Architecture at Zero: Lessons from a Zero Net Energy Design Competition

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ABSTRACT

In 2008, the California Public Utilities Commission adopted the *California Long-Term Energy Efficiency Strategic Plan* presenting a future vision for California including "Big Bold" zero net energy (ZNE) performance goals. Efforts from a diverse group of stakeholders including other public agencies and utilities are underway to address the technical, market-based, educational, industry and process challenges currently inherent in ZNE projects.

This paper outlines one such effort, the 2011 Architecture at Zero design competition co-sponsored by the Pacific Gas and Electric (PG&E) Zero Net Energy Pilot Program and the San Francisco Chapter of the American Institute of Architects (AIA SF) that sought to raise awareness of zero net energy buildings and building practices, as well as to challenge designers to showcase their own deep efficiency solutions. The Architecture at Zero competition invited architects, engineers and affiliated professions as well as students to submit a hypothetical ZNE design for a real-world mixed-use urban infill site in Emeryville, California.

Developed by a dedicated team from PG&E's ZNE Pilot Program, PG&E's Pacific Energy Center and AIA SF, the competition was also championed by the host city and site owner, and juried by a panel of experts. This paper written by the competition development team will share the goals, process and results of this unique collaboration as well as highlighting lessons learned. We will share insights into the outcomes of Architecture at Zero 2011 and outline the subsequent changes and refinements that were made for the next iteration of the competition.

Setting the Context for Zero Net Energy Program Activities in California

The California Long Term Energy Efficiency Strategic Plan [1] (referred to here as the Strategic Plan) was set forth by the California Public Utilities Commission (CPUC) in September of 2008 and includes four "Big Bold Energy Efficiency Strategies" for California's future. Two of these strategic goals are that all new residential construction in California be ZNE by 2020 and that all new commercial construction be ZNE by 2030. The Strategic Plan recognizes that building codes are the single most effective tool to create market penetration of energy efficiency technologies and practices in California and is thus interested in the long term alignment between California building codes and Assembly Bill 32 (AB32), California's landmark greenhouse gas

[1] *California Long Term Energy Efficiency Strategic Plan: Achieving Maximum Energy Savings in California for 2009 and Beyond* is available at:
http://www.cpuc.ca.gov/NR/rdonlyres/D4321448-208C-48F9-9F62-1BBB14A8D717/0/EEStrategicPlan.pdf

emissions legislation.[2] As codes progress forward toward a zero net energy target, interim reach codes and voluntary tiers of action will be identified.[3]

The Strategic Plan is supported by various stakeholders including the Governor's Office, the California Energy Commission, the California Air Resource Board, state utilities and local governments[4]. The Pacific Gas and Electric Zero Net Energy Pilot Program[5] is in direct response to the Strategic Plan goals.

Pacific Gas and Electric Company's Zero Net Energy Pilot Program

The PG&E Zero Net Energy Pilot Program[6] initiates research, development, and demonstration (RD&D) projects, public outreach, and educational efforts promoting ZNE building practices through three main areas of activity: 1) design and technical assistance to selected grid-tied residential, commercial, and community-scale new construction projects; 2) technical assessments and research including a barriers-and-opportunities study for ZNE in California and a study on the technical potential for ZNE in commercial and residential new construction in California; and 3) outreach and education including workshops, stakeholder forums, best practice guidelines and the Architecture at Zero annual design competition (beginning in 2011).

Architecture at Zero 2011 was the result of collaboration between PG&E staff from the PG&E ZNE Pilot Program and the PG&E Pacific Energy Center, staff from the American Institute of Architects San Francisco Chapter, and Resource Refocus LLC, a consultant to the PG&E Zero Net Energy Pilot Program. The competition focused on a community-scale project on an urban infill site and was designed to address a type and scale of project that does not always fit into standard utility energy efficiency programs.

Why a Zero Net Energy Competition? The Importance of Site and Scale

The goal of the Architecture at Zero annual design competition is to create a visible showcase event highlighting zero net energy building practices for both the design community and the general public. The competition is intended to allow designers to explore their ideas related to the new paradigm of ultra-high performance building and operations that "zero net

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[2] Assembly Bill 32, the "Global Warming Solutions Act" (2006) stipulates that by the year 2020 statewide greenhouse gas (ghg) emissions must be reduced to 1990 ghg levels. More information on AB32 can be found at: http://www.arb.ca.gov/cc/ab32/ab32.htm

[3] Strategic Plan, page 9.

[4] California Long Term Energy Efficiency Strategic Plan Executive Summary, available at: http://www.cpuc.ca.gov/NR/rdonlyres/70EC7B35-48DD-4FA3-9DD6-BC231BD458E9/0/EESP_ExecutiveSummary.pdf

[5] The PG&E ZNE Pilot Program is a direct response to the CPUC ruling that "the utilities jointly and individually should design and implement several ZNE building pilot projects during the 2009-2011 period in order to advance rapidly towards the ZNE commercial and residential building programmatic initiatives adopted by the CPUC in Interim Opinion On Issues Relating To Future Savings Goals And Program Planning for 2009-2011 Energy Efficiency And Beyond, Decision, D.07-10-032, October 18, 2007, page 38 and by the California Energy Commission (CEC) in its 2007 Integrated Energy Policy Report (IEPR)."

[6] The authors would like to acknowledge Roland Risser, Bill Miller, and Nick Rajkovich for their work in the initial development of the PG&E ZNE Pilot Program prior to its approval in 2010.

energy" represents, and ideally, to spark a broader conversation about the future of the design/build process and standard industry practices in California.

The competition is based on a basic "site definition" of zero net energy[5], that the site (as defined by the project boundary) be able to generate an amount of grid-tied renewable energy that is equal to (or more than) the amount of energy that the building consumes over the period of a calendar year. To achieve this level of performance, a balancing act is required; a zero net energy design has to begin with deep efficiency resulting in significant load reduction to come to a point where on-site energy generation is a feasible means of matching the consumption demand. In California, it is a rule of thumb that building loads should be at least 50% or more below standard baselines as defined by the *2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings* also known as "Title 24".[7] This balancing act is also crucial to achieving a meaningful zero net energy result. For example, it might be possible in some cases to get a conventionally built building to "net zero" through large amounts of solar photovoltaics (PV), but this is not generally considered to be the least-cost solution, and indeed can be prohibitively expensive. Nor is it even possible in all cases for a conventionally built building to reach ZNE through the addition of rooftop solar. Depending on factors such as roof space, building size and type, solar access and density/intensities of use, an individual conventionally built building may be exceedingly difficult or perhaps impossible to get to zero net energy. And yet, these are the common site conditions and program challenges that await all would-be zero net energy buildings and especially those in a dense urban environment. As site conditions or other challenges mount, reducing loads as far as possible before the addition of renewables becomes a more and more critical prerequisite to achieving ZNE.

For all the factors listed above, the complicated task of achieving zero net energy as an end goal necessitates a closely integrated design process that must begin early in the life of a project to succeed. A zero net energy building (i.e., a very low energy usage building capable of becoming zero net energy with the inclusion of on-site generation) requires an inter-disciplinary design team working in concert with the project owner. This team must integrate the siting and building enclosure to reduce loads and to correctly size heating and cooling equipment from the earliest phases of design. This level of interdisciplinary coordination and cooperation between architects, engineers, site owners, design specialists and other project stakeholders remains somewhat new and unusual. A standard building process is more likely to occur as a series of discrete and sequential tasks that continuously change hands without a higher level of synthetic coordination. As such, a major goal of the competition was to highlight the necessity of integrated design and to encourage teams to demonstrate that a balance between low building loads and on-site generation had been achieved through careful decisions early in the design process.

A competition was chosen by the PG&E ZNE Pilot Program as a program activity specifically because competitions are generally thought to provide certain characteristics that are beneficial to emerging technologies and practice.[8] For example, as high visibility events that often attract press, competitions are ideally suited to spark public discourse and highlight an

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[5] "Zero Energy Buildings: A Critical Look at the Definition", P. Torcellini, S. Pless, and M. Deru National Renewable Energy Laboratory and D. Crawley U.S. Department of Energy, NREL/CP-550-39833 June 2006

[7] California Energy Commission, 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, Publication Number CEC-400-2008-001-CMF.

[8] See "Advantages of the Competition Method" in *The Handbook of Architectural Competitions*, American Institute of Architects, 2010 Revised Edition, page 8.

issue within design that may need greater attention and innovation. A well-juried competition can provide entrants an audience with known and respected design professionals and provide broader public exposure to their work. Competitions can also provide an outlet to explore creative and ambitious ideas and gain expertise in new building types away from typical constraints, and they can similarly encourage students to think about emerging practices in the field while they are learning.

The Site

The site that was chosen for Architecture at Zero 2011 is an industrial urban infill site in Emeryville, California. Emeryville is a small city just over one square mile in size on the edge of the San Francisco Bay and tucked in between its larger neighbors, Oakland to the east and south, and Berkeley to the north. Much of the interior and bay edge of the city was strongly industrial between the early 1900s (Emeryville's bayside location attracted industry from San Francisco following the 1906 earthquake) through to the 1960s[9]. The City has re-invented itself since the 1980s through ambitious redevelopment projects and by attracting large amounts of regionally serving retail along with high-tech and science industries. The City has also transformed numerous old industrial sites into Emeryville's now trademark modern-industrial style lofts and condos.[10] The city retains an industrial feel where modern glass and steel buildings mix comfortably with older brick ones.

The Architecture at Zero 2011 site was a former Sherwin-Williams paint factory property that was in the completion stages of remediation for the duration of the competition. The site is mostly vacant with a factory office building on the edge of the site being retained for architectural and historic interest. The competition team felt that this was an ideal site because it represented a substantial real-world design challenge on a rare eight acre urban infill site that would allow for a community-scale design challenge. To make the challenge as real as possible, the competition team worked in coordination with the City of Emeryville to select a design program and criteria that was in alignment with the City's General and Specific Plans for the area[11].

While the competition positioned itself as an "open ideas" competition that would not necessarily result in an actual built project, closely aligning the competition design program with the City's vision for the site ensured that the City remained keenly interested in the competition and that the competition process would provide real benefit to them. The competition team also worked with a project champion from the Sherwin-Williams Company who generously donated the time to provide feedback and assistance in gathering site information[12]. In terms of site selection, it was critical to the competition development team to have the interest and support of the site owner and stakeholders. To develop a competition like Architecture at Zero, a strong

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[9] City of Emeryville website official history pages "Emeryville is Born, 1890s to 1930s", "Emeryville comes of Age, 1930s to 1960s", and "The Expanding City, 1960s to 1980s" http://www.ci.emeryville.ca.us. Accessed 4/29/2012

[10] City of Emeryville website official history pages "The Expanding City 1960s to 1980s" and "Emeryville Today 1990s to 2000s" http://www.ci.emeryville.ca.us. Accessed 4/29/2012

[11] The City of Emeryville General Plan (2009) and the Park Avenue District Plan (2006) can be accessed from the City of Emeryville website, http://ca-emeryville.civicplus.com

[12] The Competition team would like to acknowledge Charles Bryant, Director of Planning and Building at the City of Emeryville and Larry R. Mencin, Senior Environmental Project Manager at the Sherwin-Williams Company for their responsiveness and helpfulness in realizing this competition.

relationship and collaboration with the site owner and stakeholders is critical, and finding project champions was a key consideration for the site selection processes for both Architecture at Zero 2011 and Architecture at Zero 2012.

The site is located in the historic core of the city, near the town center. Emeryville is bifurcated by a railway, and the western edge of the site abuts the railroad tracks. The site is otherwise surrounded by low one-and-two-story buildings and has good solar access.

Figure 1

The former Sherwin-Williams factory site in Emeryville, CA, circa the 1930s. Photo is courtesy of the Sherwin-Williams Company

Program and Technical Requirements for the 2011 Competition

The design challenge included a specific mixed-use program to be accommodated on the site, including 240 residential units at designated square footages, associated laundry, mechanical, community, parking and circulation spaces, 1200 square feet of retail space, and a new public 4,000 square foot branch library. Entrants were provided with the retail and library operating hours.

One of the primary challenges faced in putting together the Architecture at Zero 2011 competition was determining the level and specificity of technical requirements that would be asked of competition entrants. Bearing in mind that the ethos of the Architecture at Zero competition is to be a learning opportunity for those interested in exploring ZNE design as much as a showcase for those who may already know how to do it, the competition coordination team ultimately decided that a successful submittal would have to demonstrate a fundamentally "feasible" ZNE design solution. A feasible design solution would include a demonstrated application of sustainable design principles and a careful integration of renewable generation based on resources available at the site. For the purposes of the competition, "renewables" were considered to be solar power, wind power, micro-hydro, geothermal, and biomass / biofuels; however, it was expected that submissions would primarily incorporate solar and wind generation into their designs. The technical requirements did not specify target energy use intensities for each use type in the program, but instead gave guidance that average building loads as defined by the 2008 *Building Energy Efficiency Standards for California* would need to be reduced by at least 50%.

Submissions were required to include an annotated section highlighting building load reduction strategies and any seasonal variation in how those strategies would work. Entrants were also asked to address the building envelope, water heating, space heating, space cooling, ventilation, lighting (including daylighting), and any process loads, appliances, and plugs loads for each use type.

Each submission was required to include a renewable energy source as part of the project and designate the placement and orientation of renewables on the submitted site plan. Entrants were asked to include a calculation of expected annual electrical demand, expected energy production, and to list assumptions made in that calculation (such as PV panel type, orientation, and solar access). Submitting graphic analysis of the renewable energy generated on the site over one year was suggested, but not required**.** All entrants were asked to provide a detailed site plan, section and perspective drawings of their building designs, and a schematic diagram of proposed on-site generation on their entry boards.

Results from Architecture at Zero 2011

A total of 17 national and international entries were received from both professional and student teams.

Architecture at Zero 2011 Professional Category winners included Chris Parlette of Berkeley, California, and Tom Tang and Yijie Dang of New York, New York. Student Category winners included Jihyoon Yoon of Harvard University, and the student team of Curtis Ryan, Sara Maas, Kyle Blomquist and Megan Gezalus of the University of Wisconsin. The HOK San Francisco office entry received a special mention from the jury.[13]

The Jury

The ZNE competition development team sought a balance of expertise on the jury that would reflect the multidisciplinary nature of the competition program and ensure that quality efforts to achieve the designated energy performance goals, instances of design excellence and instances of exceptional interpretation of the competition program scope would all be recognized and given a footing within the jury review. The jury deliberation was accordingly a lively process during which the jurors debated the relative merits of the submitted projects and tried to find strong design ideas that also carried through to strategic thinking about renewables strategies, building envelope and building systems characteristics, siting and form.

The competition jury was comprised of a mix of well-known architecture, design and engineering experts: Susan Szenasy, Editor-in-chief of Metropolis Magazine; Bob Berekebile, FAIA, Principal, BNIM; Lawrence Scarpa, FAIA, Principal, Brooks + Scarpa Architecture; Allison Williams, FAIA, Design Principal, Perkins + Will; and Stephen Selkowitz, Building

[13] Winning 2011entries are available for viewing on the Architecture at Zero website, www.architectureatzero.com

Technologies Department Head at Lawrence Berkeley National Laboratory. The jury was tasked with assessing the design and technical merits of the projects and distributing the awards for a total of $25,000 in prize money to award winners. The jury was given initial guidelines on judging criteria based on the program and technical requirements from the competition development team including the provision that a design's energy efficiency should be the most heavily weighted factor. The jury review process and award decisions remained solely at their own discretion.

In the end, the jury found that many of the entries excelled in *some* aspects of the competition criteria, but none in their estimation delivered the "total package" in terms of exceptional design concept and exceptional documentation of energy performance in such a way as to merit a grand prize designation. Instead, the jury recognized two winners from each category (student and professional) as well as a separate, special "Jury Recognition" entry.

It is worth noting that the jury found the caliber of work submitted by the student teams to be equally sophisticated as the professional entries. The sense that zero net energy building is an unfamiliar concept to architects and designers was expressed by the jury, who remarked on the gaps in standard architectural practice and training in regards to energy efficiency in general and to the interdisciplinary nature of zero net energy design in particular. *Metropolis* Editor Susan Szenasy devoted one of her monthly columns to her experience as Architecture at Zero 2011 juror, stating "Judging from the entries, students should be welcomed into the discussion. Their solid research, clear documentation, and imaginative designs can inspire the professionals and the public alike. It seemed, on that early December day, that architects have a steep learning curve ahead of them. But then we're all learning, together, to make thinking about and designing ZNE a habit, not a rarity." [14]

The ZNE "Learning Curve": Entries and Project Approaches

The schemes that were deemed most successful by the jury showed creative treatment of the site program as well as a defined, if at times fanciful, set of strategies to reach the net zero energy target. The jurors valued "big ideas", and some entries that went for high concepts over real-world practicality or feasibility were among the jury's favorites because they sparked the most conversation and captured the imagination. For example, one scheme recognized by the jury titled "Battery Park – from zero to positive", used inspiration from biomorphic design principles to design large egg-shaped buildings. Strategies cited by this team in its supporting documentation team included "natural ventilation for summer cooling as influenced by the passive filtration of a sea sponge: a net positive organism".[15] This team also proposed very high-density buildings with communal kitchens in an attempt to reduce site-wide energy usage.

[14] Szenasy, S. (2012, January). Steep Learning Curve: The challenge of designing a net-zero neighborhood raises questions about how architects understand deep sustainability. *Metropolis*, *31*(6), 16.

[15] Entrants were asked to provide a .pdf of supplemental information of their choice to support the feasibility of their ZNE design solutions in addition to the submission boards. This could include a narrative of how the design problem was approached, energy models, calculations or other supporting diagrams.

Figure 2

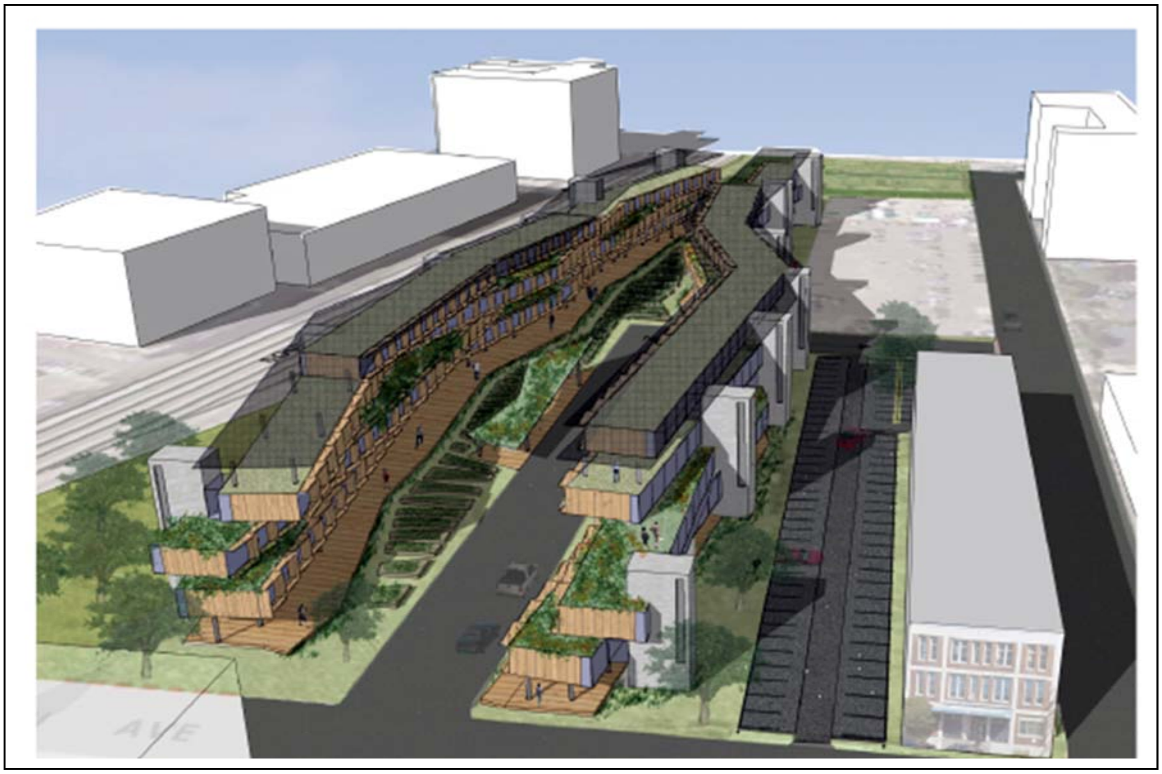
Perspective view from the HOK San Francisco office entry “Battery Park: from zero to positive” that received a “Special Recognition” award from the jury

In addition to the entry boards, teams were asked to submit supplemental information containing documentation of their own choosing that would substantiate their design approaches to the competition problem statement. These supplements are valuable because they provide a window into the strategic thinking on zero net energy design from each individual or team entrant. For example, Professional Category winner Chris Parlette used a practical approach of basing his energy calculations on an existing net zero residential project in the same general metro area as the competition site and created his own modified baseline targets from this sample. The team of one of the winning student entries, “Ripple Effect”, heavily focused their design strategy on utilizing passive siting and daylighting techniques to reduce building loads before applying solar PV. Other entrants cited various primary approaches including the use of the Passive House standards, double façade treatments, and thermal massing with heavy insulation. The overwhelming choice of power as expected was solar photovoltaic panels. Most teams eliminated the usage of natural gas although one team used a “radiant heating and hot water (system)…provided by sewer heat recovery and supplemented by a bio-gasification system that is tied to a ‘living’ blackwater filtration machine housed on-site with the central plant”. Another project used a combined heat and power system fueled by woodchips harvested from a forest planted on the site. Most projects opted for passive cooling systems. Some teams also anticipated the importance of occupant behavior to achieving a true zero net outcome, with one advocating for individual metering and cost layers as a check on occupant energy usage and others suggesting automated controls.

Figure 3

Perspective from "Towards Zero Net Energy", a winning professional entry by Chris Parlette, Berkeley, CA

Figure 4



Birdseye view of winning student entry 'Ripple Effect' by Curtis Ryan, Sara Maas, Kyle Blomquist, and Megan Gelazus, University of Wisconsin at Milwaukee

Some schemes did demonstrate a lack of knowledge of fundamental energy efficiency design principles- including correctly identifying where the sun is coming from- and many more demonstrated unfamiliarity with renewable energy concepts. For example, one scheme relied heavily on wind generation to power a “hybrid geothermal system” when wind generation is not very likely to be a reliable usable factor on the site. Even one of the winning schemes proposed the inclusion of wind turbines on the edge of the site near the railroad, to be powered by passing trains - also not likely to be a viable option for power generation. One team suggested power-generating equipment in the community gym. Finally, it is interesting to note that many teams did not view ZNE design as separable from larger sustainability aims and several projects paid almost equal attention to grey-water reuse and rainfall harvesting systems.[16]

Participant Feedback

After the competition, the coordination team asked for feedback from entrants and from people who had expressed interest in the competition but who did not ultimately enter. One of the major barriers to entering cited by non-entrants was that they did not find out about the competition until close to the competition deadline. However, another major barrier was the “technical calculation part.” As one student noted, “we spent most of our time on finding energy data and learning to calculate energy and loads… at one point we got stuck and couldn’t figure out … how accurate the data needs to be.”[17] Another potential entrant noted that “the complexity of the design problem and the extensive requirements for engineering and documents seemed overwhelming.” Because of these concerns, the competition planning team has markedly increased both the specificity of documentation required and guidance and resources on how to approach the technical components for the Architecture at Zero 2012 competition. The consensus idea behind this approach is that a more prescriptive set of guidelines, coupled with greater step by step information on how to achieve them, could serve to reduce confusion without compromising the intended rigor of the competition.

The feedback from those who did choose to enter was markedly different and quite positive. Suggested changes from entrants primarily focused on process improvements, such as website navigation, the submission process, competition duration, and interest in receiving more feedback on each project from the jury.

The feedback from entrants did include some concerns that there was too much detail requested on energy information that “seemed to be irrelevant to the Jury in the end.” One entrant hoped that more weight would be given in the future to designs that “have a chance of succeeding as a built solution or lead to productive experimentation.” Another entrant was concerned that architecture students would see the results as endorsing that “basic concepts such as passive solar orientation could be ignored or compensate(ed) by bold design statements.”

In response to this general concern, the competition team has eliminated the requirement for supplemental information documents and is instead requiring that all building performance documentation appear on the entry boards. Entrants will also need to use a standardized board template in another effort to provide jurors with as fair a comparison of data as possible. The

[16] Architecture at Zero 2011 project supplemental information was collected in .pdf form from entrants and has been archived by the competition development team.
[17] Quotes are taken from participant feedback gathered by Rebecca Kennedy, Awards Coordinator, AIA San Francisco, from December 2011 to March 2012.

competition development team believes that these changes will simplify the process for jurors and result in greater comparability among entries.

Architecture at Zero 2012

Having gone through the process once, the Architecture at Zero development team has adjusted course slightly and has taken the feedback from jurors and participants to heart by including the aforementioned changes in the 2012 competition. The team is also looking at ways to encourage higher participation levels in 2012, especially among students, and offering a longer submissions period. The team is performing earlier direct outreach to graduate design studios and professional organizations in both the design and efficiency arenas and will also be seeking new ways to engage the public at large through greater use of web-based media.

Architecture at Zero 2012, open to entries from mid-May to October 1^{st}, poses an even bigger and bolder design challenge than the previous year that will require teams to submit a (hypothetical) conceptual energy plan and a detailed building design for a site on the University of California at Merced campus. U.C. Merced is the newest addition to the University of California campuses, and Architecture at Zero 2012 will provide students and professional teams an opportunity to test out their zero net energy design ideas at a much larger scale. The variable and more extreme climate of the Central Valley regions will also provide a different set of occupant comfort level issues to design for. Architecture at Zero 2012 will be juried, and winners announced, in late October of 2012.

Summary

As stated earlier in this paper, California building codes are continuing a steady trajectory towards higher levels of efficiency, spurred by the ambitious statewide ZNE policy goals, and more broadly, statewide greenhouse gas emissions reduction legislation. A lot is being asked of the building sector moving forward, and it is being asked for quickly.

It is arguable that high performance building design is still in its infancy, and zero net energy design - as an even narrower subset of this - is still not well-known or understood among large numbers of architects and design professionals. Perhaps even more foreign to today’s standard practice is ZNE’s imperative of closely integrated design teams and project delivery among the various professional disciplines and project stakeholders. This is a steep learning curve, and it represents a complex new paradigm for the way California buildings will eventually need to be made.

As the Architecture at Zero competition enters its second year, it seems that the intended goals of the competition, to be a catalyst for conversation about zero net energy building, a venue for experimentation, and most importantly, a learning event for designers and the broader public alike, are already being met. Although modest in scope, efforts like Architecture at Zero are crucial stepping stones to a more energy efficient future.

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