Size Matters:
Solar CalPoly and the 2005 Solar Decathlon
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Background
“One [irony] is the growing size of California residences, combined with the fact that very large houses can readily be counted—even showcased—as “efficient and environmental,” while they are destined to consume more energy and resources than more modest houses.”

The size of the average American dwelling has more than doubled in the past fifty years, from 1,000 s.f. in 1950 to 2,200 s.f. in 2000 (coupled with a decrease in household size during the same period, resulting in 286 s.f./person to 847 s.f./person). At the same time, in states like California, the appetite for consumption has steadily increased. In the past twenty years, residential electricity consumption has increased by 50%, at a rate higher than the corresponding population growth.

Ecological luminaries such as architect Ed Mazria have re-analyzed the statistics, revealing that architecture with all of its associated technologies and materials consume nearly 50% of the energy generated in the United States. Architects are thus strategically poised to positively intervene to effect change in our culture’s insupportable, consumptive trajectory. With this resurgent need for ecologically responsive design, a team of Cal Poly students and faculty designed and built a compact, climate responsive, resource efficient solar dwelling in an attempt to demonstrate that one can live contentedly within a modest ecological footprint.

The Challenge: The 2005 Solar Decathlon Competition
The vehicle that prompted this project was the U.S. Department of Energy sponsored 2005 Solar Decathlon competition. Initiated with the first Solar Decathlon in 2002, the competition is designed to challenge teams of university students and faculty from around the world to design a small 500-800 s.f. solar powered residence. Apart from the challenge of designing, raising funds, and building the homes, Decathlete teams must transport and then erect their homes on the National Mall for the weeklong fall competition period. In 2005, eighteen contestant teams represented the United States, Canada, Puerto Rico, and Spain. The “decathlon” consists of ten contests that includes architectural and lighting design; buildability/livability; comfort systems and appliances; communication (documenting and disseminated the team’s design story); and powering an electric vehicle. During competition week, students “operate” the houses, performing typical daily tasks that include ensuring that the house stays thermally comfortable, cooking meals, running computers, washing clothes, simulating showers, and driving an electric car.

The Process: Ideals into Action
It is a long road of planning that eventually leads to competition time on the National Mall. At Cal Poly, the project was initiated in traditional design studios then progressed to independent, interdisciplinary coursework that
included architecture along with architectural, mechanical, and electrical engineering students. At the same time, the project galvanized student interest from a broad range of other disciplines through the student-activated Renewable Energy Club (REC). Fueled by dozens of pizzas, the REC provided the organizational framework for student involvement throughout all of the phases of the project, including fundraising, construction, and competition in Washington, D.C.

As the only team from California, we had the desire to create a project that could not only exemplify the team's ideals but that also reflected our contemporary condition. Following the initial design studios, we held an internal design competition juried by faculty as well as Pritzker prize winning architect Glenn Murcutt (who served on the architecture jury for the 2002 Solar Decathlon). From this, the project crystallized around the idea of a very small, climate responsive, resource efficient dwelling with a minimalist design aesthetic, one that could be hauled across the country to the competition site by a single truck. The team motto evolved into a succinct proclamation: "simple, fundamental, elegant."

The Solution: A Minimalist Idea

"...the issue of consumption, not to mention overconsumption, is curiously absent from the sustainability discourse.....Give Americans sustainable technology, and we'll supersize it beyond recognition."

Simplicity and sufficiency were guiding design principles for the Solar CalPoly project. From the project's inception, the students' design proposals for the house were modestly sized, challenging contemporary residential trends. The resulting design is 530 square feet of conditioned living space, thoughtfully designed and detailed to house two individuals. The team worked to design the house from the inside-out with the same care as designing a sailboat, a functionally elegant vessel with architecturally integrated elements, furnishings and storage, making every detail and space count. Transparency, access to adjoining outdoor spaces, and use of a portion of the roof for an outdoor room expands both the virtual and actual size of the house while keeping its ecological and spatial footprint small.

Transportation across the country and set-up time in Washington, D.C. were major design drivers for the Solar CalPoly team. Because the house had the longest land mass travel distance of any of the 2005 Solar Decathlon entries in order to get to the National Mall and because of our desire to minimize our use of fossil fuel, the team agreed on a “one truck” solution. The result was the design of a simple, straightforward architectural volume which could be pulled by a single lowboy tractor/trailer. The team used pre-fab construction not only to minimize construction logistics on the Mall, but also because Solar CalPoly’s pre-fab prototype could serve as a useful alternative housing example, particularly in the state of California.
Responding to the climate architecturally before relying on mechanical means for thermal comfort was also fundamental to our design process. The Solar CalPoly dwelling was intended to be “switch-rich,” providing opportunities for user control to “sail” the building, adjusting the “trim” in response to climate and user comfort. Fixed, operable and deciduous shading devices are employed to optimize solar gain in the winter and minimize unwanted heat gains in the summer. A Trombe wall is incorporated into the south side of the house to provide thermal storage and dampen out the daily temperature swings. “Switch-rich” strategies not only help users adapt the building to seasonal variations but they also support the potential of this prototype project to adapt to various climates.

With conscientious attention to materiality and detail, the project presented an alternative to our culture’s increasingly large, over-commodified dwelling spaces. In this way, it sought to be a political statement, to remind us that we don’t necessarily need more in order to live well.

Results: More Than A Game
All competitions result in named winners and the 2005 Solar Decathlon is no exception. However, it is appropriate to acknowledge the incredible achievement of each of the eighteen teams that turned their aspirations into concrete reality: a functioning solar home sited for a week at the very steps of the national government. The hope is that the triumph of each team from their respective geographic corner is spreading the message about ecologically responsive and responsible residential design.

But who did win and how did they do it? During competition week, attention amongst team members focused on the tactical use of power to strategically gain points in the competition. Roughly half of the points were awarded subjectively through juries. The rest of the points were numerically weighted, with points assigned for a task completed (successfully heating shower water to 110° F; maintaining an indoor house temperature of 68-72° F, and so on). In 2005, the competition was lively due to the overcast conditions that hung over the Mall during most of the solar-only week (72% less than normal solar radiation). As a result, the homes that performed the best were those that were highly efficient (simple, small volume spaces) as well as those teams who managed their limited energy resources effectively. As expected, the winning teams also performed consistently well across all of the contests.

It is revealing that three of the top four finishers had significantly sized photovoltaic (PV) systems: first place Colorado at 7.1kW, second place Cornell at 6.2kW, fourth place Virginia Tech at 7.2kW (third place Cal Poly had a 4.9kW system, among a handful of smallest systems).

The PV system sizes begin to reveal a deeper issue relating to consumption, both for the competition and for the larger societal message indicative of these designs. In both the 2002 as well as the 2005 competition, the overall winner of the competition ultimately hinged upon the electric car contest, a challenge that awarded points to the team who could drive their car the farthest each day (essentially encouraging teams to channel any excess energy generated by the house to the car; the winner for the day would receive all the day’s points, with each runner up receiving a proportional fraction of points in relation to the winner). The message of this contest: drive as far as you can to win.

In our earliest planning stages, the Cal Poly team understood the message of the car contest, and we took an alternate stand. The team’s ideals were more supportive of creating a small ecological footprint in all ways, not only for the house but also for an auxiliary appliance such as a car. We purposely sized our PV system without any assignment of power to the car. Instead, we used the extra space on the roof as a social space, a roof deck to augment a necessarily economically sized unit.
The second issue arising from the system sizes of these model homes is the conflicting message that they send to the public. With the smallest of these 2005 systems at 3.2kW (UMass Dartmouth) and the largest at 10.8kW (NYIT), all of these are far larger than they need to be in relation to the small size of the dwellings. One competition reviewer noted: “All of the competition houses had very large PV arrays, especially for one-bedroom houses...So a lot of people touring the houses assumed that a three-bedroom house must need a 30kW array.” The constraints of the competition lured teams toward larger systems for a variety of reasons. The previously noted wild-card car driving competition is one; the unpredictability of the weather is another. Clearly, in inclement weather conditions such as occurred at the 2005 competition, those with larger battery banks could more easily maintain typical house functions. Despite the innumerable positive lessons represented by the Solar Decathlon competition, the “battle of the batteries” that ensued highlights a missed opportunity. In many situations, these homes would be hooked into a power grid thus negating the need for such extensive battery banks. Naturally the homes could then share excess energy with the grid when possible and borrow it when needed. Alternatively, in an off-grid situation, residents would balance their energy use in response to fluctuating weather conditions. In relation to system size, it is also interesting to note that though a handful of teams such as Cal Poly employed passive design approaches to demonstrate simple strategies for energy saving design, there were no direct point awards for this approach.

As the brainchild of the head organizer Richard King, the Solar Decathlon is a remarkable competition. With its multiple missions of educating students about the benefits of renewable energy, heightening public awareness about energy efficiency issues, and assisting with market penetration of solar technologies, the competition was (and will no doubt continue to be) a life-altering experience, particularly for the student participants. To their credit, the DOE and NREL organizers continue to evolve the competition, and they were open to continuous questions about the motives behind the competition regulations. However, perhaps as much as project details is a broader issue that could be a target for future competitions. Consider the following: “[t]he Solar Decathlon is intended to demonstrate to the public that a completely solar-powered house can provide its occupants with a zero annual utility bill and an abundant lifestyle with all the modern amenities [emphasis added].” It is this sense of “abundance,” a sense of unconstrained plentitude as an American birthright, that requires re-evaluation. Along with lessons of alternate energy sources and energy efficiency may come equally valuable lessons of moderation as an alternative to the American paradigm of consumption.

For the Cal Poly team, our dreams for this project were and continue to be much larger than the modest footprint of this one dwelling. Several potential evolutions of the Solar CalPoly idea include a climate-sensitive, pre-fab project that could be modified and extruded for more dense use in an urban setting; the mobile nature of the prototype could be adapted for use as farm worker housing, for disaster relief, for elderly housing or for improved HUD regulated mobile home housing; the project could serve as a responsive, responsible infill housing prototype; and the list continues.

There is nothing startlingly new about the ideas embodied in the Solar CalPoly project. The ecologically focused ideas rekindled in the 70s by architects such as Sym van der Ryn, Pliny Fisk, Ed Mazria and others are currently enjoying a quiet rebirth, as activists such as William McDonough, David Orr, and James Wines give voice to growing environmental concerns. In a small way, the Solar CalPoly team was seeking to embody the spirit of this rejuvenated movement, aiming to transcend the trend of skindeep green-wash to instead explore the realm of truly resource efficient, climate conscious, delightful design that neither impoverishes the plant nor our human experience on it.

Conclusions: Looking Forward
A high-ranking U.S. official recently noted:

_I had an interesting opportunity to go see some research and development being done on solar energy. I'm convinced, someday in the relative near future we'll be able to have units on our houses that will be able to power electronics within our houses, and hopefully, with excess energy, be able to feed them back in the system. That's possible. We're not there yet, but it's coming._

These were words spoken by President George W. Bush, not one mile away from the National Mall, at the same time that eighteen teams were setting up their 100% solar powered exhibition homes.
Recently, California’s peak energy use topped 50,000mW in a single day despite the fact that 36 new conventional power plants were constructed in the last five years. Rather than new power plants, it seems clear that now is the time for effective, creative leadership and alternative solutions to a growing resource crisis. Demonstrations projects such as the Solar Decathlon, however well-intentioned, are merely poster children that can illuminate steps toward larger solutions.

At the same time, the roughly 100 students involved in the Solar CalPoly project represent the future. Through this project, they demonstrated that the conception and realization of a small solar-powered dwelling is an achievable alternative to our society’s unsustainable consumptive trajectory. Through this project, they have heightened the environmental awareness of all who come into contact with the project. Through this project, they put their ideals into action. As future environmental stewards, these students have every right to ask: why are we not all doing the same?

“If you’re an architect, just like you solve the functional problem and the budgetary problem, you must solve the environmental problem—and solve it by design.”

Notes:
2 Ibid., p. 29.
3 The Cal Poly architecture students on the project were working toward a 5 year undergraduate BArch. The engineering students were mixed undergraduate and graduate students working on their final projects or theses.
5 A generous donation of a 12’-0” x 52’-0” mobile home chassis formed the foundation; the resulting 624 s.f. footprint includes an unconditioned mechanical space at the project’s west end.
6 In the overall standings, Colorado Boulder came in first place, Cornell University second, Cal Poly third, and Virginia Tech fourth.
7 As the overall competition winner, Colorado’s team drove from a low of 40 to a high of 80 miles each day, averaging 64 miles/day. By comparison, Cal Poly drove from a low of 6 to a high of 32 miles with an average of 17 miles/day. The national daily average passenger vehicle travel is 34 miles/day by current standards [U.S. Department of Transportation]. As one Solar CalPoly student noted: “Our team supports a less car-oriented lifestyle, so we will drive as far as we can [in the competition] – and then we will bike.” [Solar Decathlon 2005 EERE Brochure, p. 10]
8 To further clarify, the Solar CalPoly team certainly recognized the potential for an individual house to power all necessary appliances, including a possible vehicle. However, our desire was to focus more on denser modes of living (close proximities to work, school, shopping, etc) as well as promoting alternate, more eco-friendly means of travel (biking, walking, carpooling, etc.).
9 In parts of California, the average energy demand is 3.2kW for a much larger house than any of the Solar Decathlon homes [San Diego Regional Energy Office]. For a 1700 s.f. house, the average size of a PV system in 2005 was 3.6kW [DOE Office of Energy Efficiency and Renewable Energy]. As the smallest 2005 Solar Decathlon system, U. Mass Dartmouth’s 3.2kW system served 800s.f. of space; though small by Decathlon standards, this is still overpowered for the amount of space it is serving.
11 It is also worth noting the increase in system size from the first Solar Decathlon to the second, from 5.2 kW per household in 2002 to 6.6 kw per household in 2005.
13 At the same time, the organizers also recognize that “The Solar Decathlon is ultimately a game and therefore an abstraction of reality.” (Ibid). It is clearly a demonstration competition but for university teams it can be a fairly high stakes game, with an average cost to play of $500,000 per project.
14 President George W. Bush, 4 October 2005 Rose Garden Press Conference, via Home Power, #110, 12/05 and 1/06.
15 Ed Mazria quoted in “Turning Down the Global Thermostat,” Hawthorne, Christopher, Metropolis Magazine (October 2003).

Project Team
Faculty Advisors: Jesse Maddren, Rob Peña, Sandy Stannard, with construction supervision by Richard Beller.

Special thanks to DOE, NREL, Cal Poly, College of Architecture and Environmental Design and to all Solar CalPoly Supporters. For a more extensive list, please see: http://www.solardecathlon.calpoly.edu