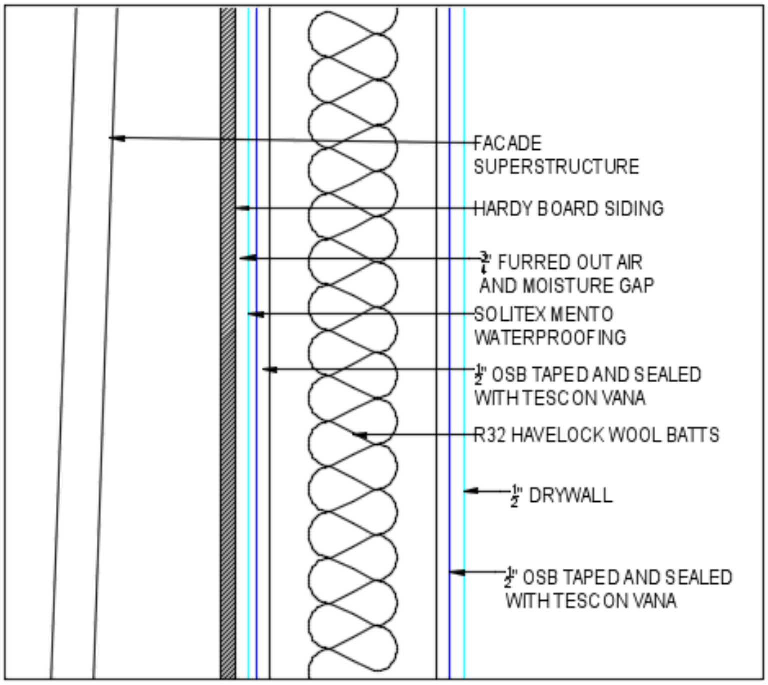
Essentially, this will minimize pipe runs in both departments, creating (1) less penetrations through our facade members, (2) less work and increased constructability, and (3) less heat loss and head loss. In addition, a dropped ceiling and furring wall in the north module creates a space to efficiently run ductwork and plumbing in an insulated environment. With our stacked configuration in mind, the plumbing, refrigeration lines, and main electrical connections can easily stack along a designated chase on the west facade and symmetry of floor plans allows for stacked bathroom fixtures.



Aerial View of Plumbing Cavity
Source – Team Drawings

Given our simple structure, we were able to pay special attention to the detailing of our roof and facade elements. From the outside moving inward, all weather is met by hardy board paneling running vertically, furred out ¾" from the Pro Clima Solitex Mento water barrier. In this ventilated gap, moisture and air will have space to run down and out of the assembly. Yet, while no rain and moisture will enter, this smart product allows water vapor to escape out of the assembly before condensing and creating problems structurally, for this water barrier sits on OSB sheathing that ties the entire house together continuously for earthquake safety. This flexible wood product will give during an earthquake or high wind event to prevent high acceleration on the roof and upper stories, yet a tight nailing pattern ensures its structural stability to keep occupants safe.

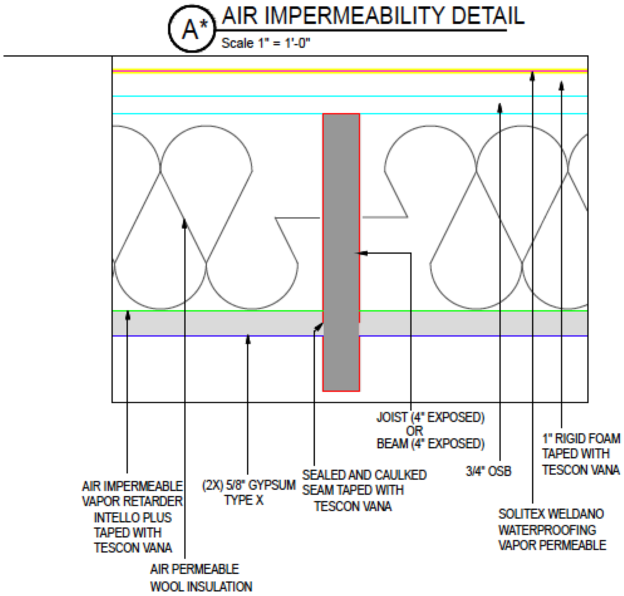
Sandwiched between OSB and 2x8 studs at 24" o.c. is Havelock wool insulation. Planning to exceed code-built standards in insulation, we used 2x8 walls and a 2x12 floor and roof to add plenty of this non-toxic wool insulation at an R value of 4.3 per inch.



Source – Team Drawings

At 43% better than code-built for insulation values, we were confident and content with the projected performance of our facade assemblies. As previously mentioned, the interior caulking and air barrier prevent air from the conditioned space (interior) escaping to the exterior. In addition to our thoughtful detailing in the facades, the roof contains a special element to deal with the possibility of cold temperatures in the Denver Fall. In order to account for semi-humid air leaking into the roof assembly and condensing against cold outer sheathing, a layer of 1" R-5 rigid foam insulation was installed directly above the roof sheathing and below the Pro Clima Weldano roof waterproofing membrane to move the dew point of this air into the center of that 1" insulation, hence rendering it non-existent.

Source – Team Photos



Source – Team Drawings

Step 3 ll Efficient Systems

With a tight envelope and smart spacial design, the next part of the process was to find efficient systems that were simple, affordable, and sustainable. Given our target market, we opted for a simple mechanical set-up that would be intuitive and easy to fix. The first major decision backed by extensive research and calculations was water heating. Making up nearly 20%[1] of energy used in the average home, water heating is a significant place to save. So we asked ourselves, is solar thermal

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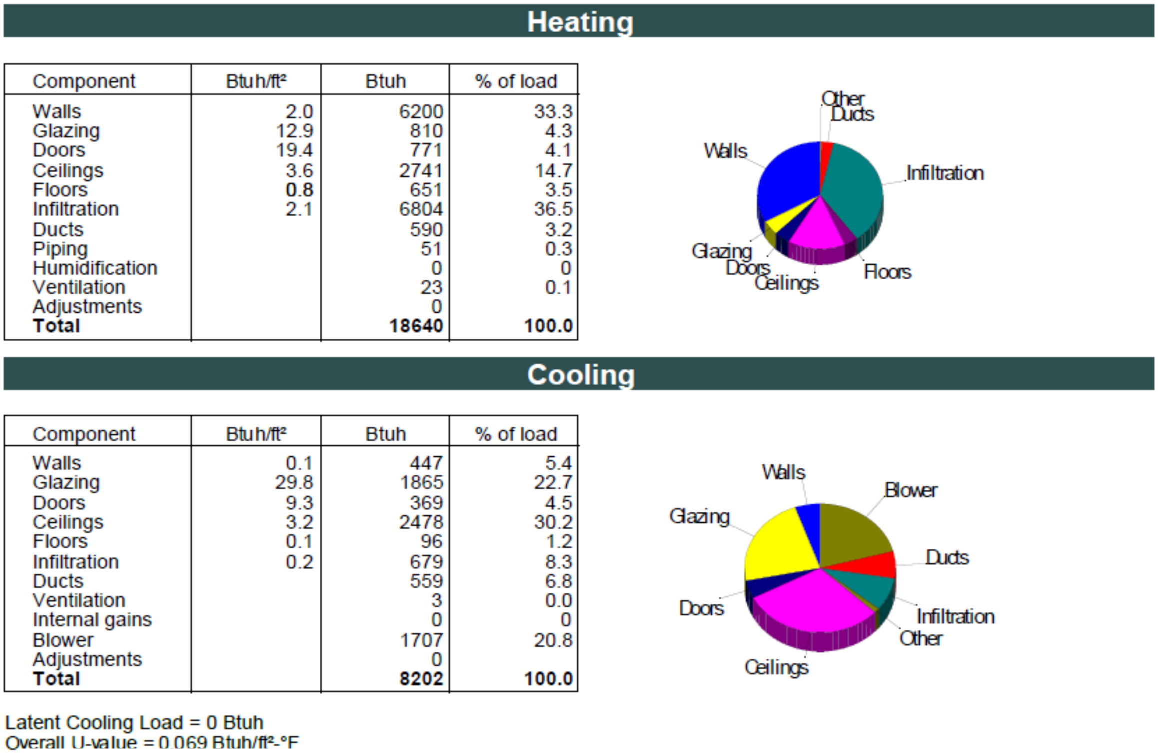
[1] https://www.northamericansolarstores.com/solar-thermal/

truly dead? Now with a variety of applications and various residential situations, we chose not to use previous projects to make this decision. Taking up a comparable amount of roof space (2 panels for an 80 gallon tank at approximately 68 sqft) versus using a high efficiency electric water heater (Sun Bandit system with 4 PV panels at about 71 sqft), the decision was easy from here. The electric water heater takes up far less space in the mechanical room with zero envelope penetrations and reliable results. The solar thermal system with an expansion tank, electric back-up, and heating fluid, creates an entire slew of new problems. Going for a simple, easy to replace, and easy to fix design mentality, the electric water heater was a better technical decision as well as a better decision for the future residents in Richmond, CA. See the hot water analysis in the appendix.

Coming in at around 50% of home energy use[1], our HVAC system was designed intentionally with two major criteria in mind: indoor air quality and heating/cooling needs. The HRV is a Zehnder ComfoAir 200 which starts to address both criteria. The HRV continuously moves air throughout the entire house via supply ducts in both bedrooms and the living room and return ducts in the bathroom, kitchen, and laundry room. This continuous movement of air creates better air quality and a higher level of comfort for the inhabitant. Additionally, the HRV runs the exhaust and intake air



Heating

Component	Btuh/ft²	Btuh	% of load
Walls	2.0	6200	33.3
Glazing	12.9	810	4.3
Doors	19.4	771	4.1
Ceilings	3.6	2741	14.7
Floors	0.8	651	3.5
Infiltration	2.1	6804	36.5
Ducts		590	3.2
Piping		51	0.3
Humidification		0	0
Ventilation		23	0.1
Adjustments		0	
Total		**18640**	**100.0**

Cooling

Component	Btuh/ft²	Btuh	% of load
Walls	0.1	447	5.4
Glazing	29.8	1865	22.7
Doors	9.3	369	4.5
Ceilings	3.2	2478	30.2
Floors	0.1	96	1.2
Infiltration	0.2	679	8.3
Ducts		559	6.8
Ventilation		3	0.0
Internal gains		0	0
Blower		1707	20.8
Adjustments		0	
Total		**8202**	**100.0**

Latent Cooling Load = 0 Btuh
Overall U-value = 0.069 Btuh/ft²-°F

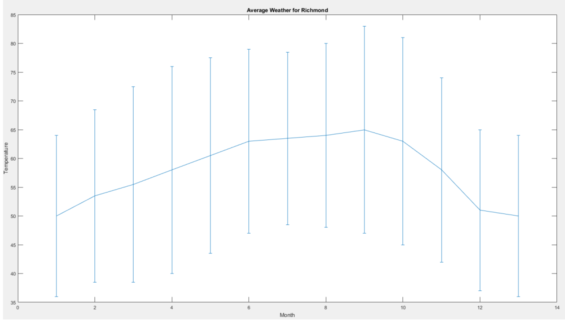
Source – Team Analyses

through a heat exchanger which brings the supply air's temperature close to that of the exhaust air at an efficiency of 90%. This means that even though we are continuously ventilating the house, the heating and cooling loads are not significantly higher. Those heating and cooling loads are addressed by our ducted Mini-Split system. Due to the highly efficient envelope and the HRV system, a single Mini-Split is ducted throughout the whole house. With our open floor plan and moveable walls, air is designed to mix within zones inside the conditioned space keeping everything at a similar temperature. Therefore, a single system was used to reduce ductwork, reduce cost, and avoid oversizing the system. With a stacked configuration in mind, this is able to connect to a central mechanical room where a single outdoor unit is used and each housing module acts a Mini-Split zone.

With few mechanized systems controlling the HVAC in the RISE home, we specifically targeted areas of common efficiency losses to ensure these minimalistic mechanical systems are not working over their limit. In addition the envelope assembly described above, Alpen ZR10 window doors with their Tyrol Series frame dramatically further improve our performance. With the very first commercially available R10 glass in North America and R16 frames, this set-up is crucial. Not only are doors a huge loss of conditioned air, but these doors allow the influx of natural light while remaining highly efficient. In addition to their engineering performance, this heavy duty frame with a multi-point locking system and slightly tinted glass addresses the safety and privacy concerns discussed with community members at Richmond neighborhood council meetings.

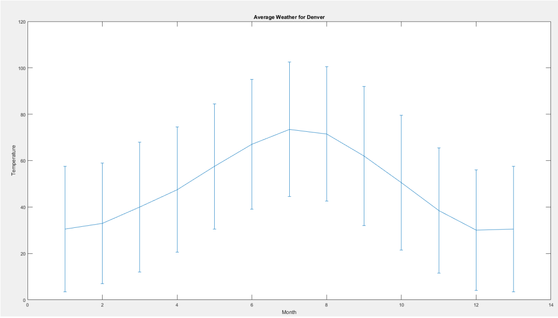
Step 4 ll Make Up the Rest with Solar

The house was designed specifically for the weather conditions in Richmond, CA averaging in the summer season to be about 72 degrees Fahrenheit during the day and in the 50s at night, while the winter conditions range from 55 during the day to low 40s at night.



Source – Team Analyses

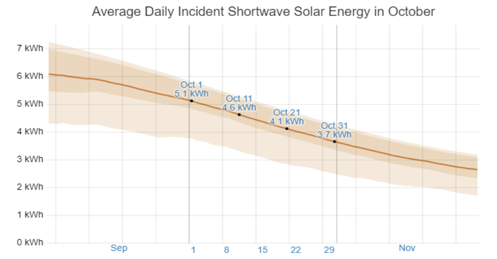
Since the competition is located in Denver, CO, the average weather at time of competition ranges from the highs of 73-61 to the lows of 46-36.



Source – Team Analyses

These averages were taken from data collected by USClimatedata.com and weatherspark.com they were cross analyzed with one another to find a definitive average. This will allow for a cool night to drop the overall temperature of the house allowing for a maintained temperature in the low 70s.

Lastly, as it is a focus of the competition, once the home has been sealed up with an efficient envelope, smart design, and quality systems, the last step is to make up the rest with solar. Sizing the system made up of Panasonic HIT 325W PV panels, with margin for error (cloudy and/or rainy days), based on our electricity loading is the final piece. The amount of indecent solar energy received during the competition will range from 5.1kW-4.1kW.



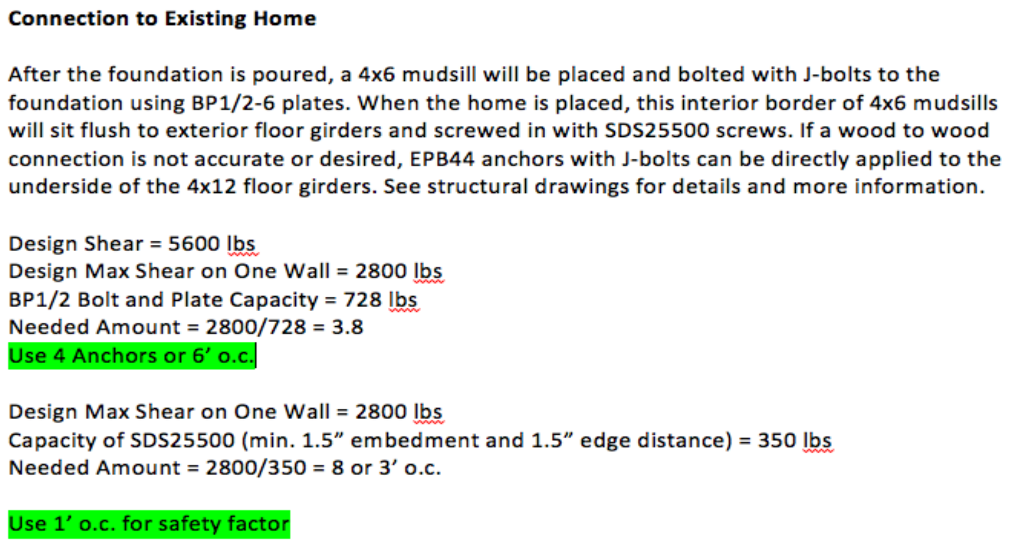
The average daily shortwave solar energy reaching the ground per square meter (orange line), with 25th to 75th and 10th to 90th percentile bands.

Source – Team Analyses

This will allow for an effective intake of solar energy. Due to our Tesla power wall 14kWh can be stored allowing for the use of all appliances at least once in a day. The self-sufficiency of this home is key. To minimize the system's footprint, we transplanted a 20 panel ground mount array design onto our roof. It is expected to produce 26.717 kWh/day during the competition, which is more than enough energy to power our home and operate an electric vehicle. In addition, further steps were taken to make sure this energy is used efficiently and sustainably. First, an e-gauge monitoring system analyzes amperage from each branch of the inverter and adds transparency for the user to make lifestyle changes that can reduce each part of the circuit. Also, the Tesla Powerwall will allow RISE to work with the grid prices efficiently, selling when energy is costly and avoiding the purchase of energy from the grid at peak hours. The Powerwall will regain charge when grid energy is low priced and repeat the process to save money. The Powerwall will also keep a portion of the battery charged at all times that can be utilized in an emergency to power critical systems such as the refrigerator.

Appendix

Placement of a Module on a Concrete Slab



Connection to Existing Home

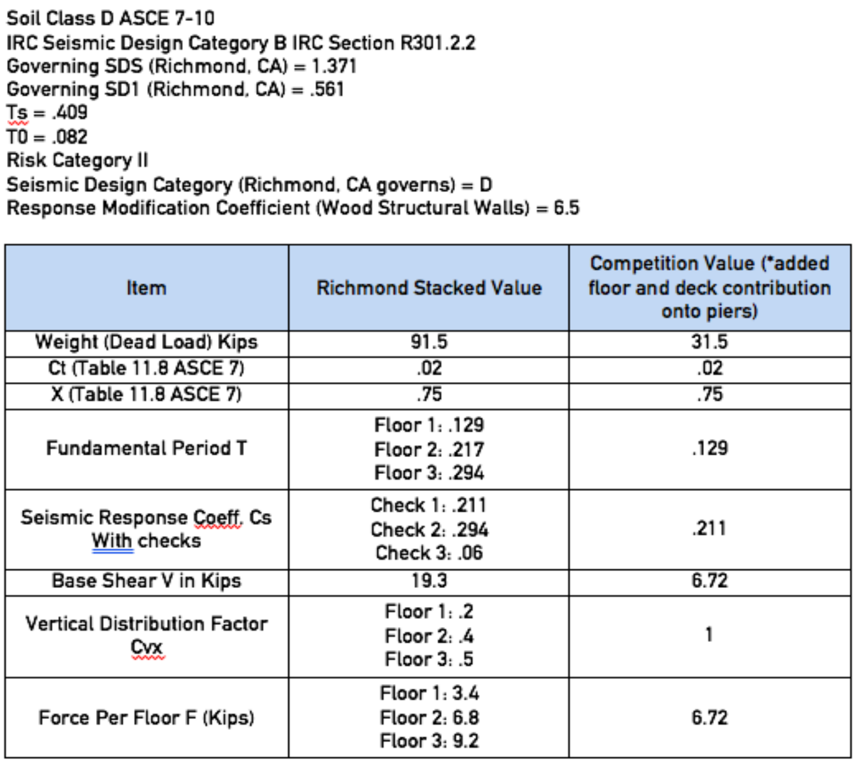
After the foundation is poured, a 4x6 mudsill will be placed and bolted with J-bolts to the foundation using BP1/2-6 plates. When the home is placed, this interior border of 4x6 mudsills will sit flush to exterior floor girders and screwed in with SDS25500 screws. If a wood to wood connection is not accurate or desired, EPB44 anchors with J-bolts can be directly applied to the underside of the 4x12 floor girders. See structural drawings for details and more information.

Design Shear = 5600 lbs
Design Max Shear on One Wall = 2800 lbs
BP1/2 Bolt and Plate Capacity = 728 lbs
Needed Amount = 2800/728 = 3.8
Use 4 Anchors or 6’ o.c.

Design Max Shear on One Wall = 2800 lbs
Capacity of SDS25500 (min. 1.5” embedment and 1.5” edge distance) = 350 lbs
Needed Amount = 2800/350 = 8 or 3’ o.c.

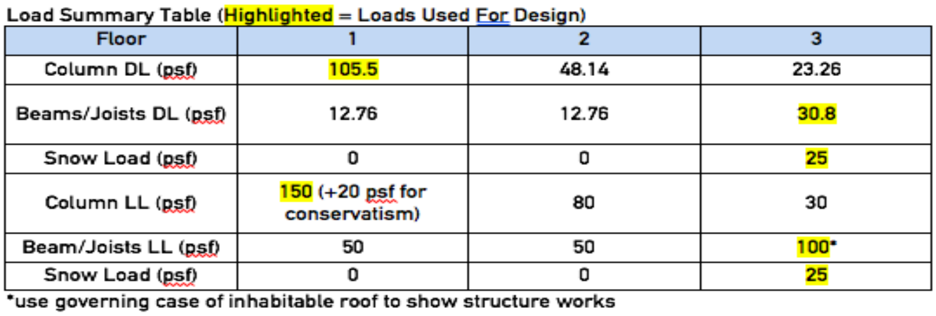
Use 1’ o.c. for safety factor

Example Design Calculations Accounting for Stackability and Earthquakes



Soil Class D ASCE 7-10
IRC Seismic Design Category B IRC Section R301.2.2
Governing SDS (Richmond, CA) = 1.371
Governing SD1 (Richmond, CA) = .561
Ts = .409
T0 = .082
Risk Category II
Seismic Design Category (Richmond, CA governs) = D
Response Modification Coefficient (Wood Structural Walls) = 6.5

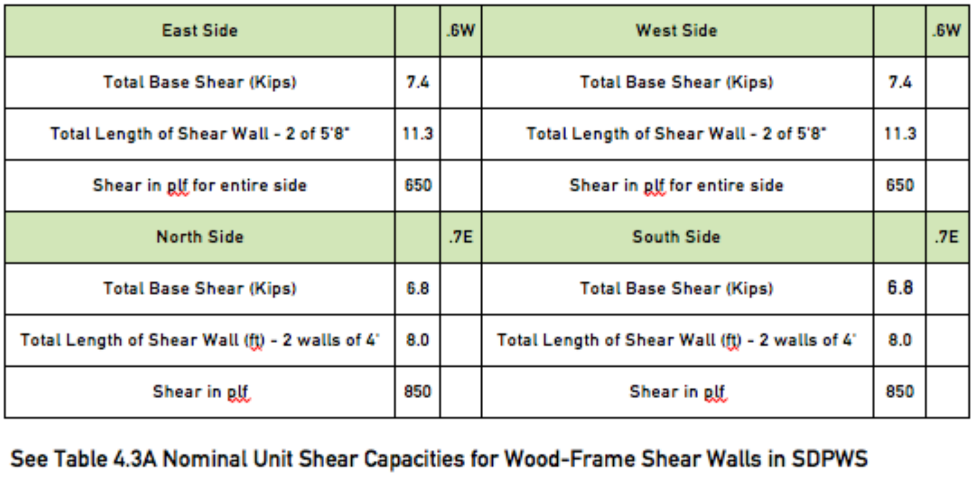
Item	Richmond Stacked Value	Competition Value (*added floor and deck contribution onto piers)
Weight (Dead Load) Kips	91.5	31.5
Ct (Table 11.8 ASCE 7)	.02	.02
X (Table 11.8 ASCE 7)	.75	.75
Fundamental Period T	Floor 1: .129 Floor 2: .217 Floor 3: .294	.129
Seismic Response Coeff. Cs With checks	Check 1: .211 Check 2: .294 Check 3: .06	.211
Base Shear V in Kips	19.3	6.72
Vertical Distribution Factor Cvx	Floor 1: .2 Floor 2: .4 Floor 3: .5	1
Force Per Floor F (Kips)	Floor 1: 3.4 Floor 2: 6.8 Floor 3: 9.2	6.72



Load Summary Table (Highlighted = Loads Used For Design)

Floor	1	2	3
Column DL (psf)	105.5	48.14	23.26
Beams/Joists DL (psf)	12.76	12.76	30.8
Snow Load (psf)	0	0	25
Column LL (psf)	150 (+20 psf for conservatism)	80	30
Beam/Joists LL (psf)	50	50	100*
Snow Load (psf)	0	0	25

*use governing case of inhabitable roof to show structure works



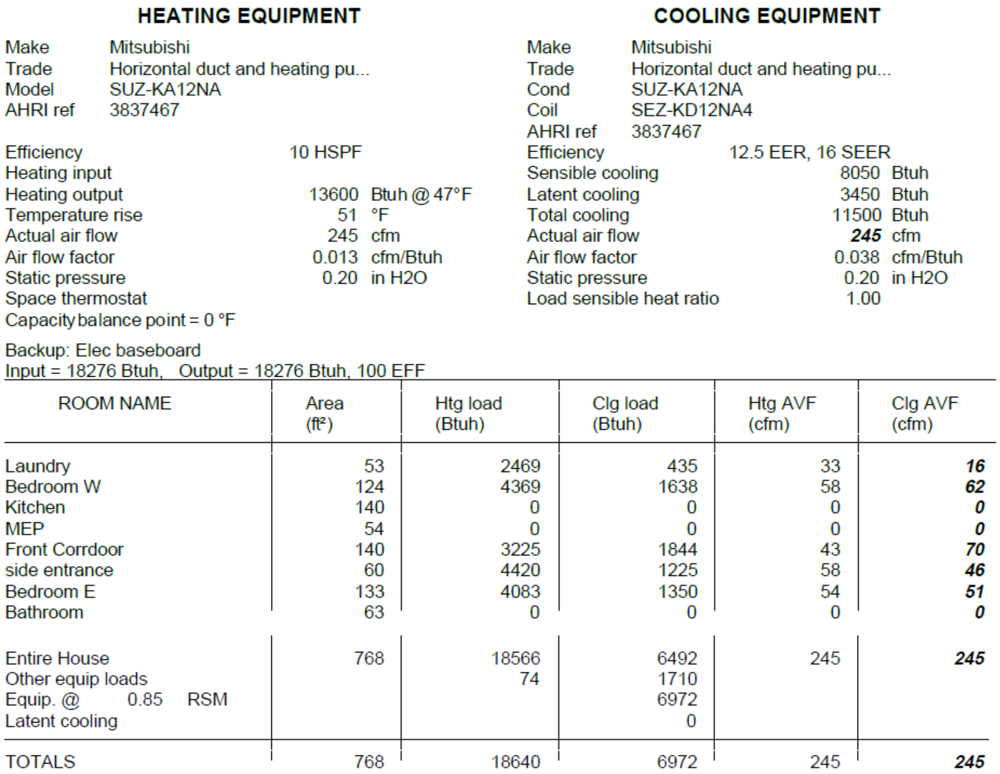
East Side		.6W	West Side		.6W
Total Base Shear (Kips)	7.4		Total Base Shear (Kips)	7.4	
Total Length of Shear Wall - 2 of 5'8"	11.3		Total Length of Shear Wall - 2 of 5'8"	11.3	
Shear in plf for entire side	650		Shear in plf for entire side	650	
North Side		.7E	South Side		.7E
Total Base Shear (Kips)	6.8		Total Base Shear (Kips)	6.8	
Total Length of Shear Wall (ft) - 2 walls of 4'	8.0		Total Length of Shear Wall (ft) - 2 walls of 4'	8.0	
Shear in plf	850		Shear in plf	850	

See Table 4.3A Nominal Unit Shear Capacities for Wood-Frame Shear Walls in SDPWS

Hot Water Analysis

Occupants: 1 [6-13], 2 [14-59]	Sunbandit Solar Hybrid Electric WH 80EU
Hot Water major loads needed for Shower, Sinks, Dishwasher, and Clothes Washer	Averages to around 55-60 gpd -Wastewater saved from Shower to flush Toilets
Tank Efficiencies - 3.0 kWh input Recovery Efficiencies - 98%	78 gallons with Energy factor of 2.70 In first hour = 63 gal Typical Set Point at 120 °F

Heating and Cooling Information



HEATING EQUIPMENT

Make	Mitsubishi	
Trade	Horizontal duct and heating pu...	
Model	SUZ-KA12NA	
AHRI ref	3837467	
Efficiency	10 HSPF	
Heating input		
Heating output	13600	Btuh @ 47°F
Temperature rise	51	°F
Actual air flow	245	cfm
Air flow factor	0.013	cfm/Btuh
Static pressure	0.20	in H2O
Space thermostat		

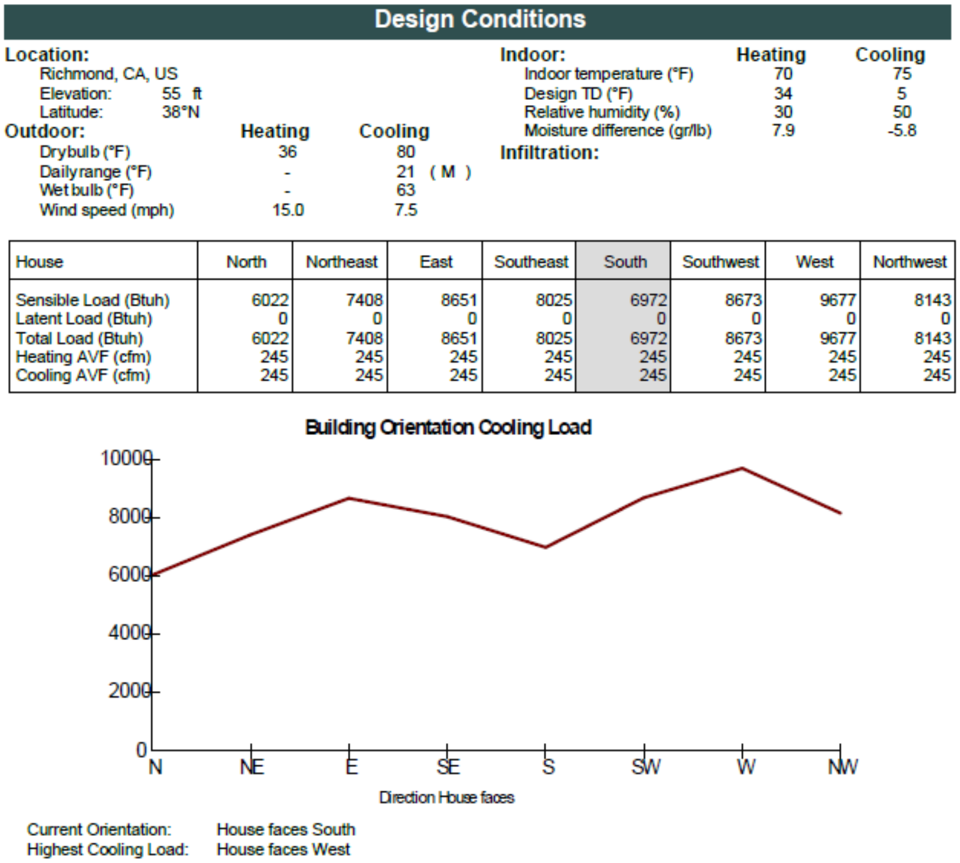
Capacity balance point = 0 °F

Backup: Elec baseboard
Input = 18276 Btuh, Output = 18276 Btuh, 100 EFF

COOLING EQUIPMENT

Make	Mitsubishi	
Trade	Horizontal duct and heating pu...	
Cond	SUZ-KA12NA	
Coil	SEZ-KD12NA4	
AHRI ref	3837467	
Efficiency	12.5 EER, 16 SEER	
Sensible cooling	8050	Btuh
Latent cooling	3450	Btuh
Total cooling	11500	Btuh
Actual air flow	***245***	cfm
Air flow factor	0.038	cfm/Btuh
Static pressure	0.20	in H2O
Load sensible heat ratio	1.00	

ROOM NAME	Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Laundry	53	2469	435	33	***16***
Bedroom W	124	4369	1638	58	***62***
Kitchen	140	0	0	0	***0***
MEP	54	0	0	0	***0***
Front Corrdoor	140	3225	1844	43	***70***
side entrance	60	4420	1225	58	***46***
Bedroom E	133	4083	1350	54	***51***
Bathroom	63	0	0	0	***0***
Entire House	768	18566	6492	245	***245***
Other equip loads		74	1710		
Equip. @ 0.85 RSM			6972		
Latent cooling			0		
TOTALS	768	18640	6972	245	***245***



Design Conditions

Location:
Richmond, CA, US
Elevation: 55 ft
Latitude: 38°N

Outdoor:	**Heating**	**Cooling**
Drybulb (°F)	36	80
Dailyrange (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

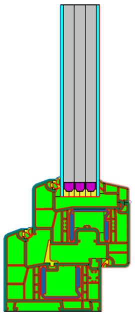
Infiltration:

House	North	Northeast	East	Southeast	South	Southwest	West	Northwest
Sensible Load (Btuh)	6022	7408	8651	8025	6972	8673	9677	8143
Latent Load (Btuh)	0	0	0	0	0	0	0	0
Total Load (Btuh)	6022	7408	8651	8025	6972	8673	9677	8143
Heating AVF (cfm)	245	245	245	245	245	245	245	245
Cooling AVF (cfm)	245	245	245	245	245	245	245	245

Building Orientation Cooling Load

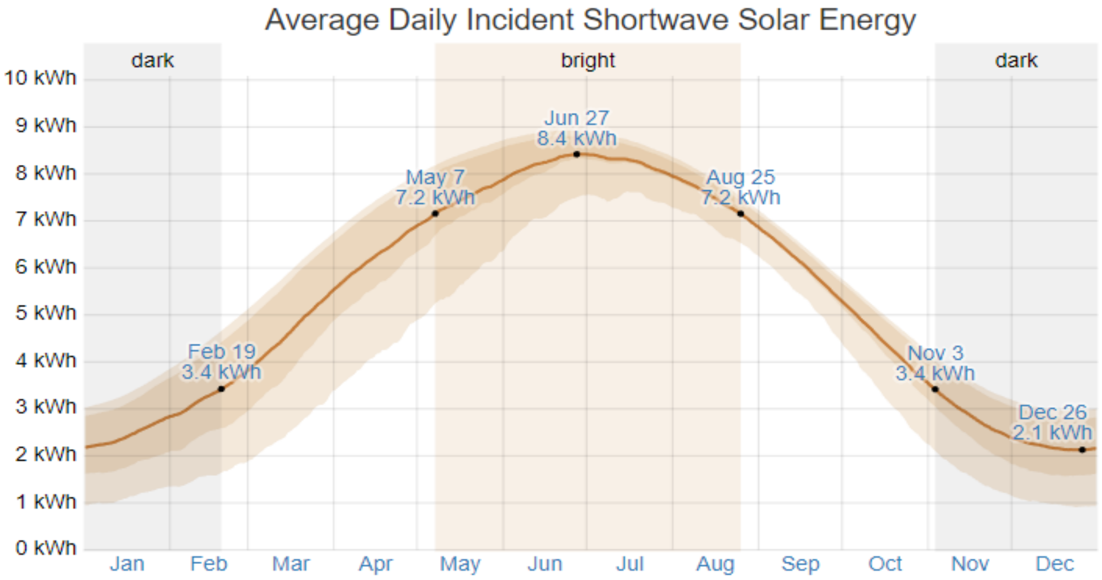
Current Orientation: House faces South
Highest Cooling Load: House faces West

Thermal Analysis of Door Jamb



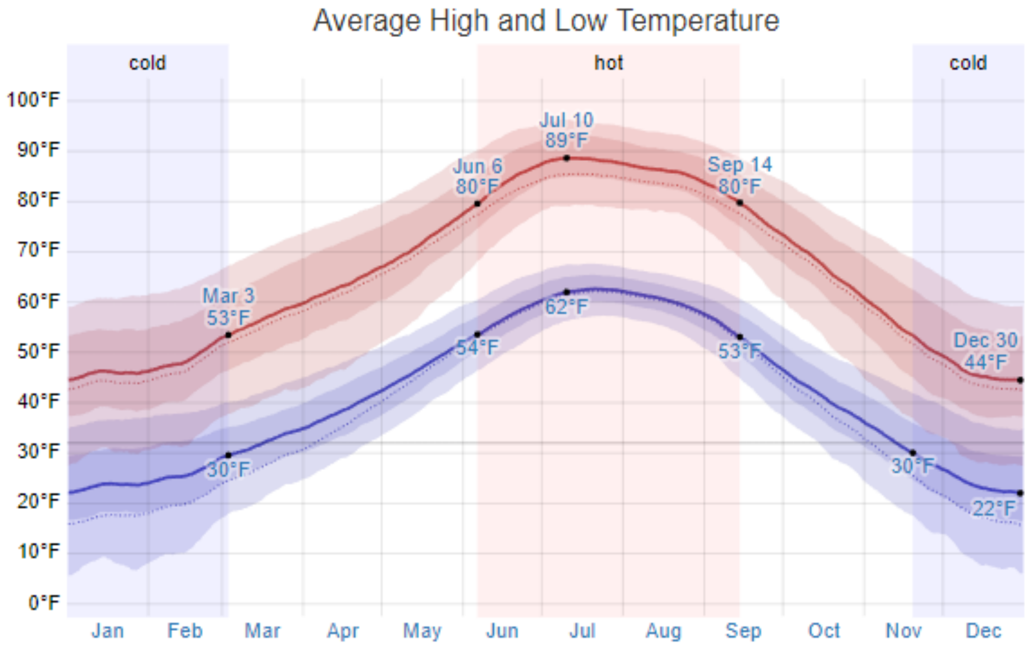
Incedent Solar Energy Analysis

Graph 1: Richmond indecent solar energy:



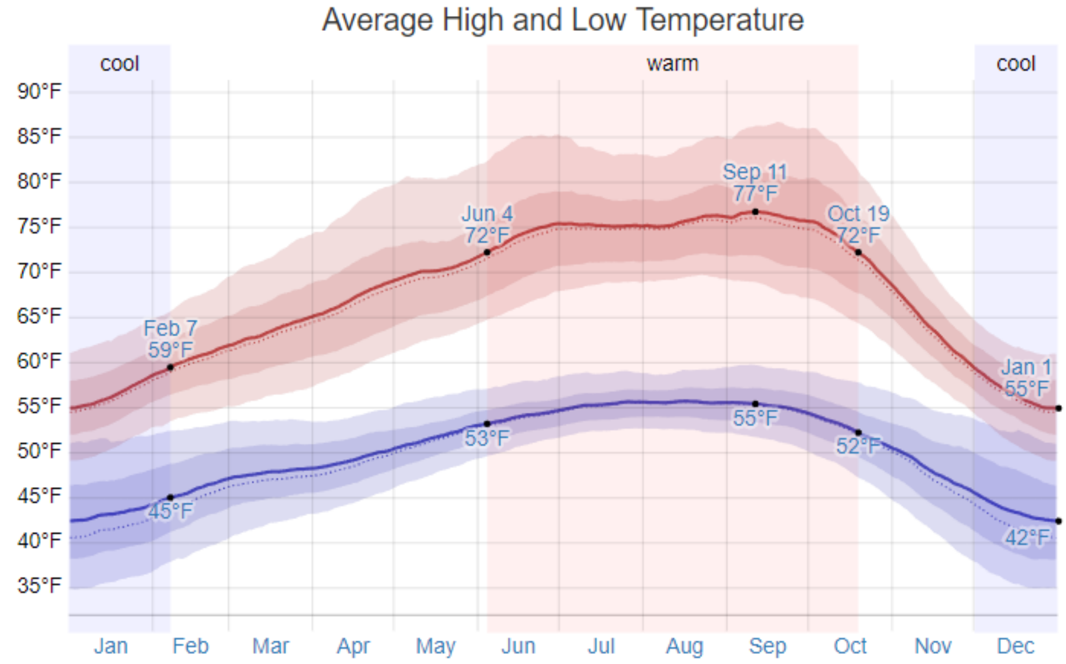
The average daily shortwave solar energy reaching the ground per square meter (orange line), with 25th to 75th and 10th to 90th percentile bands.

Graph 2: Denver, CO



The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures.

Graph 3: Richmond, CA



The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures.

Data collected from:

https://weatherspark.com/y/551/Average-Weather-in-Richmond-California-United-States

https://weatherspark.com/m/3709/10/Average-Weather-in-October-in-Denver-Colorado-United-States#Sections-Temperature

http://www.usclimatedata.com/climate/denver/colorado/united-states/usco0501

http://www.usclimatedata.com/climate/richmond/california/united-states/usca2087

http://www.wrightsoft.com/Products/Right-Suite_Universal

Load Short Form
Entire House
University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Design Information

	Htg	Clg
Outside db (°F)	36	80
Inside db (°F)	70	75
Design TD (°F)	34	5
Daily range	-	M
Inside humidity (%)	30	50
Moisture difference (gr/lb)	8	-6

Infiltration		
Method	Simplified	
Construction quality	Average	
Fireplaces		0

HEATING EQUIPMENT

Make	Mitsubishi	
Trade	Horizontal duct and heating pu...	
Model	SUZ-KA12NA	
AHRI ref	3837467	
Efficiency	10 HSPF	
Heating input		
Heating output	13600	Btuh @ 47°F
Temperature rise	51	°F
Actual air flow	245	cfm
Air flow factor	0.013	cfm/Btuh
Static pressure	0.20	in H2O
Space thermostat		

Capacity balance point = 0 °F

Backup: Elec baseboard
Input = 18276 Btuh, Output = 18276 Btuh, 100 EFF

COOLING EQUIPMENT

Make	Mitsubishi	
Trade	Horizontal duct and heating pu...	
Cond	SUZ-KA12NA	
Coil	SEZ-KD12NA4	
AHRI ref	3837467	
Efficiency	12.5 EER, 16 SEER	
Sensible cooling	8050	Btuh
Latent cooling	3450	Btuh
Total cooling	11500	Btuh
Actual air flow	*245*	cfm
Air flow factor	0.038	cfm/Btuh
Static pressure	0.20	in H2O
Load sensible heat ratio	1.00	

ROOM NAME	Area (ft^2)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Laundry	53	2469	435	33	*16*
Bedroom W	124	4369	1638	58	*62*
Kitchen	140	0	0	0	*0*
MEP	54	0	0	0	*0*
Front Corrdoor	140	3225	1844	43	*70*
side entrance	60	4420	1225	58	*46*
Bedroom E	133	4083	1350	54	*51*
Bathroom	63	0	0	0	*0*

Bold/italic values have been manually overridden

Calculations approved by ACCA to meet all requirements of Manual J 8th Ed.

Entire House	768	18566	6492	245	*245*
Other equip loads		74	1710		
Equip. @ 0.85 RSM			6972		
Latent cooling			0		
TOTALS	768	18640	6972	245	*245*

Bold/italic values have been manually overridden

Calculations approved by ACCA to meet all requirements of Manual J 8th Ed.

Building Analysis
Entire House
University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Design Conditions

Location:
Richmond, CA, US
Elevation: 55 ft
Latitude: 38°N

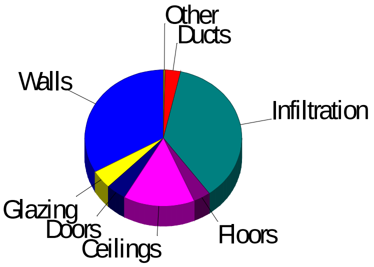
Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	36	80
Daily range (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

Infiltration:	
Method	Simplified
Construction quality	Average
Fireplaces	0

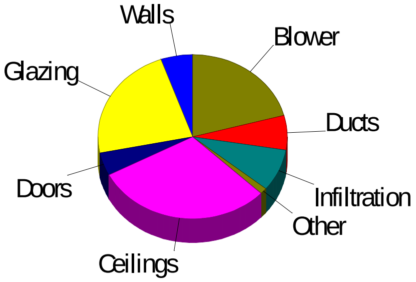
Heating

Component	Btuh/ft²	Btuh	% of load
Walls	2.0	6200	33.3
Glazing	12.9	810	4.3
Doors	19.4	771	4.1
Ceilings	3.6	2741	14.7
Floors	0.8	651	3.5
Infiltration	2.1	6804	36.5
Ducts		590	3.2
Piping		51	0.3
Humidification		0	0
Ventilation		23	0.1
Adjustments		0	
Total		**18640**	**100.0**



Cooling

Component	Btuh/ft²	Btuh	% of load
Walls	0.1	447	5.4
Glazing	29.8	1865	22.7
Doors	9.3	369	4.5
Ceilings	3.2	2478	30.2
Floors	0.1	96	1.2
Infiltration	0.2	679	8.3
Ducts		559	6.8
Ventilation		3	0.0
Internal gains		0	0
Blower		1707	20.8
Adjustments		0	
Total		**8202**	**100.0**



Latent Cooling Load = 0 Btuh
Overall U-value = 0.069 Btuh/ft²-°F

Data entries checked.

Component Constructions

Entire House

University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Design Conditions

Location:

Richmond, CA, US
Elevation: 55 ft
Latitude: 38°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	36	80
Daily range (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

Infiltration:

Method	Simplified
Construction quality	Average
Fireplaces	0

Construction descriptions	**Or**	**Area** ft²	**U-value** Btuh/ft²-°F	**Insul R** ft²-°F/Btuh	**Htg HTM** Btuh/ft²	**Loss** Btuh	**Clg HTM** Btuh/ft²	**Gain** Btuh
Walls								
12F-3sw: Frm wall, wd ext, 1/2" wood shth, r-30 cav ins, 1/2" gypsum board int fnsh, r-3 ext bd ins, 2"x6" wood frm, 24" o.c. stud, r-2 int bd ins	n	1025	0.058	24.0	1.97	2021	0.14	146
	e	734	0.058	24.0	1.97	1448	0.14	104
	s	691	0.058	24.0	1.97	1363	0.14	98
	w	693	0.058	24.0	1.97	1367	0.14	99
	all	3144	0.058	24.0	1.97	6200	0.14	447
Partitions								
(none)								
Windows								
1F-c3of: 3 glazing, clr low-e outr, 1/2" gap, insulated fiberglass frm mat, clr low-e mid, air gas, 1/4" thk, clr innr; 6.67 ft head ht	s	63	0.380	0	12.9	810	21.5	1350
Doors								
11G0: Door, wd pnl type	e	19	0.540	0	18.4	343	8.78	164
11J0: Door, mtl fbrgl type	e	21	0.600	6.3	20.4	428	9.75	205
Ceilings								
17B-6al: Rf/clg ceiling, asphalt shingles roof mat, wd cons, r-6 deck ins, 1" thkns		767	0.105	6.0	3.57	2740	3.23	2478
18A-38zd: Rf/clg ceiling, membrane roof mat, frm cons, r-5 deck ins, 5/8" gypsum board int fnsh, 12" thkns, r-38 ceil ins		1	0.029	38.0	0.99	1	0.34	0
Floors								
19A-38cvhp: Flr floor, frm flr, 12" thkns, hrd wd flr fnsh, r-2 ext ins, r-38 cav ins, leaky crwl ovr		768	0.029	38.0	0.85	651	0.12	96

Component Constructions

Laundry

University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Design Conditions

Location:
Richmond, CA, US
Elevation: 55 ft
Latitude: 38°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	36	80
Daily range (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

Infiltration:	
Method	Simplified
Construction quality	Average
Fireplaces	0

Construction descriptions	Or	Area ft²	U-value Btuh/ft²-°F	Insul R ft²-°F/Btuh	Htg HTM Btuh/ft²	Loss Btuh	Clg HTM Btuh/ft²	Gain Btuh
Walls								
12F-3sw: Frm wall, wd ext, 1/2" wood shth, r-30 cav ins, 1/2" gypsum board int fnsh, r-3 ext bd ins, 2"x6" wood frm, 24" o.c. stud, r-2 int bd ins	n	214	0.058	24.0	1.97	423	0.14	30
	e	40	0.058	24.0	1.97	79	0.14	6
	s	85	0.058	24.0	1.97	168	0.14	12
	w	99	0.058	24.0	1.97	195	0.14	14
	all	439	0.058	24.0	1.97	865	0.14	62
Partitions								
(none)								
Windows								
(none)								
Doors								
(none)								
Ceilings								
17B-6al: Rf/clg ceiling, asphalt shingles roof mat, wd cons, r-6 deck ins, 1" thkns		53	0.105	6.0	3.57	190	3.23	172
Floors								
19A-38cvhp: Flr floor, frm flr, 12" thkns, hrd wd flr fnsh, r-2 ext ins, r-38 cav ins, leaky crwl ovr		53	0.029	38.0	0.85	45	0.12	7

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Component Constructions

Bedroom W

University of Denver

Job: RISE Solar Decathlon
Date: Aug 09, 2017
By: Anthony Augelli

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Design Conditions

Location:
Richmond, CA, US
Elevation: 55 ft
Latitude: 38°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	36	80
Daily range (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

Infiltration:

Method	Simplified
Construction quality	Average
Fireplaces	0

Construction descriptions	**Or**	**Area** ft²	**U-value** Btuh/ft²-°F	**Insul R** ft²-°F/Btuh	**Htg HTM** Btuh/ft²	**Loss** Btuh	**Clg HTM** Btuh/ft²	**Gain** Btuh
Walls								
12F-3sw: Frm wall, wd ext, 1/2" wood shth, r-30 cav ins, 1/2" gypsum board int fnsh, r-3 ext bd ins, 2"x6" wood frm, 24" o.c. stud, r-2 int bd ins	n	17	0.058	24.0	1.97	33	0.14	2
	e	105	0.058	24.0	1.97	207	0.14	15
	s	81	0.058	24.0	1.97	160	0.14	12
	w	243	0.058	24.0	1.97	479	0.14	34
	all	446	0.058	24.0	1.97	879	0.14	63
Partitions								
(none)								
Windows								
1F-c3of: 3 glazing, clr low-e outr, 1/2" gap, insulated fiberglass frm mat, clr low-e mid, air gas, 1/4" thk, clr innr; 6.67 ft head ht	s	15	0.380	0	12.9	189	21.5	316
Doors								
(none)								
Ceilings								
17B-6al: Rf/clg ceiling, asphalt shingles roof mat, wd cons, r-6 deck ins, 1" thkns		124	0.105	6.0	3.57	444	3.23	402
Floors								
19A-38cvhp: Flr floor, frm flr, 12" thkns, hrd wd flr fnsh, r-2 ext ins, r-38 cav ins, leaky crwl ovr		124	0.029	38.0	0.85	105	0.12	16

Component Constructions

Kitchen

University of Denver

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Design Conditions

Location:

Richmond, CA, US
Elevation: 55 ft
Latitude: 38°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	36	80
Daily range (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

Infiltration:

Method	Simplified
Construction quality	Average
Fireplaces	0

Construction descriptions	**Or**	**Area** ft²	**U-value** Btuh/ft²-°F	**Insul R** ft²-°F/Btuh	**Htg HTM** Btuh/ft²	**Loss** Btuh	**Clg HTM** Btuh/ft²	**Gain** Btuh
Walls								
12F-3sw: Frm wall, wd ext, 1/2" wood shth, r-30 cav ins, 1/2" gypsum board int fnsh, r-3 ext bd ins, 2"x6" wood frm, 24" o.c. stud, r-2 int bd ins	n	238	0.058	24.0	1.97	469	0.14	34
	e	4	0.058	24.0	1.97	8	0.14	1
	s	93	0.058	24.0	1.97	184	0.14	13
	w	95	0.058	24.0	1.97	187	0.14	13
	all	430	0.058	24.0	1.97	848	0.14	61
Partitions								
(none)								
Windows								
(none)								
Doors								
(none)								
Ceilings								
17B-6al: Rf/clg ceiling, asphalt shingles roof mat, wd cons, r-6 deck ins, 1" thkns		140	0.105	6.0	3.57	500	3.23	452
Floors								
19A-38cvhp: Flr floor, frm flr, 12" thkns, hrd wd flr fnsh, r-2 ext ins, r-38 cav ins, leaky crwl ovr		140	0.029	38.0	0.85	119	0.12	17

Component Constructions

MEP

University of Denver

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Design Conditions

Location:

Richmond, CA, US

Elevation:	55 ft
Latitude:	38°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	36	80
Daily range (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

Infiltration:

Method	Simplified
Construction quality	Average
Fireplaces	0

Construction descriptions	**Or**	**Area** ft²	**U-value** Btuh/ft²-°F	**Insul R** ft²-°F/Btuh	**Htg HTM** Btuh/ft²	**Loss** Btuh	**Clg HTM** Btuh/ft²	**Gain** Btuh
Walls								
12F-3sw: Frm wall, wd ext, 1/2" wood shth, r-30 cav ins, 1/2" gypsum board int fnsh, r-3 ext bd ins, 2"x6" wood frm, 24" o.c. stud, r-2 int bd ins	n	211	0.058	24.0	1.97	416	0.14	30
	e	102	0.058	24.0	1.97	202	0.14	15
	s	83	0.058	24.0	1.97	163	0.14	12
	all	396	0.058	24.0	1.97	781	0.14	56
Partitions								
(none)								
Windows								
(none)								
Doors								
(none)								
Ceilings								
17B-6al: Rf/clg ceiling, asphalt shingles roof mat, wd cons, r-6 deck ins, 1" thkns		54	0.105	6.0	3.57	194	3.23	175
Floors								
19A-38cvhp: Flr floor, frm flr, 12" thkns, hrd wd flr fnsh, r-2 ext ins, r-38 cav ins, leaky crwl ovr		54	0.029	38.0	0.85	46	0.12	7

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Component Constructions

Front Corrdoor

University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Design Conditions

Location:
Richmond, CA, US
Elevation: 55 ft
Latitude: 38°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	36	80
Daily range (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

Infiltration:

Method	Simplified
Construction quality	Average
Fireplaces	0

Construction descriptions	**Or**	**Area** ft²	**U-value** Btuh/ft²-°F	**Insul R** ft²-°F/Btuh	**Htg HTM** Btuh/ft²	**Loss** Btuh	**Clg HTM** Btuh/ft²	**Gain** Btuh
Walls								
12F-3sw: Frm wall, wd ext, 1/2" wood shth, r-30 cav ins, 1/2" gypsum board int fnsh, r-3 ext bd ins, 2"x6" wood frm, 24" o.c. stud, r-2 int bd ins	n	105	0.058	24.0	1.97	207	0.14	15
	e	107	0.058	24.0	1.97	210	0.14	15
	s	73	0.058	24.0	1.97	144	0.14	10
	w	105	0.058	24.0	1.97	207	0.14	15
	all	390	0.058	24.0	1.97	768	0.14	55
Partitions								
(none)								
Windows								
1F-c3of: 3 glazing, clr low-e outr, 1/2" gap, insulated fiberglass frm mat, clr low-e mid, air gas, 1/4" thk, clr innr; 6.67 ft head ht	s	33	0.380	0	12.9	431	21.5	718
Doors								
(none)								
Ceilings								
17B-6al: Rf/clg ceiling, asphalt shingles roof mat, wd cons, r-6 deck ins, 1" thkns		140	0.105	6.0	3.57	500	3.23	452
Floors								
19A-38cvhp: Flr floor, frm flr, 12" thkns, hrd wd flr fnsh, r-2 ext ins, r-38 cav ins, leaky crwl ovr		140	0.029	38.0	0.85	119	0.12	17

Component Constructions

side entrance

University of Denver

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Project Information

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Design Conditions

Location:

Richmond, CA, US		
Elevation:	55	ft
Latitude:	38°N	

Outdoor:	**Heating**	**Cooling**	
Dry bulb (°F)	36	80	
Daily range (°F)	-	21	(M)
Wet bulb (°F)	-	63	
Wind speed (mph)	15.0	7.5	

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

Infiltration:

Method	Simplified
Construction quality	Average
Fireplaces	0

Construction descriptions	**Or**	**Area** ft²	**U-value** Btuh/ft²-°F	**Insul R** ft²-°F/Btuh	**Htg HTM** Btuh/ft²	**Loss** Btuh	**Clg HTM** Btuh/ft²	**Gain** Btuh
Walls								
12F-3sw: Frm wall, wd ext, 1/2" wood shth, r-30 cav ins, 1/2" gypsum board int fnsh, r-3 ext bd ins, 2"x6" wood frm, 24" o.c. stud, r-2 int bd ins	n	84	0.058	24.0	1.97	166	0.14	12
	e	91	0.058	24.0	1.97	180	0.14	13
	s	84	0.058	24.0	1.97	166	0.14	12
	all	259	0.058	24.0	1.97	511	0.14	37
Partitions								
(none)								
Windows								
(none)								
Doors								
11J0: Door, mtl fbrgl type	e	21	0.600	6.3	20.4	428	9.75	205
Ceilings								
17B-6al: Rf/clg ceiling, asphalt shingles roof mat, wd cons, r-6 deck ins, 1" thkns		60	0.105	6.0	3.57	212	3.23	192
18A-38zd: Rf/clg ceiling, membrane roof mat, frm cons, r-5 deck ins, 5/8" gypsum board int fnsh, 12" thkns, r-38 ceil ins		1	0.029	38.0	0.99	1	0.34	0
Floors								
19A-38cvhp: Flr floor, frm flr, 12" thkns, hrd wd flr fnsh, r-2 ext ins, r-38 cav ins, leaky crwl ovr		60	0.029	38.0	0.85	51	0.12	8

Component Constructions

Bedroom E

University of Denver

Job: RISE Solar Decathlon
Date: Aug 09, 2017
By: Anthony Augelli

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

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61st and Pena Station, Denver, CO 80249

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Design Conditions

Location:
Richmond, CA, US
Elevation: 55 ft
Latitude: 38°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	36	80
Daily range (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

Infiltration:

Method	Simplified
Construction quality	Average
Fireplaces	0

Construction descriptions	Or	Area ft²	U-value Btuh/ft²-°F	Insul R ft²-°F/Btuh	Htg HTM Btuh/ft²	Loss Btuh	Clg HTM Btuh/ft²	Gain Btuh
Walls								
12F-3sw: Frm wall, wd ext, 1/2" wood shth, r-30 cav ins, 1/2" gypsum board int fnsh, r-3 ext bd ins, 2"x6" wood frm, 24" o.c. stud, r-2 int bd ins	n	83	0.058	24.0	1.97	163	0.14	12
	e	251	0.058	24.0	1.97	495	0.14	36
	s	190	0.058	24.0	1.97	375	0.14	27
	w	97	0.058	24.0	1.97	192	0.14	14
	all	621	0.058	24.0	1.97	1224	0.14	88
Partitions								
(none)								
Windows								
1F-c3of: 3 glazing, clr low-e outr, 1/2" gap, insulated fiberglass frm mat, clr low-e mid, air gas, 1/4" thk, clr innr; 6.67 ft head ht	s	15	0.380	0	12.9	189	21.5	316
Doors								
(none)								
Ceilings								
17B-6al: Rf/clg ceiling, asphalt shingles roof mat, wd cons, r-6 deck ins, 1" thkns		133	0.105	6.0	3.57	475	3.23	430
Floors								
19A-38cvhp: Flr floor, frm flr, 12" thkns, hrd wd flr fnsh, r-2 ext ins, r-38 cav ins, leaky crwl ovr		133	0.029	38.0	0.85	113	0.12	17

Component Constructions

Bathroom

University of Denver

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Design Conditions

Location:
Richmond, CA, US
Elevation: 55 ft
Latitude: 38°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	36	80
Daily range (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

Infiltration:	
Method	Simplified
Construction quality	Average
Fireplaces	0

Construction descriptions	**Or**	**Area** ft²	**U-value** Btuh/ft²-°F	**Insul R** ft²-°F/Btuh	**Htg HTM** Btuh/ft²	**Loss** Btuh	**Clg HTM** Btuh/ft²	**Gain** Btuh
Walls								
12F-3sw: Frm wall, wd ext, 1/2" wood shth, r-30 cav ins, 1/2" gypsum board int fnsh, r-3 ext bd ins, 2"x6" wood frm, 24" o.c. stud, r-2 int bd ins	n	73	0.058	24.0	1.97	145	0.14	10
	e	35	0.058	24.0	1.97	68	0.14	5
	s	1	0.058	24.0	1.97	3	0.14	0
	w	55	0.058	24.0	1.97	108	0.14	8
	all	164	0.058	24.0	1.97	323	0.14	23
Partitions								
(none)								
Windows								
(none)								
Doors								
11G0: Door, wd pnl type	e	19	0.540	0	18.4	343	8.78	164
Ceilings								
17B-6al: Rf/clg ceiling, asphalt shingles roof mat, wd cons, r-6 deck ins, 1" thkns		63	0.105	6.0	3.57	224	3.23	202
Floors								
19A-38cvhp: Flr floor, frm flr, 12" thkns, hrd wd flr fnsh, r-2 ext ins, r-38 cav ins, leaky crwl ovr		63	0.029	38.0	0.85	53	0.12	8

Project Summary
Entire House
University of Denver

Job:	**RISE Solar Decathlon**
Date:	**Aug 09, 2017**
By:	**Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Notes:

Design Information

Weather: Richmond, CA, US

Winter Design Conditions

Outside db	36	°F
Inside db	70	°F
Design TD	34	°F

Heating Summary

Structure	17976	Btuh
Ducts	590	Btuh
Central vent (SER=92% 8 cfm) Heat recovery	23	Btuh
Humidification	0	Btuh
Piping	51	Btuh
Equipment load	18640	Btuh

Infiltration

Method	Simplified
Construction quality	Average
Fireplaces	0

	Heating	**Cooling**
Area (ft²)	768	768
Volume (ft³)	15463	15463
Air changes/hour	0.61	0.32
Equiv. AVF (cfm)	182	124

Heating Equipment Summary

Make	Mitsubishi
Trade	Horizontal duct and heating pu...
Model	SUZ-KA12NA
AHRI ref	3837467

Efficiency	10 HSPF	
Heating input		
Heating output	13600	Btuh @ 47°F
Temperature rise	51	°F
Actual air flow	245	cfm
Air flow factor	0.013	cfm/Btuh
Static pressure	0.20	in H2O
Space thermostat		

Capacity balance point = 0 °F

Backup: Elec baseboard
Input = 18276 Btuh, Output = 18276 Btuh, 100 EFF

Summer Design Conditions

Outside db	80	°F
Inside db	75	°F
Design TD	5	°F
Daily range	M	
Relative humidity	50	%
Moisture difference	-6	gr/lb

Sensible Cooling Equipment Load Sizing

Structure	5934	Btuh
Ducts	559	Btuh
Central vent (SER=92% 8 cfm) Heat recovery	3	Btuh
Blower	1707	Btuh
Use manufacturer's data	n	
Rate/swing multiplier	0.85	
Equipment sensible load	6972	Btuh

Latent Cooling Equipment Load Sizing

Structure	-487	Btuh
Ducts	-17	Btuh
Central vent (8 cfm) Heat recovery	-30	Btuh
Equipment latent load	0	Btuh
Equipment Total Load (Sen+Lat)	6972	Btuh
Req. total capacity at 0.70 SHR	0.8	ton

Cooling Equipment Summary

Make	Mitsubishi
Trade	Horizontal duct and heating pu...
Cond	SUZ-KA12NA
Coil	SEZ-KD12NA4
AHRI ref	3837467

Efficiency	12.5 EER, 16 SEER	
Sensible cooling	8050	Btuh
Latent cooling	3450	Btuh
Total cooling	11500	Btuh
Actual air flow	*245*	cfm
Air flow factor	0.038	cfm/Btuh
Static pressure	0.20	in H2O
Load sensible heat ratio	1.00	

Bold/italic values have been manually overridden

Calculations approved by ACCA to meet all requirements of Manual J 8th Ed.

AED Assessment
Entire House
University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Design Conditions

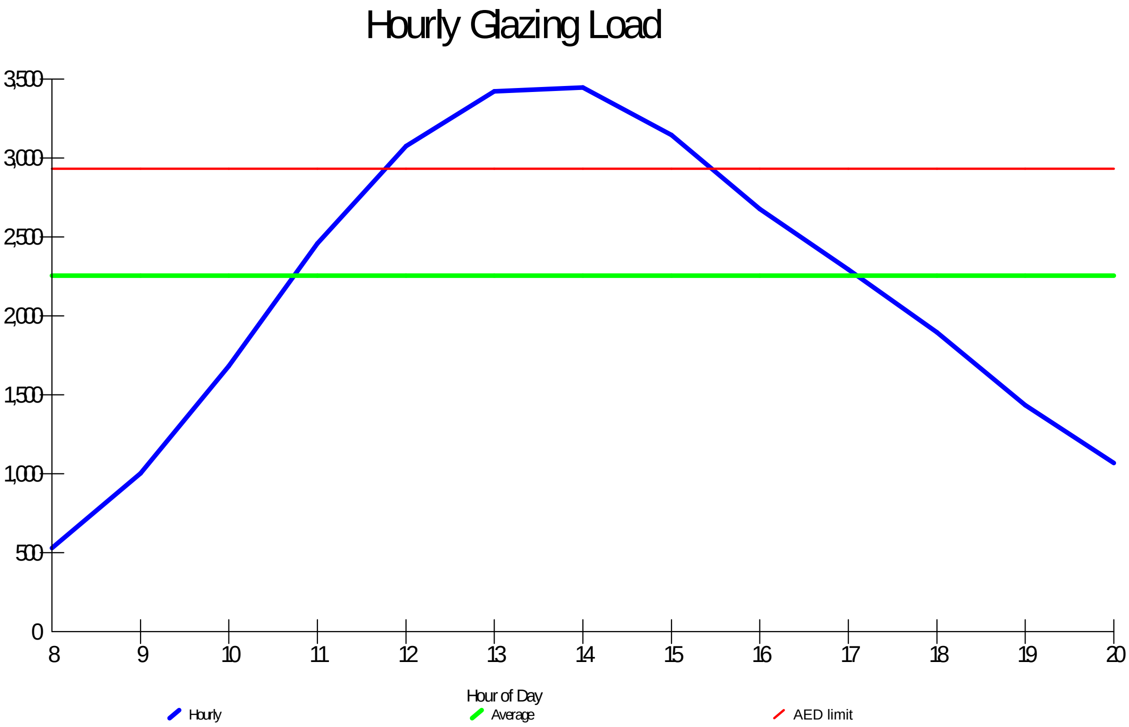
Location:
Richmond, CA, US
Elevation: 55 ft
Latitude: 38°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	36	80
Daily range (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

Infiltration:

Test for Adequate Exposure Diversity



Maximum hourly glazing load exceeds average by 52.8%.

House does not have adequate exposure diversity (AED), based on AED limit of 30%.

AED excursion: 514 Btuh (PFG - 1.3*AFG)

Right-J® Worksheet
Entire House
University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

		Entire House	Laundry
1	Room name	Entire House	Laundry
2	Exposed wall	271.2 ft	31.3 ft
3	Room height	20.1 ft	19.8 ft heat/cool
4	Room dimensions		10.7 x 5.0 ft
5	Room area	768.2 ft²	53.3 ft²

	Ty	Construction number	U-value (Btuh/ft²-°F)	Or	HTM (Btuh/ft²)		Area (ft²) or perimeter (ft)		Load (Btuh)		Area (ft²) or perimeter (ft)		Load (Btuh)	
					Heat	Cool	Gross	N/P/S	Heat	Cool	Gross	N/P/S	Heat	Cool
6	W	12F-3sw	0.058	n	1.97	0.14	1025	1025	2021	146	214	214	423	30
.	W	12F-3sw	0.058	e	1.97	0.14	774	734	1448	104	40	40	79	6
.	D	11G0	0.540	e	18.36	8.78	19	19	343	164	0	0	0	0
.	D	11J0	0.600	e	20.40	9.75	21	21	428	205	0	0	0	0
11	W	12F-3sw	0.058	s	1.97	0.14	754	691	1363	98	85	85	168	12
	G	1F-c3of	0.380	s	12.92	21.55	63	0	810	1350	0	0	0	0
	W	12F-3sw	0.058	w	1.97	0.14	693	693	1367	99	99	99	195	14
	C	17B-6al	0.105	-	3.57	3.23	767	767	2740	2478	53	53	190	172
	C	18A-38zd	0.029	-	0.99	0.34	1	1	1	0	0	0	0	0
	F	19A-38cvhp	0.029	-	0.85	0.12	768	768	651	96	53	53	45	7
6	c) AED excursion									514				0
	Envelope loss/gain								11172	5254			1101	241
12	a) Infiltration								6804	679			920	92
	b) Room ventilation								0	0			0	0
13	Internal gains:		Occupants @		230		0			0	0			0
			Appliances/other							0				0
	Subtotal (lines 6 to 13)								17976	5934			2020	333
	Less external load								0	0			0	0
	Less transfer								0	0			0	0
	Redistribution								0	0			370	64
14	Subtotal								17976	5934			2391	397
15	Duct loads						3%	9%	590	559	3%	9%	78	37
	Total room load								18566	6492			2469	435
	Air required (cfm)								245	245			33	16

Calculations approved by ACCA to meet all requirements of Manual J 8th Ed.

Right-J® Worksheet
Entire House

University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

		Bedroom W	Kitchen
1	Room name	Bedroom W	Kitchen
2	Exposed wall	35.8 ft	35.8 ft
3	Room height	20.8 ft heat/cool	19.8 ft heat/cool
4	Room dimensions	10.7 x 11.7 ft	11.8 x 11.8 ft
5	Room area	124.4 ft²	140.0 ft²

	Ty	Construction number	U-value (Btuh/ft²-°F)	Or	HTM (Btuh/ft²)		Area (ft²) or perimeter (ft)		Load (Btuh)		Area (ft²) or perimeter (ft)		Load (Btuh)	
					Heat	Cool	Gross	N/P/S	Heat	Cool	Gross	N/P/S	Heat	Cool
6	W	12F-3sw	0.058	n	1.97	0.14	17	17	33	2	238	238	469	34
.	W	12F-3sw	0.058	e	1.97	0.14	105	105	207	15	4	4	8	1
.	D	11G0	0.540	e	18.36	8.78	0	0	0	0	0	0	0	0
.	D	11J0	0.600	e	20.40	9.75	0	0	0	0	0	0	0	0
11	W	12F-3sw	0.058	s	1.97	0.14	96	81	160	12	93	93	184	13
	G	1F-c3of	0.380	s	12.92	21.55	15	0	189	316	0	0	0	0
	W	12F-3sw	0.058	w	1.97	0.14	243	243	479	34	95	95	187	13
	C	17B-6al	0.105	-	3.57	3.23	124	124	444	402	140	140	500	452
	C	18A-38zd	0.029	-	0.99	0.34	0	0	0	0	0	0	0	0
	F	19A-38cvhp	0.029	-	0.85	0.12	124	124	105	16	140	140	119	17
6	c) AED excursion									120				0
	Envelope loss/gain								1618	917			1466	531
12	a) Infiltration								964	96			901	90
	b) Room ventilation								0	0			0	0
13	Internal gains:		Occupants @		230		0			0	0			0
			Appliances/other							0				0
	Subtotal (lines 6 to 13)								2582	1014			2367	621
	Less external load								0	0			0	0
	Less transfer								0	0			0	0
	Redistribution								1648	484			-2367	-621
14	Subtotal								4230	1497			0	0
15	Duct loads						3%	9%	139	141	3%	9%	0	0
	Total room load								4369	1638			0	0
	Air required (cfm)								58	62			0	0

Right-J® Worksheet
Entire House
University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

		MEP	Front Corrdoor
1	Room name	MEP	Front Corrdoor
2	Exposed wall	26.0 ft	47.0 ft
3	Room height	19.8 ft heat/cool	20.8 ft heat/cool
4	Room dimensions	10.5 x 5.2 ft	11.8 x 11.8 ft
5	Room area	54.2 ft²	140.0 ft²

	Ty	Construction number	U-value (Btuh/ft²-°F)	Or	HTM (Btuh/ft²)		Area (ft²) or perimeter (ft)		Load (Btuh)		Area (ft²) or perimeter (ft)		Load (Btuh)	
					Heat	Cool	Gross	N/P/S	Heat	Cool	Gross	N/P/S	Heat	Cool
6	W	12F-3sw	0.058	n	1.97	0.14	211	211	416	30	105	105	207	15
.	W	12F-3sw	0.058	e	1.97	0.14	102	102	202	15	107	107	210	15
.	D	11G0	0.540	e	18.36	8.78	0	0	0	0	0	0	0	0
.	D	11J0	0.600	e	20.40	9.75	0	0	0	0	0	0	0	0
11	W	12F-3sw	0.058	s	1.97	0.14	83	83	163	12	107	73	144	10
	G	1F-c3of	0.380	s	12.92	21.55	0	0	0	0	33	0	431	718
	W	12F-3sw	0.058	w	1.97	0.14	0	0	0	0	105	105	207	15
	C	17B-6al	0.105	-	3.57	3.23	54	54	194	175	140	140	500	452
	C	18A-38zd	0.029	-	0.99	0.34	0	0	0	0	0	0	0	0
	F	19A-38cvhp	0.029	-	0.85	0.12	54	54	46	7	140	140	119	17

6	c) AED excursion					0				274
	Envelope loss/gain				1021	238			1818	1517
12	a) Infiltration				830	83			887	89
	b) Room ventilation				0	0			0	0
13	Internal gains:	Occupants @ 230	0			0	0			0
		Appliances/other				0				0
	Subtotal (lines 6 to 13)				1851	321			2704	1606
	Less external load				0	0			0	0
	Less transfer				0	0			0	0
	Redistribution				-1851	-321			418	80
14	Subtotal				0	0			3123	1686
15	Duct loads		3%	9%	0	0	3%	9%	102	159
	Total room load				0	0			3225	1844
	Air required (cfm)				0	0			43	70

Calculations approved by ACCA to meet all requirements of Manual J 8th Ed.

Right-J® Worksheet
Entire House

University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

1	Room name	side entrance	Bedroom E
2	Exposed wall	26.7 ft	45.7 ft
3	Room height	19.6 ft heat/cool	19.8 ft heat/cool
4	Room dimensions	10.7 x 5.7 ft	10.5 x 12.7 ft
5	Room area	60.4 ft²	133.0 ft²

	Ty	Construction number	U-value (Btuh/ft²-°F)	Or	HTM (Btuh/ft²)		Area (ft²) or perimeter (ft)		Load (Btuh)		Area (ft²) or perimeter (ft)		Load (Btuh)	
					Heat	Cool	Gross	N/P/S	Heat	Cool	Gross	N/P/S	Heat	Cool
6	W	12F-3sw	0.058	n	1.97	0.14	84	84	166	12	83	83	163	12
.	W	12F-3sw	0.058	e	1.97	0.14	112	91	180	13	251	251	495	36
.	D	11G0	0.540	e	18.36	8.78	0	0	0	0	0	0	0	0
.	D	11J0	0.600	e	20.40	9.75	21	21	428	205	0	0	0	0
11	W	12F-3sw	0.058	s	1.97	0.14	84	84	166	12	205	190	375	27
	G	1F-c3of	0.380	s	12.92	21.55	0	0	0	0	15	0	189	316
	W	12F-3sw	0.058	w	1.97	0.14	0	0	0	0	97	97	192	14
	C	17B-6al	0.105	-	3.57	3.23	60	60	212	192	133	133	475	430
	C	18A-38zd	0.029	-	0.99	0.34	1	1	1	0	0	0	0	0
	F	19A-38cvhp	0.029	-	0.85	0.12	60	60	51	8	133	133	113	17
6	c) AED excursion									0				120
	Envelope loss/gain								1204	442			2002	971
12	a) Infiltration								587	59			1332	133
	b) Room ventilation								0	0			0	0
13	Internal gains:		Occupants @		230		0			0	0			0
			Appliances/other							0				0
	Subtotal (lines 6 to 13)								1791	500			3334	1104
	Less external load								0	0			0	0
	Less transfer								0	0			0	0
	Redistribution								2488	620			619	130
14	Subtotal								4280	1120			3953	1233
15	Duct loads						3%	9%	140	105	3%	9%	130	116
	Total room load								4420	1225			4083	1350
	Air required (cfm)								58	46			54	51

Right-J® Worksheet
Entire House
University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

1	Room name	Bathroom	
2	Exposed wall	22.8 ft	
3	Room height	19.8 ft heat/cool	
4	Room dimensions	9.2 x 6.8 ft	
5	Room area	62.6 ft²	

	Ty	Construction number	U-value (Btuh/ft²-°F)	Or	HTM (Btuh/ft²)		Area (ft²) or perimeter (ft)		Load (Btuh)		Area or perimeter		Load	
					Heat	Cool	Gross	N/P/S	Heat	Cool	Gross	N/P/S	Heat	Cool
6	W	12F-3sw	0.058	n	1.97	0.14	73	73	145	10				
.	W	12F-3sw	0.058	e	1.97	0.14	53	35	68	5				
.	├─D	11G0	0.540	e	18.36	8.78	19	19	343	164				
.	└─D	11J0	0.600	e	20.40	9.75	0	0	0	0				
11	W	12F-3sw	0.058	s	1.97	0.14	1	1	3	0				
	└─G	1F-c3of	0.380	s	12.92	21.55	0	0	0	0				
	W	12F-3sw	0.058	w	1.97	0.14	55	55	108	8				
	C	17B-6al	0.105	-	3.57	3.23	63	63	224	202				
	C	18A-38zd	0.029	-	0.99	0.34	0	0	0	0				
	F	19A-38cvhp	0.029	-	0.85	0.12	63	63	53	8				
6	c) AED excursion									0				
	Envelope loss/gain								943	397				
12	a) Infiltration								383	38				
	b) Room ventilation								0	0				
13	Internal gains:		Occupants @		230		0			0				
			Appliances/other							0				
	Subtotal (lines 6 to 13)								1326	435				
	Less external load								0	0				
	Less transfer								0	0				
	Redistribution								-1326	-435				
14	Subtotal								0	0				
15	Duct loads						3%	9%	0	0				
	Total room load								0	0				
	Air required (cfm)								0	0				

Loads for Multiple Orientations

Entire House

University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

Design Conditions

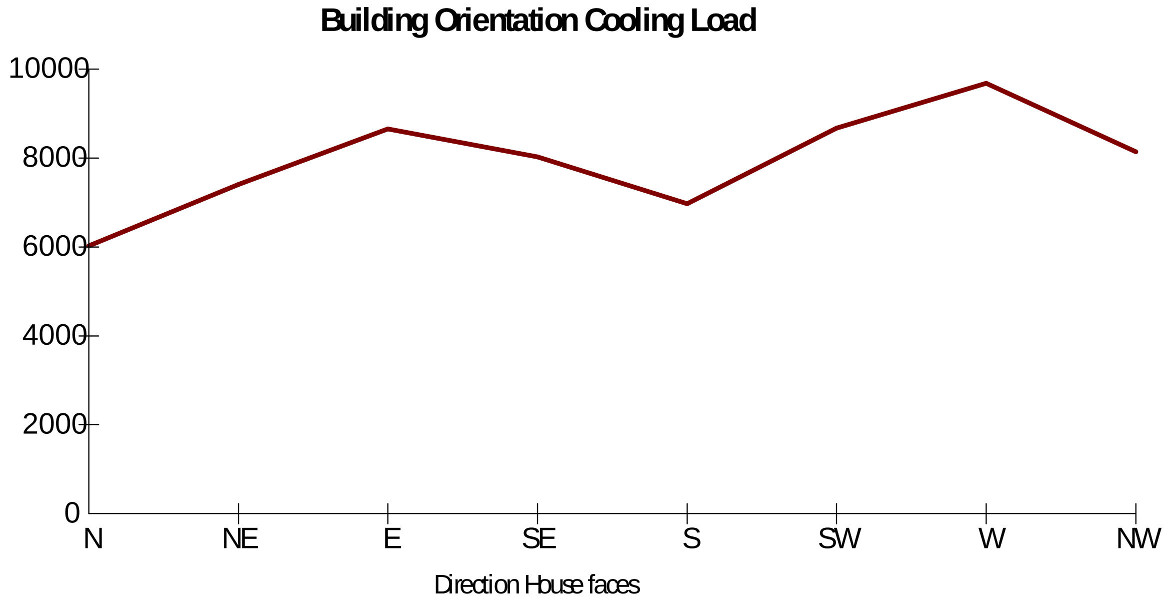
Location:
Richmond, CA, US
Elevation: 55 ft
Latitude: 38°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	36	80
Daily range (°F)	-	21 (M)
Wet bulb (°F)	-	63
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	34	5
Relative humidity (%)	30	50
Moisture difference (gr/lb)	7.9	-5.8

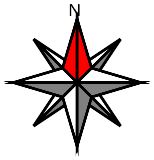
Infiltration:

House	North	Northeast	East	Southeast	South	Southwest	West	Northwest
Sensible Load (Btuh)	6022	7408	8651	8025	6972	8673	9677	8143
Latent Load (Btuh)	0	0	0	0	0	0	0	0
Total Load (Btuh)	6022	7408	8651	8025	6972	8673	9677	8143
Heating AVF (cfm)	245	245	245	245	245	245	245	245
Cooling AVF (cfm)	245	245	245	245	245	245	245	245

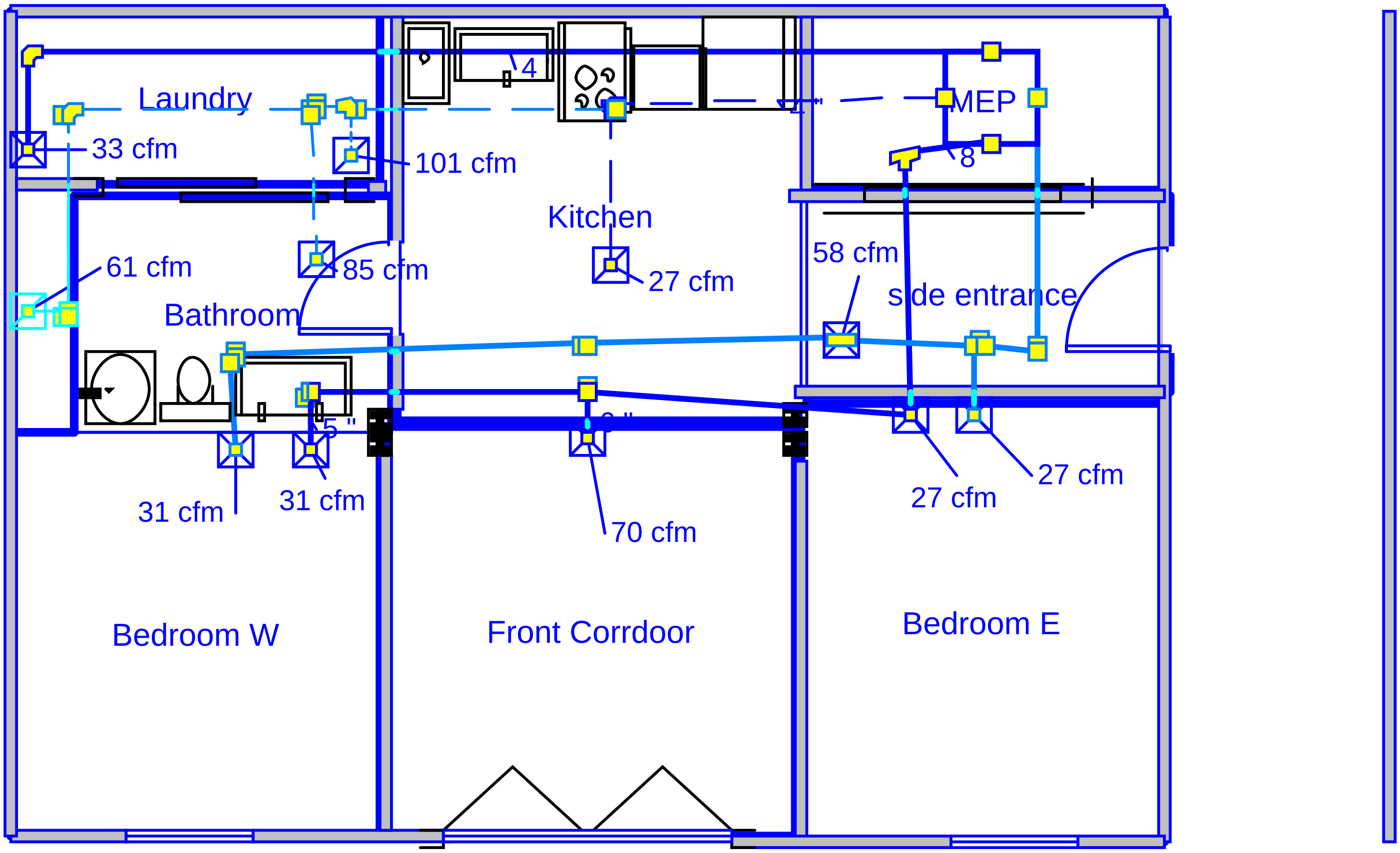


Current Orientation: House faces South
Highest Cooling Load: House faces West

Calculations approved by ACCA to meet all requirements of Manual J 8th Ed.



Level 1



Job #: RISE Solar Decathlon **Performed by Anthony Augelli for:** Solar Decathlon 2017 61st and Pena Station Denver, CO 80249 solardecathlon.gov	**University of Denver** Denver, CO 80210 Phone: 7192138234 Anthony.Augelli@du.edu	Scale: 1 : 67 Page 1 Right-Suite® Universal 2017 17.0.23 RSU25869 2017-Aug-10 10:29:58 ...soft HVAC\RISE-HVAC analysis.rup

Duct System Summary

Entire House

University of Denver

Job: **RISE Solar Decathlon**
Date: **Aug 09, 2017**
By: **Anthony Augelli**

Denver, CO 80210 Phone: 7192138234 Email: Anthony.Augelli@du.edu

Project Information

For: Solar Decathlon 2017, US Department of Energy
61st and Pena Station, Denver, CO 80249

Web: solardecathlon.gov

	Heating		Cooling	
External static pressure	0.20	in H2O	0.20	in H2O
Pressure losses	0	in H2O	0	in H2O
Available static pressure	0.20	in H2O	0.20	in H2O
Supply / return available pressure	0.164 / 0.036	in H2O	0.164 / 0.036	in H2O
Lowest friction rate	0.043	in/100ft	0.043	in/100ft
Actual air flow	245	cfm	*245*	cfm

Total effective length (TEL) 463 ft

Supply Branch Detail Table

Name		Design (Btuh)	Htg (cfm)	Clg (cfm)	Design FR	Diam (in)	H x W (in)	Duct Matl	Actual Ln (ft)	Ftg.Eqv Ln (ft)	Trunk
Bedroom E	h	2041	27	25	0.073	4.0	0x 0	ShMt	10.0	215.0	st3
Bedroom E-A	h	675	27	25	0	0	0x 0	ShMt	0	0	
Bedroom W-A	c	819	29	31	0.043	5.0	0x 0	ShMt	29.0	350.0	st3
Bedroom W-B	c	819	29	31	0	0	0x 0	ShMt	0	0	
Front Corrdoor	c	1844	43	70	0.057	6.0	0x 0	ShMt	20.7	265.0	st3
Laundry	h	2469	33	16	0.121	4.0	0x 0	ShMt	30.7	105.0	
side entrance-A	h	1225	58	46	0	0	0x 0	ShMt	0	0	

Supply Trunk Detail Table

Name	Trunk Type	Htg (cfm)	Clg (cfm)	Design FR	Veloc (fpm)	Diam (in)	H x W (in)	Duct Material	Trunk
st3	Peak AVF	98	126	0.043	361	8.0	0 x 0	ShtMetl	

Return Branch Detail Table

Name	Grille Size (in)	Htg (cfm)	Clg (cfm)	TEL (ft)	Design FR	Veloc (fpm)	Diam (in)	H x W (in)	Stud/Joist Opening (in)	Duct Matl	Trunk
rb6	0x 0	27	25	84.3	0.043	309	4.0	0x 0		ShMt	
rb5	0x 0	61	47	0	0	0	0	0x 0		ShMt	
rb1	0x 0	85	72	0	0	0	0	0x 0		ShMt	
rb3	0x 0	71	101	0	0	0	0	0x 0		ShMt	

Bold/italic values have been manually overridden