Solar Decathlon Market Study – SCI-Arc/Caltech DALE

ET13SCE7180 Report

Prepared by

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Acknowledgments

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Disclaimer

EXECUTIVE SUMMARY

The Solar Decathlon is a an international competition sponsored by the U.S. Department of Energy (DOE) that challenges up to 20 collegiate teams to design, build, and operate solar-powered houses that are cost-effective, energy-efficient, and attractive.[i] These competition homes are highly visible and typically see more than 60,000 visitors per year. The 2013 Solar Decathlon Competition—held at the Orange County Great Park in Irvine, California—created a remarkable opportunity for Southern California Edison (SCE) to engage with customers on subjects such as energy-efficiency (EE), demand response (DR), and distributed generation (DG).

Through a partnership, SCE provided strategic technical design assistance and on-site building diagnostics to a team in the competition composed of students from Southern California Institute of Architecture and California Institute of Technology (SCI-Arc/Caltech). Because the competition is every other year (biennially), the long timeline allows for ample guidance from concept to finished product. SCE's assistance emphasized the importance of best practices within construction and key demand-side management (DSM) practices, including loading order, zero net energy (ZNE), grid-tied DG, and net energy metering (NEM). In turn, these activities allowed SCE to extract rich market intelligence on the latest EE/DR/DG technologies and practices.

The SCI-Arc/Caltech Solar Decathlon 2013 house, called Dynamic Augmented Living Environment (DALE), was a test of reconfigurable components. Specifically, DALE featured a novel approach with controllable modules to maximize control of indoor comfort with reduced energy usage. The end goal was to test several technologies involved in passive thermal control as part of a ZNE residential home. In addition to the outreach that occurred during the competition, findings from this home and partnership were documented and shared with various utility-administered energy-efficiency programs.

Abbreviations and Acronyms

API	application programming interface
Caltech	California Institute of Technology
DALE	Dynamic Augmented Living Environment
DG	distributed generation
DHW	domestic hot water
DOE	Department of Energy
DR	demand response
DSM	demand-side management
EE	energy efficiency
F	Fahrenheit
HAN	home area network
HSPF	heating seasonal performance factor
HVAC	heating, ventilating, and air conditioning
NEM	net energy metering
NREL	National Renewable Energy Laboratory
PPD	predicted percentage displeased
PLC	programmable logic controller
SCE	Southern California Edison
SCI-Arc	Southern California Institute of Architecture
SEER	seasonal energy efficiency ratio
UI	user interface
VFD	variable frequency drive
ZNE	zero-net energy

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INTRODUCTION

The Solar Decathlon is a biennial competition hosted by the U.S. Department of Energy (DOE) and National Renewable Energy Laboratory (NREL) that challenges up to 20 teams from universities around the world to design and build solar-powered homes that are capable of operating at zero net energy (ZNE) within their respective target markets. Because the competition is held every other year, participating teams have well over a year to from start to finish to deliver their design. These teams are tasked with immense responsibility: they must raise a large majority of their project funding, as well as design, build, and transport their competition homes. To date, six editions of the competition have been held in the United States; two have been held in Spain as part of an independent Solar Decathlon Europe competition; and the inaugural Solar Decathlon China took place in China in August 2013. This report highlights the 2013 Solar Decathlon held at the Orange County Great Park in Irvine, California, which brought together 19 competing teams from Austria, the Czech Republic, Canada, and various areas in the United States.

BACKGROUND – ABOUT DALE

First and foremost, the Solar Decathlon is an education project, with the goal of encouraging teams to design and build an innovative ZNE prototype that can serve as a demonstration project for sustainable living. The competition focuses particularly on the role that emerging technologies can play in improving the quality of individual and collective dwelling experiences, as well as of the urban environment. The participating collegiate teams from around the world are invited to compete in 10 different contests ranging from architecture to energy balance, for a possible 1000 points.

The competition itself spans approximately 25 consecutive days, including 8–10 days for assembling the houses. During the assembly period, event organizers and sponsors provide infrastructure including electrical grids, communication and internet equipment, infrastructure facilities, monitoring and scoring instrumentation, signage, and walkways. Once these activities are complete, the competition begins and continues for an additional 10 days—a period when the houses are open to the public. After the competition is over, the teams and organizers have 5 days to disassemble the village and return home.[ii]

Southern California Institute of Architecture (SCI-Arc) and California Institute of Technology (Caltech) participated jointly in the 2013 Solar Decathlon held in Irvine. The competition prototype produced by the SCI-Arc/Caltech team, called the Dynamic Augmented Living Environment (DALE), featured a mix of novel and existing technologies that have been employed in other energy-efficient buildings. As discussed further in the Background section, DALE sought to balance engineering, architecture, affordability, and marketability considerations in response to the very detailed competition rules.

In support of this challenge, SCE provided the SCI-Arc/Caltech team with demand-side management (DSM)–related technical design assistance and on-site building diagnostics. This assistance elucidated and stressed the importance of best practices within construction and key DSM practices, including loading order, ZNE, grid-tied distributed generation (DG), and net energy metering (NEM). The competition also allowed SCE to extract rich market intelligence on the latest DSM technologies. Thus, the partnership fostered a rich two-way learning environment and presented a rewarding opportunity to learn about DSM from customers. A technology summary can be found in the Appendix.

TECHNOLOGY/PRODUCT EVALUATION

A complete summary of technology used in DALE can be found in the Appendix. Southern California's agreeable climate begs homeowners to open their doors and windows and enjoy the pleasant weather. DALE (see Figure 1) took this practice a step further by allowing homeowners to open up the entire house without sacrificing privacy or shade. The team's goal was to design a house that embraced the Southern California climate rather than rely on active systems for cooling of the house.

To this end, DALE featured module and canopy movement systems to provide reconfigurable ventilation and shading strategies that allowed the home to open (in effect, split in two) and create an outdoor living space that tripled the inhabitable square footage, while providing residents comfort and privacy. The movable systems comprised a variety of hardware, as well as software that correctly positioned the modules and canopies according to user input, while keeping the inhabitants and their belongings safe. This enabled a high degree of passive home control and indoor-outdoor connections—features that are not sufficiently utilized in the benign Mediterranean climate.

The technology for opening up the entire house was based on gantry crane motors, which can easily move a structure the size of DALE. The team not was aware of any existing houses that can move similarly, with the closest design based on shading rather than opening.

FIGURE 1. DALE AT THE 2013 SOLAR DECATHLON IN IRVINE, CALIFORNIA, SEEN IN THE OPEN POSITION

Giving Residents Control

To provide residents control, DALE featured a touch screen panel with an intuitive user interface (UI) that fed high-level commands to a programmable logic controller (PLC) in the mechanical room. Using this screen, the homeowner could select from one of several preset module and canopy configurations, enter a new configuration manually, or program an additional configuration for the PLC to remember. The PLC checked this input for validity, computed the necessary module and canopy moves and the order that the moves should occur, and then activated the safety equipment. The homeowner could also use touch screen to individually control the motorized louvers located on both sides of the canopies. With so many degrees of freedom, DALE's inhabitants are able to enjoy an energy-efficient, fully customizable, indoor/outdoor lifestyle.

Moving the Modular Components

To make these moves possible, each module is equipped with a variable-frequency drive (VFD) that gradually accelerates and decelerates a pair of one-horsepower end trucks, similar to the wheeled motors typically used in gantry cranes. This ramping provides two distinct advantages over single-speed operation: smoother starts and stops and less mechanical stress on the motors and modules. Additionally, end trucks rated for loads much heavier than the modules were chosen so they can better handle dynamic loading inside the house. Finally, the modules themselves protect the end trucks from the environment, further reducing maintenance and repair costs for this system. In the unlikely event that power is lost while the home is opened, the end trucks are equipped with a manual brake override that allow the inhabitants to manually close the home.

To make canopy movement possible, a three-stage, ball-based linear telescopic slide system made of stainless steel is attached to the roof support structure of each module. Movement during the first and second stages is accomplished by means of a spur gear articulating with a horizontal gear rack. Movement during the third stage is accomplished by means of a tensioned chain running along the sliding rails that is fixed at one point. As with module movement, a VFD gradually accelerates and decelerates a pair of half-horsepower motors equipped with speed reducers and provides a reduction in maintenance and repair costs (similar to that described above) for this system. Each canopy slides parallel to the track and can cantilever approximately 10 feet from center in either direction.

Solving Plumbing and Wiring Issues

Equipping the home with two independently moving modules makes plumbing and electrical wiring difficult, since the municipal water supply line and local microgrid are stationary. To accommodate the lines that run between these fixed points and the core module, a durable cable carrier mounted underneath the mechanical room guides flexible cables and hoses along the length of the rails. A second cable carrier mounted underneath each module accommodates the lines that run between them. As with the end trucks, weather-resistant cable carriers were positioned underneath the modules to protect the lines from the environment, thereby reducing maintenance and repair costs. Cable carriers were also used to overcome the wiring issues of having two canopies that can move in two directions relative to the modules. The placement of solar photovoltaic panels on top of the canopies and small motors for the louvers and various safety sensors on the canopies also necessitated wires running from each module to its canopy.

Controlling Energy Use

To provide a view of the energy consumption of the house, the team turned to a system that could use existing equipment. A system founded by Caltech Solar Decathlon 2011 alumni can read SmartMeter™ data over home area network (HAN) and use this data to attempt to determine the energy consumption within the house. The system requires an inexpensive gateway connected to an Ethernet port, rather than the more conventional 40-circuit monitoring system typically priced at $2,500. The team wanted to test the system, reduce the cost of the house for the affordability contest, and determine if the technology could be readily implemented.

DALE's heating, ventilating, and air-conditioning (HVAC) and domestic hot water (DHW) systems are compatible with the module and canopy movement while achieving the same level of functionality and efficiency as the corresponding systems in a more typical home. Movement concerns were addressed by choosing units that are well-suited for smaller homes and by placing the equipment for both systems on just one of the modules, thereby avoiding the complexities associated with flexible, non-standard piping metals. The team used a ductless HVAC system comprising a dual-zone heat pump with a single outdoor unit and two indoor units. The outdoor unit is among the most efficient in its size class, rated at a cooling seasonal energy efficiency ratio (SEER) of 18 and a heating seasonal performance factor (HSPF) of 8.9 at 47° Fahrenheit (F); the indoor units are rated at 15 SEER and 9.6 HSPF. The heat pump cools or heats the refrigerant, R-410a, into a liquid or gaseous form and sends it to the two indoor units, which then drive air cooled or heated by the refrigerant piping into the house.

DALE's energy application (DALE Control) frees homeowners from the burden of using multiple applications to control their appliances and HVAC system. The DALE Control for tablets is intuitive, user-friendly, and easily programmable, allowing homeowners to store their preferences and filling a niche of the home-control market with an all-in-one app. DALE Control communicates with a home automation system through a director application programming interface (API) to determine which devices are connected to DALE's server and thus can be controlled through the app. DALE Control also has an automatic light mode in which the overall light level is fixed by the homeowner; light sensors measure the indoor and outdoor ambient light levels and the app adjusts the lights as needed. DALE's HVAC system is controlled via a smart thermostat that can be controlled wirelessly from inside the house and monitored over the Internet. The technology used in DALE is aimed at the residential sector, although some parts can be incorporated into commercial structures.

Energy Performance

The Solar Decathlon organizers closely monitor each competition home's energy usage for an 8-day period, during which each team aims to achieve the goal of ZNE. ZNE is defined by the competition as generating more energy (kWh) than is used over the competition period, as measured by the home's site electric meter. Datalogging of energy consumption and production was completed through the organizer's installed meters. Data was uploaded to a central database and made available in 15-minute intervals to provide the competing teams near-instant feedback on their home's energy use and demand. Additionally, wireless dataloggers for temperature, humidity, and refrigerator/freezer temperature were provided. Further details are available in the Solar Decathlon Rulebook.[iii]

As part of the competition requirements, the home needed to maintain a strict temperature range. However, meeting this range was not required during tour hours, when the configuration of the home was optimized for pedestrian visitation rather than interior comfort.

Measurements of interior comfort conditions and energy balance were made using wireless sensors provided by the organizers (DOE and NREL) in conjunction with current transformers placed in the house's electrical panel. Net Energy Metering was provided by SCE SmartMeters.

As discussed earlier, the home was designed with two prefabricated modules that move across a rail system. This system was analyzed and designed through various analytical methods. Historical Southern California weather data was used in combination with ASHRAE Standard 55 equations to provide a wealth of information:

- Numeric descriptions of how hot or cold an average person will feel given seven parameters: air temperature, mean radiant temperature, relative humidity, wind speed, clothing level, activity level, and metabolic rate
- The predicted percentage displeased (PPD), representing the percentage of people that will be unhappy in a given weather condition.

Using these ASHRAE equations, the project team calculated the hourly PPD, given 30 years of weather data for the El Toro Marine base near in Irvine, to determine when the house could be opened comfortably and how much energy could be saved. Figure 2 shows the projected monthly energy use (via EnergyPro software) for the home with and without active envelope movement.

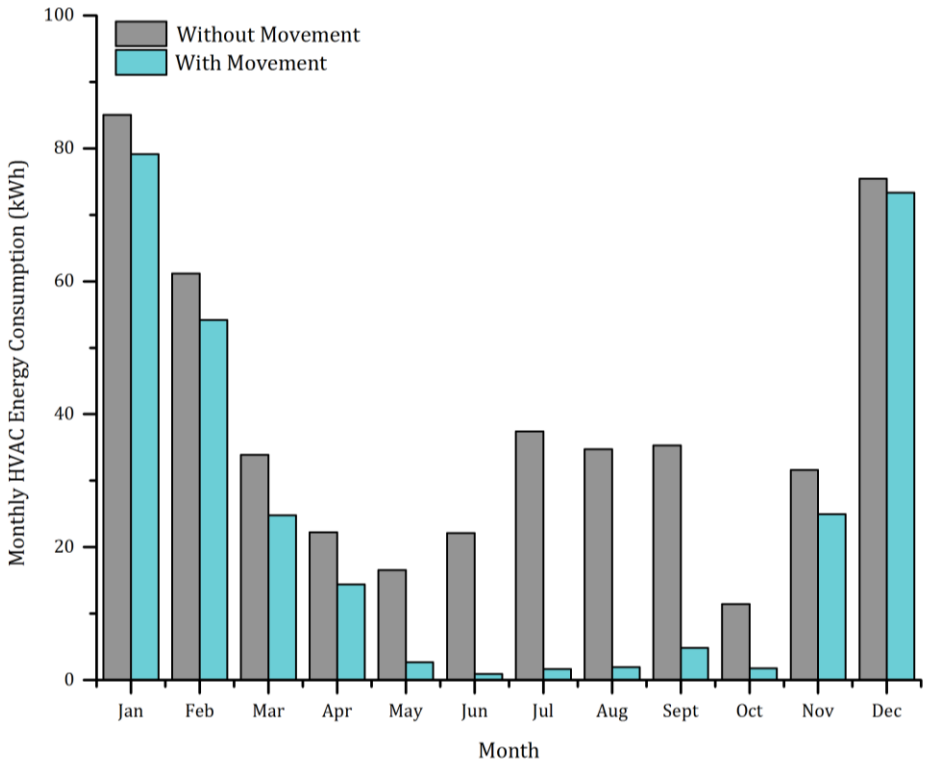

FIGURE 2. PROJECTED MONTHLY ENERGY USE FOR DALE WITH AND WITHOUT MOVEMENT

An overview of the final competition results, as well as specific information on the individual contests, can be found on the DOE Solar Decathlon's website (http://www.solardecathlon.gov/blog/archives/category/solar-decathlon/solar-decathlon-2013). The following section, Results and Discussion, also discusses DALE's energy performance.

RESULTS AND DISCUSSION

Competition-wise, the SCI-Arc/Caltech team placed 14th overall in the 2013 competition. The team placed 4th, 5th, and 6th in communications, affordability, and architecture, respectively. All 20 teams involved in the 2013 contest finished with a positive energy balance, presumably because of favorable weather conditions and oversized solar-electric arrays. DALE's array was designed to produce sufficient energy in 95% of historical weather conditions in Irvine in October, which allowed a sufficient surplus to manage additional unanticipated needs for hot water heating. The team placed 12th in the engineering contest. The competition jury questioned the choice of having two moving modules, as opposed to a single moving structure that would have allowed fixed water and electrical connections.

DALE's open-ability feature is highly innovative, and especially appropriate for areas with mild climates, such as Southern California. In general, the house movement was functional, with areas for improvement, as would be expected, given the novel technology used. The home user interface was functional but had occasional errors that required resetting. The gaskets along the edges of the enclosures had minor leaks because of the symmetrical design called for by the architectural team. Wind issues were also encountered that were not anticipated during the design process. When home's brakes were applied, the structure could handle wind. However, without brakes, the Santa Ana winds were powerful enough to push the house.

Overall, DALE's project team concluded that the novel moving component of the house had some real benefits related to energy savings, natural ventilation, daylighting, and human comfort. However, it also drastically increased the maintenance and up-front costs of the home in comparison to other typically constructed homes. Nonetheless, the team's ability to bring this concept to life in a constructed home was a feat to be recognized.

CONCLUSIONS AND RECOMMENDATIONS

This partnership with team SCI-Arc/Caltech allowed SCE to extract rich market intelligence on the latest EE/DR/DG technologies and practices. In this particular case, the HVAC technologies, lighting technologies, solar canopy, and ability to completely open the home to the outdoors were all sources of rich findings. SCE provided the competing team with strategic technical design assistance and on-site building diagnostics, stressing the importance of key DSM practices. Some of these key DSM practices include Loading Order, ZNE, Grid-Tied DG, and NEM.

Most of the sustainable technology used in DALE worked as planned. The moving technology of the house functioned well, but the safety equipment was not fully implemented and the touch control system had intermittent issues; addressing wind was another concern. Near the end of construction, the team spent a significant amount of time making the shade canopies fully operational. Future designs will do better with a cloth-based shade structure and stationary solar panels. The primarily student-led installation of plumbing and electrical also resulted in a few issues, some quickly fixed and others that required the team to rely on backup technology. Future construction projects, especially those that require advanced construction techniques, should rely on more trained labor.

It is recommended that SCE's DSM programs continue to stay involved with this nationally-recognized competition. The technologies and building practices demonstrated and displayed to the public at these events represent countless hours of consolidated market research, in particular with regards to DSM technologies. The 2015 Solar Decathlon has already been announced and will be held for the second time at the Orange County Great Park in Irvine, within SCE's service area.

REFERENCES

[i] U.S. Department of Energy (2014), Solar Decathlon, http://www.solardecathlon.gov/

[ii] University of Texas at Austin (2013), U.S. Department of Energy: Solar Decathlon 2015, http://www.utexas.edu/research/osp/proposal/limited/solar_decathlon.html

[iii] U.S. Department of Energy (2013), Solar Decathlon Rules, http://www.solardecathlon.gov/rules.html

APPENDIX: TECHNOLOGY SUMMARY

Technology at a Glance

• Average solar-electric system DC rating	7.5 kW
• # of solar-electric systems with micro-inverters	5/19
• # of homes with solar-thermal systems	9/19
• # of homes using A-A / A-W / W-W heat pumps	10/7/1
• # of homes using LEDs as primary light source	18/19
• # of homes using mechanical ventilators	15/19
• # of homes using triple-pane windows	7/19
• # of homes using closed cell spray foam	7/19
• # of homes that used EnergyPlus simulation	9/19

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Specific Technologies

- Vacuum insulated panels, Panasonic
- Alloy actuator wire for automated exterior shading, Dynalloy
- Interior & exterior wood fiber insulation, PEAK
- Exterior infrared / interior humidity coatings, Envirocoatings
- Small duct high velocity air distribution, Unico
- Pre-manufactured radiant panels, Messana
- Capillary tubing radiant cooling systems, BEKA
- Water to water HP with integrated DHW, Envision
- Residential scale chiller with ice storage (TES)
- Bifacial PV panels, Prism Solar

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Solar Decathlon 2013 - Technology Evaluation Summary

	SCI-Arc and Caltech	Stevens Institute of Tech.
Team #	101	102
Home Name	DALE	Ecohabit
Competition Placement	14th	4th
Contest Awards	-	2nd in Architecture
Construction Cost	$308K	$285K
Envelope Construction	vinyl wrap over engineered lumber	wood slats over fiber cement rain screen
Wall Insulation	5" ROXUL semi-rigid batt	3" Envirofoam cc spray foam
Roof Insulation	6.5" ROXUL semi-rigid batt	6" Envirofoam cc spray foam
Windows	dual pane, aluminum	dual pane, aluminum
Exterior Shades	motorized canopies	wood slats & overhangs
Interior Shades	-	-
Daylighting Features	motorized modules	clearstories
Lighting	Elite LED recessed	Lithonia LED recessed
Exterior Lighting	American LED rope	Lithonia LED recessed
Cooling System	Mitsubishi air to air HP	Daikin air to air HP
Heating System	Mitsubishi air to air HP	Daikin air to air HP
H&AC Distribution System	ductless, concealed	ducted
Ventilation System	Fantech AEV	Fantech ERV
Domestic Hot Water System	AO Smith backup	Airgenerate Airtap hybrid HP w/ recirc.
Ceiling Fans	-	Big Ass Fans
Appliances	Bosch	LG
Fume Hood	BSH downdraft variable	XO range hood
Home Area Network	Honeywell Redlink	Brultech GreenEye
Solar-Electric System	Hanwha 6 kW	Dow 6.1 kW solar shingles
Solar-Thermal System	Solar US evacuated tubes	-
Energy Simulation Tools	EnergyPro, Trace	IES VE Pro, SolidWorks
Other	entire modules separate, furniture is moveable	green roof, decorative liquid dessicant system

Solar Decathlon 2013 - Technology Evaluation Summary

	Czech Technical Univ.	Stanford
Team #	103	104
Home Name	AIR House	Start.Home
Competition Placement	3rd	5th
Contest Awards	1st in Arch, 2nd in Eng	1st in Affordability
Construction Cost	$300K	$288K
Envelope Construction	wood battens over cross laminated panels	wood board siding over SIPs
Wall Insulation	6" Steico wood fiber	R-Control SIPs w/ 3.5" EPS
Roof Insulation	8.5" Steico wood fiber	R-Control SIPs w/ 7.5" EPS
Windows	dual pane, aluminum	dual pane, vinyl
Exterior Shades	wood battens & overhangs	overhangs
Interior Shades	drapes	fabric shades
Daylighting Features	-	clearstories & tubular
Lighting	Zumtobel LED recessed slot	Contech LED pendant
Exterior Lighting	Greenlux LED strip	Progress incandescent wall
Cooling System	Daikin air to water HP	Mitsubishi air to air HP
Heating System	Daikin air to water HP	Mitsubishi air to air HP
H&AC Distribution System	Rehau radiant ceiling panels	ductless, wall mounted
Ventilation System	Atrea HRV	Fantech HRV
Domestic Hot Water System	Airgenerate Airtap hybrid HP backup	GE Geospring hybrid HP
Ceiling Fans	-	Big Ass Fans
Appliances	Whirlpool	GE
Fume Hood	Whirlpool exhaust hood	GE range hood variable
Home Area Network	Schneider Merten	custom w/ load control
Solar-Electric System	Aide Solar 6.1 kW	Stion 6.5 kW thin film w/ micro inverters
Solar-Thermal System	Regulus flat plate	-
Energy Simulation Tools	SB Method & SB Tool	EnergyPlus, Vasari, SAM
Other	grey water collection	Dupont phase change material in ceilings, Vantage Pro2 weather station

Solar Decathlon 2013 - Technology Evaluation Summary	Norwich Univ.	Team Texas: Univ. of Texas at El Paso and El Paso Community College
Team #	105	106
Home Name	Delta T-90 House	ADAPT
Competition Placement	12th	18th
Contest Awards	1st in Affordability	-
Construction Cost	$164K	$315K
Envelope Construction	wood rain screen over OSB	corrugated HDPE & steel siding over SIPs
Wall Insulation	11" dense-pack cellulose + 2" ROXUL rigid wool	SIPs w/ 5.5" cc spray foam
Roof Insulation	11" dense-pack cellulose + 2" ROXUL rigid wool	SIPs w/ 7.5" cc spray foam
Windows	Intus triple pane, uPVC	dual pane, aluminum
Exterior Shades	wood slats	aluminum slats
Interior Shades	-	-
Daylighting Features	triple pane skylight	-
Lighting	Yeti Solar LED pendant	EcoSmart LED flood
Exterior Lighting	-	EcoSmart LED flood
Cooling System	Mitsubishi air to air HP	Daikin air to water HP
Heating System	Mitsubishi air to air HP	Daikin air to water HP
H&AC Distribution System	ductless, wall mounted	radiant ceiling and floor
Ventilation System	Lunos e^2 HRVs	-
Domestic Hot Water System	Stiebel-Eltron Tempra Plus on-demand tankless	AO Smith ProMax
Ceiling Fans	Big Ass Fans	Casa Coronado
Appliances	Frigidaire	Thermador, LG, Samsung
Fume Hood	GE undercabinet range hood	-
Home Area Network	eMonitor 24R	-
Solar-Electric System	SoloPower 6 kW thin film amorphous	Prism Solar 6.9 kW bifacial panels
Solar-Thermal System	-	-
Energy Simulation Tools	RHVAC	-
Other	Passivhaus approach	Jesco DL-FLEX-UP LED rope mood lighting

Solar Decathlon 2013 - Technology Evaluation Summary	Missouri Univ. of Science & Technology	Team Austria: Vienna University of Technology
Team #	107	109
Home Name	Chameleon House	LISI
Competition Placement	16th	1st
Contest Awards	-	1st in Comm, 2nd in Market
Construction Cost	$280K	$325K
Envelope Construction	Energy Panel Systems SIPs	3-ply wood panels over interlocked sheathing
Wall Insulation	6" Energy Panel Systems SIPs	9.4" Isocell blown-in cellulose
Roof Insulation	10" Energy Panel Systems SIPs	11.8" Isocell blown-in cellulose
Windows	dual pane, vinyl	Josko triple pane, wood
Exterior Shades	overhangs	adjustable curtains & shades
Interior Shades	automated shades	-
Daylighting Features	clearstories & transoms	-
Lighting	fluorescent track lighting + LED	Parlat LED recessed slot
Exterior Lighting	LED	Parlat LED garden
Cooling System	Unico air to water HP	CLEEN air to water HP
Heating System	Unico air to water HP	CLEEN air to water HP
H&AC Distribution System	Unico small duct high velocity cooling and radiant floor	ClimaLevel radiant floor
Ventilation System	ERV	Hoval ERV
Domestic Hot Water System	backup tank	CLEEN Patenta HP
Ceiling Fans	-	-
Appliances	Frigidaire, Kenmore, LG	Elektra
Fume Hood	Frigidaire range hood	Elektra downdraft variable
Home Area Network	-	-
Solar-Electric System	TenKsolar 8.6 kW	KPV 8.6 kW
Solar-Thermal System	flat plate	-
Energy Simulation Tools	Ecotect, EnergyPlus	TRNSYS, GEBA
Other	solarium	grey water collection

Solar Decathlon 2013 - Technology Evaluation Summary

	Middleburry College	University of Southern California
Team #	110	111
Home Name	InSite	fluxHome
Competition Placement	8th	10th
Contest Awards	-	1st in Appliances
Construction Cost	$263K	$336K
Envelope Construction	wood panel siding over engineered sheathing	standing seam rainscreen over engineered sheathing
Wall Insulation	10" Cel-Pak blown-in cellulose + demin	5.5" Ownens Corning loose fill
Roof Insulation	12" Cel-Pak blown-in cellulose + demin	10" batt
Windows	Intus triple pane, uPVC	dual pane, aluminum
Exterior Shades	solar canopy	overhangs
Interior Shades	-	fabric shades
Daylighting Features	clearstories	motorized skylights & tubulars
Lighting	Hagen LED pendant	CA Accent Lighting LED
Exterior Lighting	RAB LED sconce	CA Accent Lighting LED
Cooling System	Daikin air to air HP	Daikin air to water HP
Heating System	Daikin air to air HP	Daikin air to water HP
H&AC Distribution System	ducted	ducted
Ventilation System	UltimateAire ERV	exhaust only
Domestic Hot Water System	EcoSmart on-demand tankless	Ronco backup
Ceiling Fans	-	-
Appliances	Frigidaire	Bosch
Fume Hood	Whirlpool range hood	Bosch downdraft variable
Home Area Network	-	Crestron
Solar-Electric System	Lumon 6.2 kW	Bosch 8.6 kW
Solar-Thermal System	-	Bosch flat plate
Energy Simulation Tools	EnergyPlus	HEED, Ecotect, Vasari
Other	centralized mechanical ventilation chimney	motorized ventilation chimney/skylights, translucent glazing

Solar Decathlon 2013 - Technology Evaluation Summary	Univ. of North Carolina at Charlotte	Univ. of Louisville, Ball State Univ. and Univ. of Kentucky
Team #	112	113
Home Name	UrbanEden	Phoenix House
Competition Placement	13th	15th
Contest Awards	-	1st in Affordability
Construction Cost	$350K	$248K
Envelope Construction	precast geopolymer concrete	SIPs w/ Fiber Cement board/ Floor joists w/ 3" CC Spray Foam
Wall Insulation	6" XPS foam	Thermacore SIPs w/ 6" cc spray foam
Roof Insulation	11" XPS foam	R-Control SIPs w/ 8" cc spray foam
Windows	Schuco triple pane, wood	dual pane, aluminum
Exterior Shades	overhang & solar canopy	overhang
Interior Shades	-	fabric shades
Daylighting Features	clearstories	clearstories
Lighting	LED Recessed	LED Acculite
Exterior Lighting	LED	LED
Cooling System	Trane air to water HP	Daikin air to air HP
Heating System	Trane air to water HP	Daikin air to air HP
H&AC Distribution System	BEKA capillary tube radiant ceiling	ducted, underfloor
Ventilation System	Trane ERV	Ultimate Air ERV
Domestic Hot Water System	Vaughn Air hybrid HP	GE Geospring hybrid HP
Ceiling Fans	-	-
Appliances	Fridgidaire	GE
Fume Hood	Fridgidaire exhaust hood	GE downdraft
Home Area Network	-	Wiser Sneider
Solar-Electric System	Bosch 9.2 kW	PREEM 7.6 kW frameless
Solar-Thermal System	-	-
Energy Simulation Tools	BEopt (E+), Ecotect, Vasari	BEopt (E+), eQUEST
Other		gray water system

Solar Decathlon 2013 - Technology Evaluation Summary	Univ. of Nevada Las Vegas	Team Capitol DC: Catholic Univ. of America, GW Univ. and American Univ.
Team #	114	115
Home Name	DesertSol	HARVEST HOME
Competition Placement	2nd	7th
Contest Awards	1st in Market, 2nd in Comm	2nd in Comfort & Appliances
Construction Cost	$298K	$291K
Envelope Construction	reclaimed wood siding over glass-strengthened wood	reclaimed wood rainscreen over SIPs
Wall Insulation	1" cc spray foam + 4.5" oc spray foam	ACME SIPs w/ 4.5" EPS
Roof Insulation	1" cc spray foam + 11" oc spray foam	ACME SIPs w/ 8.25" EPS
Windows	dual pane, aluminum	dual pane, aluminum
Exterior Shades	overhangs	Dynalloy custom autoshade
Interior Shades	-	-
Daylighting Features	clearstories	-
Lighting	Recessed LED	LED Downlight spots
Exterior Lighting	LED	LED
Cooling System	Mitsubishi air to air HP	York air to air HP
Heating System	Mitsubishi air to air HP	York HP w/ fancoil reheat
H&AC Distribution System	ductless, wall mounted and radiant floor	ducted
Ventilation System	Panasonic ERV	-
Domestic Hot Water System	Bosch backup	Sunmaxx Solar backup
Ceiling Fans	Big Ass Fans	-
Appliances	Bosch Induction	Fridgidaire
Fume Hood	Bosch exhaust hood	Frigidaire exaust hood
Home Area Network	Ipad	Schneider Electric
Solar-Electric System	SunPower 6.8 kW w/ micro inverters	Yingli 7.8 kW w/ Enphase micro inverters
Solar-Thermal System	Solarus evacuated tubes	flat panel
Energy Simulation Tools	BEopt (E+), Ecotect	EPlus, Ecotect, Trace, Vasari
Other	rainwater collection, recycled crates flooring	recycled materials, rainwater collection, hang drying

Solar Decathlon 2013 - Technology Evaluation Summary	Team Alberta: Univ. of Calgary	Arizona State Univ. and Univ. of New Mexico
Team #	116	117
Home Name	Borealis	SHADE
Competition Placement	9th	17th
Contest Awards	-	-
Construction Cost	$270K	$295K
Envelope Construction	fiber cement panels over staggered studs	fiber cement cladding over staggered studs
Wall Insulation	7" Demilec Heatlok Soy cc spray foam	7" Demilec Heatlok Soy cc spray foam
Roof Insulation	7" Demilec Heatlok Soy cc spray foam	8" Demilec Heatlok Soy cc spray foam
Windows	Innotech triple pane, uPVC	dual pane, aluminum
Exterior Shades	-	overhang &solar canopy
Interior Shades	mini-blinds	-
Daylighting Features	skylights	solar canopy
Lighting	LED MR-16	LED MR-16
Exterior Lighting	LED	LED
Cooling System	Carrier air to air HP	Chillking water chiller
Heating System	Carrier air to air HP	HP water heater
H&AC Distribution System	Unico small duct high velocity	BEKA capillary tube radiant ceiling
Ventilation System	Kubix HRV	RenewAire ERV w/ fancoil
Domestic Hot Water System	Steibel Eltron backup	Airgenerate Airtap hybrid HP w/ recirc.
Ceiling Fans	-	-
Appliances	Whirlpool, Blomberg	Fisher & Paykel
Fume Hood	Maytag range hood	IKEA range hood
Home Area Network		
Solar-Electric System	CanadianSolar 10 kW	SolarWorld 8.82 kW
Solar-Thermal System	Velux evacuated tubes	-
Energy Simulation Tools	HOT2000, eQUEST, TRNSYS	eQUEST, Homer, TRNSYS
Other	water/aiir purification system	TES ice tank, PCM in floor and TES tank, interior humidity and exterior heat mgmt coatings

Solar Decathlon 2013 - Technology Evaluation Summary

	Santa Clara Univ.	West Virginia Univ.
Team #	118	119
Home Name	Radiant House	PEAK
Competition Placement	11th	19th
Contest Awards	1st in Comfort	-
Construction Cost	$340K	$290K
Envelope Construction	light gauge metal siding over staggered studs	log siding over SIPs
Wall Insulation	4" Rhino Linings cc spray foam	R-Control SIPs w/ 6.5" EPS
Roof Insulation	6.5" Rhino Linings cc spray foam	R-Control SIPs w/ 10" EPS
Windows	dual pane, aluminum	dual pane, aluminum
Exterior Shades	overhangs & fabric shades	-
Interior Shades	fabric shades	-
Daylighting Features	clearstories	-
Lighting	EST LED recessed	LED
Exterior Lighting	Hampton Bay LED	LED
Cooling System	Daikin air to water HP	Mitzubishi air to air HP
Heating System	Daikin air to water HP	Mitzubishi air to air HP
H&AC Distribution System	Messana radiant ceiling panels	ductless, wall mounted
Ventilation System	Air Magic HRV, UFAD	passive ventilation chiimney
Domestic Hot Water System	Daikin Altherma wrapped in PCM	A.O. Smith backup
Ceiling Fans	exterior	Hampton Bay
Appliances	Bosch	GE
Fume Hood	Bosch downdraft variable	Dacor range hood variable
Home Area Network	Arduino	
Solar-Electric System	Bosch 7.1 kW	SolarWorld 8.5 kW w/ micro inverters
Solar-Thermal System	Free Hot Water flat plate	Apricus evacuated tubes
Energy Simulation Tools	HAP	EnergyPlus
Other	weather station	green roof, solar carport, peak haus health monitoring

Solar Decathlon 2013 - Technology Evaluation Summary	Team Ontario: Queen's Univ., Carleton Univ. and Algonquin College
Team #	120
Home Name	ECHO
Competition Placement	6th
Contest Awards	1st in Eng, 2nd in Afford
Construction Cost	$260K
Envelope Construction	rainscreen over vacuum insulated panels
Wall Insulation	Panasonic VIPs ~ R-30/inch
Roof Insulation	Panasonic VIPs ~ R-30/inch
Windows	Jeld-Wen triple pane, vinyl
Exterior Shades	solar canopy
Interior Shades	fabric shades
Daylighting Features	-
Lighting	recessed LED
Exterior Lighting	-
Cooling System	Envision water to water HP
Heating System	Envision water to water HP
H&AC Distribution System	ducted
Ventilation System	Venmar ERV
Domestic Hot Water System	integrated w/ HW
Ceiling Fans	Big Ass Fans
Appliances	Fisher & Paykel, LG
Fume Hood	GE range hood variable
Home Area Network	Crestron
Solar-Electric System	Eclipsall 7.8 kW w/ micro inverters
Solar-Thermal System	-
Energy Simulation Tools	EnergyPlus, TRNSYS
Other	