Solar Decathlon Market Study – USC FluxHome

ET13SCE7170 Report

Prepared by

Emerging Products
Customer Programs & Services
Southern California Edison

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Acknowledgments

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Disclaimer

EXECUTIVE SUMMARY

The Solar Decathlon is an international competition sponsored by the U.S. Department of Energy 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 participating in the competition from the University of Southern California (USC). 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 USC Solar Decathlon 2013 house, called fluxHome™, is an innovative and affordable model for sustainable living that incorporates off-the-shelf elements with digital fabrication technology. Rather than focus on one particular technology or system, fluxHome aimed to seamlessly merge passive and active design strategies into a coherent whole. 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

DG	distributed generation
DHW	domestic hot water
DOE	Department of Energy
DR	demand response
DSM	demand-side management
ECM	energy conservation measure
EE	energy efficiency
F	Fahrenheit
HAN	home area network
HVAC	heating, ventilating, and air conditioning
NEM	net energy metering
NREL	National Renewable Energy Laboratory
SCE	Southern California Edison
SD	Schematic Design
SEER	seasonal energy efficiency ratio
SOA	School of Architecture
USC	University of Southern California
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 FLUXHOME

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 competing collegiate teams 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]

The University of Southern California (USC) was one of the 19 international teams participating in the 2013 Solar Decathlon. The competition prototype produced by the USC team, fluxHome™, featured a mix of novel and existing technologies that have been employed in other energy-efficient buildings. As discussed in further in the Background section, fluxHome was conceived as a new model for sustainable dwelling and an alternative to the suburban tract house. Further, it was branded with a unique and distinctive identity that expresses the vibrant Southern California social, cultural, and environmental landscape.

In support of this challenge, Southern California Edison (SCE) provided the USC 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 the fluxHome can be found in the Appendix. Shown in Figure 1, fluxHome employed off-the-shelf technology that has been on the market for the past several years. What made fluxHome an innovative prototype was its integration of the various systems to demonstrate possibilities for sustainable dwelling in Southern California. In conceiving the home, the design team followed basic, yet enduring, principles of the integration, including maintaining a compact footprint, ensuring adaptability for different users and lifestyle scenarios, using renewable and recycled materials, and keeping it simple.

fluxHome provided an alternative to traditional buildings, which feature independent systems for hot water and heating, ventilation, and air conditioning (HVAC) that typically operate simultaneously and sometimes in conflict with each other. Lacking communication capabilities, the individual systems miss opportunities for more resilient and efficient operation. In contrast, fluxHome was installed with an air-to-water inverter-driven heat pump system that combined domestic hot water and HVAC into a single outdoor unit (thereby saving space in the mechanical room) to enable energy savings. To further boost the built-in efficiencies, a packaged solar thermal hot water heater was installed to supplement the heating load.

FIGURE 1. FLUXHOME AT THE 2013 SOLAR DECATHLON IN IRVINE, CALIFORNIA

Throughout the course of design, which began in 2011, the design team sought to understand how passive systems could be implemented into the project. As the design progressed, an energy model for a 10-day test period was developed. Since the majority of energy modeling software is developed for

annual analysis over a typical meteorological year, this project used spreadsheets from Trane Trace to manipulate daily exports.

fluxHome's innovative heat pump package provided heating, cooling, and domestic water heating in one product. Energy-saving features of this system included the following:

- A high-efficiency fan coil for the heat pump package that used an electronically commutated motor (ECM) to vary fan speed for efficient part-load operation during the temperate months of the Southern California climate
- A low-friction scroll compressor for the air-to-water heat pump and circulation of chilled and heating hot water, rather than distributed refrigerant, to the fan-coil
- Efficient components and reduced refrigerant (relative to an indoor/outdoor split system) that maximize energy efficiency and minimize the potential for ozone depletion and global warming

The system further enhances overall efficiency by supplementing the domestic water heating with solar thermal energy using roof-mounted solar collectors.

The Solar Decathlon organizers closely monitored 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. 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.

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]

After the competition, Team USC produced a post-competition assessment that was included in the competition submittal. 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 fluxHome's energy performance.

RESULTS AND DISCUSSION

Team USC compared the estimated building energy performance against the actual performance (Figure 2). The graph demonstrates the three conditions modeled:

- Extreme (extremely hot) case
- Average case
- Temperate (mildest temperature) case

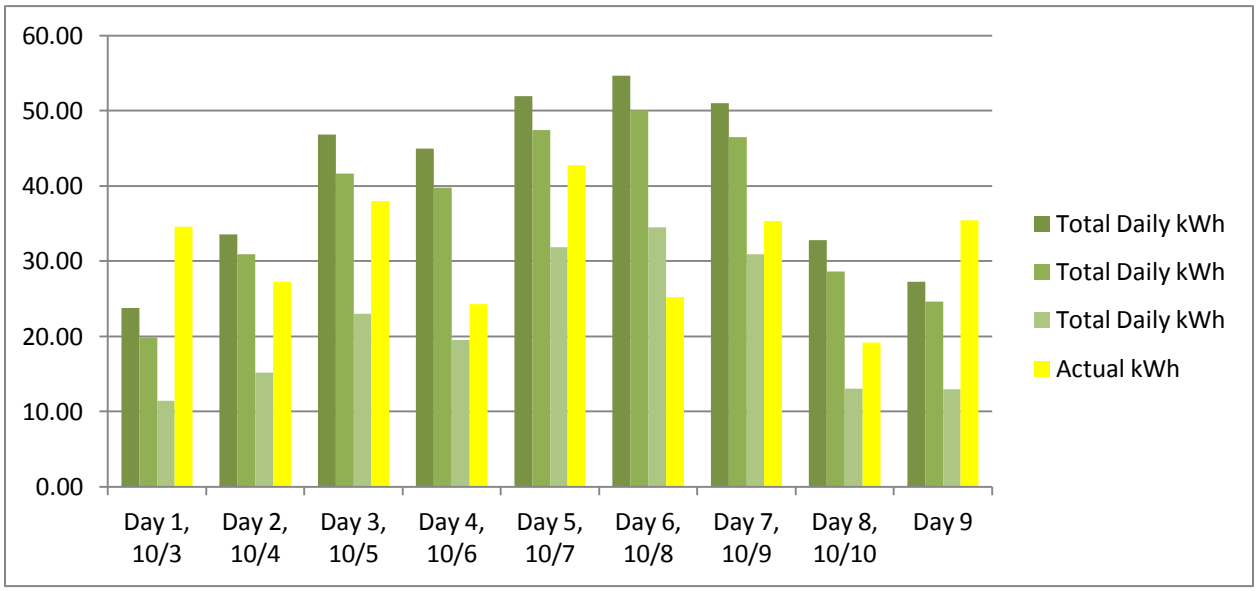


FIGURE 2. PROJECTED VERSUS ACTUAL FLUXHOME DAILY ENERGY USE DURING COMPETITION

As shown, the home's actual energy consumption was lower than the extreme case and average case, despite experiencing extreme temperatures during the competition. Figure 2 does not include public visitation hours. While this is a favorable overall result, it should be noted that the team did need to develop a strategy during the competition to conserve energy. Specifically, during temperate outdoor periods, the team manually turned off the HVAC unit. Because this was a manual effort, the home drifted outside the prescribed comfort zones of 71–75°F during some periods. The team also experienced a learning curve as they began to understand the specific heat transfer characteristics of the home, which included the following:

- Length of time to cool the home during HVAC start-up
- Impact of radiant surfaces during natural ventilation mode
- Temperature decay/drift during night-time condition with HVAC OFF

SCE's Emerging Technologies group conducted a series of blower door tests to assess amount of air infiltration occurring. Testing took place during the design phase, as well as on-site before the competition phase.

CONCLUSIONS AND RECOMMENDATIONS

Some conclusions and recommendations for future Team USC Solar Decathlon projects follow:

- Increase and expand the project to include faculty and students from the various programs within the School of Architecture (SOA), including Architecture, Building Science, and Landscape Architecture. This includes integrating the competition work into the curriculum of each program.
- Develop a new net-zero design seminar at USC that complements the Schematic Design (SD) lab design research studio. The new seminar should be open to undergraduate and graduate students, as well as members from the various SOA program and address the conceptual and technical issues of net-zero design in a way the leads to interdisciplinary collaboration.
- Explore research opportunities for occupational behavior in net-zero buildings in collaboration with other building science research institutions and entities.
- Initiate construction of the prototype earlier in the schedule to ensure at least one (or preferably two) semesters for operating the house and testing the systems. Earlier construction is a key factor for assessing the home's performance and "tuning" the home's systems. Monitoring and field-testing the equipment should be a mandatory part of the program and studio/seminar curriculum. Purchasing the sensors that DOE uses to measure the house's performance is probably the single most important factor in improving the performance of the house and the potential success of the project.
- In conjunction with early prototyping and testing, furnish the home with additional measuring devices for monitoring temperature and energy consumption. The competition revealed the importance of sub-metering individual appliances to identify the best load-shedding activities. These devices would help in commissioning and tuning the building and would also present students with opportunities for individual research and thesis studies.
- During the two-week contest, a number of lessons learned emerged regarding optimizing the systems and operating the building to achieve both short- and long-term net-zero goals. Optimization strategies uncovered included the ability for automated control during unoccupied modes. Ideally, this would allow for remote opening and closing of high/low windows via actuators. However, at minimum it should be possible to turn on/off HVAC and adjust temperatures remotely.
- In the context of net-zero design, larger PV arrays allow for greater flexibility in practice and in competition. It was observed that all 19 teams in the competition finished above the energy target and were considered net-energy producers at the end of the test period. It was clear that in some cases, teams had to implement extreme load shedding in order to achieve this target. This result may be analogous to the market and its willingness to adopt net-zero buildings.

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.

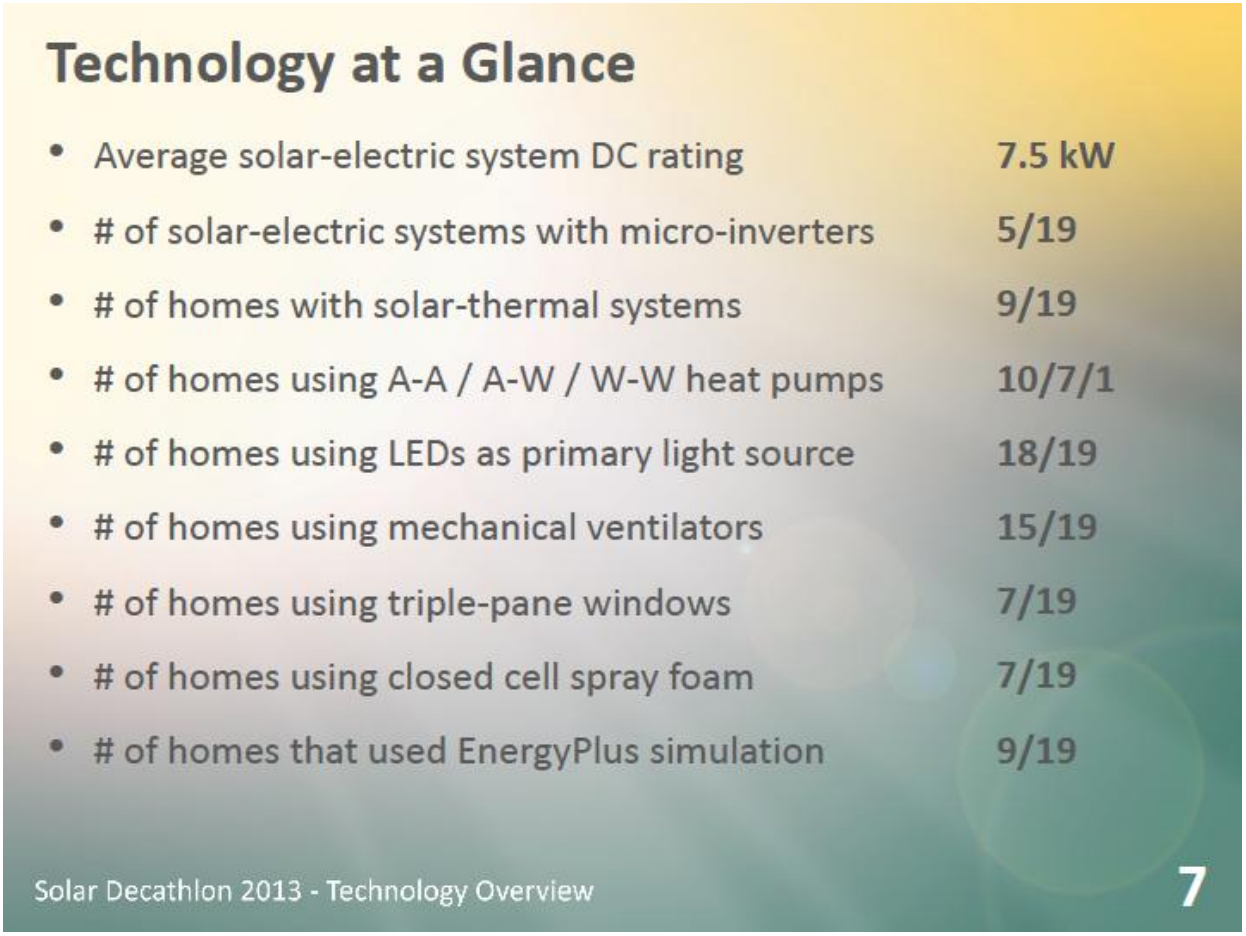
REFERENCES

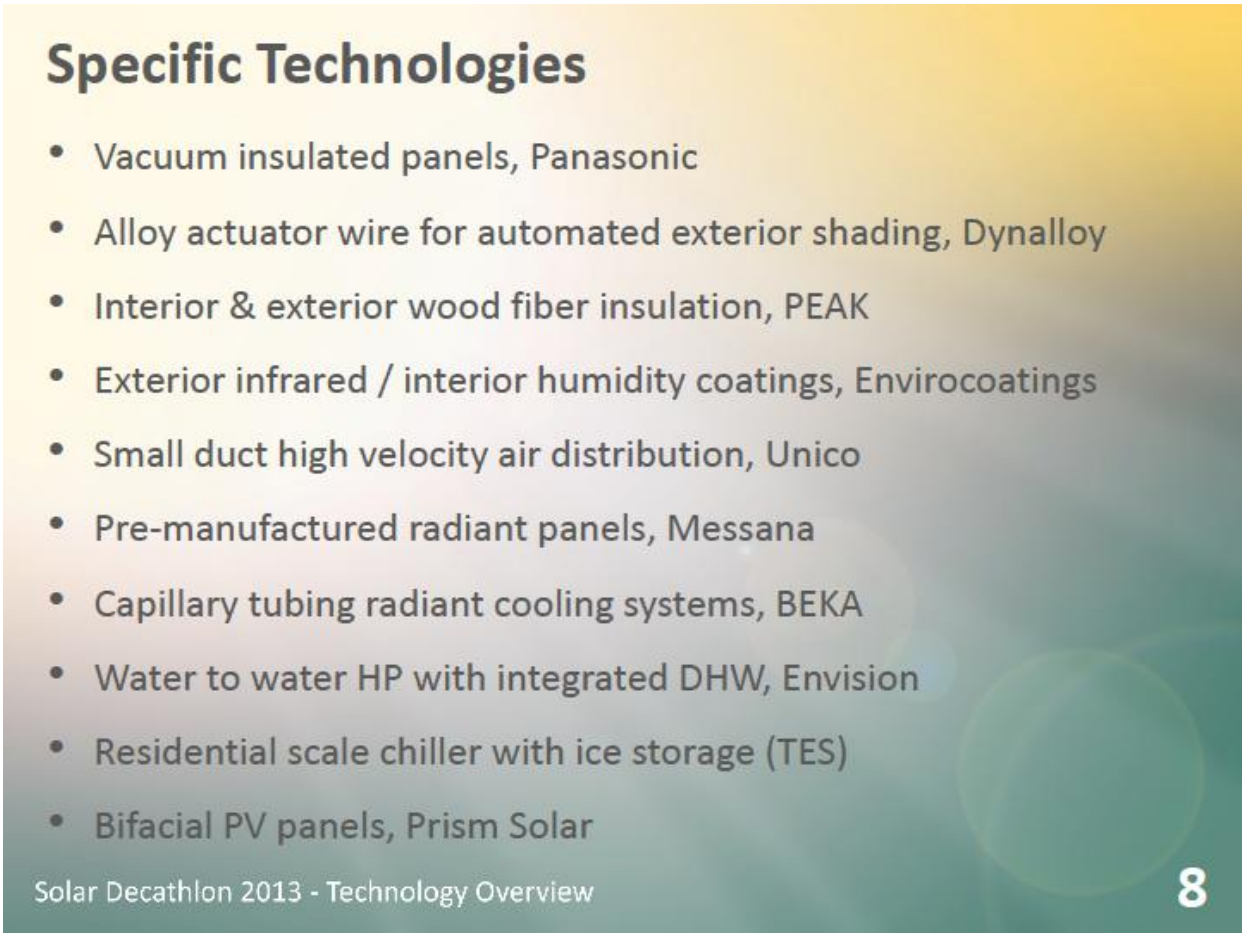
[i] U.S. Department of Energy (2014), Solar Decathlon, http://www.solardecathlon.gov/

[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 (COULD NOT USE COMMENT: MENTION THAT THIS IS FOR ALL THE HOMES IN THE COMPETION)




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
Solar Decathlon 2013 - Technology Overview
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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 e² 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	