Final Report

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01. Results of Media Outreach

The traditional media representation of the SURE HOUSE was significant leading up to the Solar Decathlon competition and even more so at it's conclusion. Over 100 media spots were featured about the project since it's inception. Local, regional and national outlets produced coverage including Fox, New York Times, National Geographic, Popular Science, Fast Company, CBS-NY, NJ.com, and Star Ledger. There were also many design, engineering, and sustainability blog features written such as Inhabitat, Archinect, and Gizmag.

The social media outreach for the SURE HOUSE was successful with almost 2,500 Facebook 'Likes', over 750 followers on Instagram and over 650 followers on Twitter. Photography, video and interactive 3D walkthroughs as well as short informative text engaged our followers throughout the design, construction and exhibition stages of the project.

02. Results of On-Site exhibition activities

There was an unknown number of visitors to the SURE HOUSE during the exhibition in the Irvine Great Park. Approximately 125 exit interviews were conducted as visitors left the home to poll them on their favorite feature of the SURE HOUSE. These interviews confirmed our proof of concept as well as the tour's effectiveness at information dissemination. Highly represented visitor responses include:

- spaciousness with privacy
- passive house technology
- bathroom and indoor/outdoor accessibility
- storm shutters and integrated PV
- storm plugs and floodproofing
- USB and induction charging
- cabinetry and integrated storage
- energy usage display
- integrated track lighting

There were several successes in the exhibition experiences we provided. Our team put a heavy focus on signage as well as a physical wall mockup, which served a dual purpose as talking points for our tour guides during less busy times and then as a means for self-guided learning during busier times. The signage was well integrated throughout the home including information tags on specific appliances/fixtures and color coded labeling to convey the general workings of our mechanical/electrical/plumbing systems. Our tour guides added a very valuable aspect to the visitor experience by being well versed in the project; as everyone was involved in the design and construction of the home it allowed them to effectively field diverse questions.

Although the overall exhibition was a huge success there were some issues our team encountered. The direct sunlight and excessive heat on certain days during the competition proved to be a challenge since

we were unable to cool the space for our visitors while still remaining competitive in the energy contests. Our tour route also encountered bottlenecking conditions during some of the busier our times, particularly around our mechanical room. Our home and many of the homes at the competition were beautifully lit and many visitors wanted to witness this, so it would've enhanced the visitor experience to allow for exhibition with nighttime tours. Finally, there were so many people that were not able to make it to the actual event that we would've liked to do a final 3D scan to allow people to virtually tour our home at their convenience.

03. Website Evaluation

a. Statistics

Our website was a very important aspect of our overall outreach. We developed an encompassing adaptable sitemap very early on in the project. The site had static pages that provided general and specific information on the project but it also had dynamic elements such as blog posting and live social media updates. This made the site a communications hub for all individuals that wanted to learn more about the project. The statistics for the website can be seen in the table below.

Figure 04.1: 2015 Website Statistics

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Sessions	549	789	1,385	2,001	2,338	2,251	3,157	3,758	2,268	16,039
Users	326	475	814	1,451	1,887	1,815	2,478	2,797	1,742	13,179
Pageviews	1,676	2,414	6,821	6,425	5,113	5,335	8,033	10,395	6,499	45,820
Avg. Duration	3:25	3:26	5:19	3:03	2:00	2:25	2:40	2:48	2:42	3:04

b. Successful Elements

Some of the major successes of our web platform included team made graphics to explain our design and engineering systems as well as a very organized layout for people to learn more about many of the aspects of the home. We did not get the opportunity to post as much ongoing content to the site as we would've liked due to the business of the team to stay on top of the project and associated deliverables. In retrospect we would have included a live stream of our construction site both here in New Jersey as well as in California to engage our followers further. Additionally, we really would have liked to call out all the specific products used throughout the home in an interactive way, possibly using QR codes, that would recognize some of our sponsors and inform many of our visitors.

04. Organizer Communication Effectiveness

a. With teams:

Competition organizers did an exceptional job of communicating clearly and in a timely manner with teams, both during the design phase and on-site during the exhibition. Use of online tools (Yahoo group) allowed for a transparent record of communications and competition organizers were always prompt with their responses to individual queries.

b. With public:

Clearly, the public exhibition was not a success for the 2015 Solar Decathlon cycle. Both the lack of overall attendance, and the makeup of the attendees (almost entirely 'homeowners' not professional designers, engineers, green-building practitioners, or building science professionals) were very disappointing. While we understand that the first weekend suffered due to the unseasonable heat, the pathetic attendance during the second weekend should make clear that public interest was not generated in sufficient quantity to drive visitors to make the long trip to the competition site.

05. Future Plans for the Home

The SURE HOUSE home is currently being stored in California while the team undertakes the fundraising needed to ship the home back to the east coast. Once it has returned to New Jersey, the home will be installed at the Liberty Science Center in Jersey City, New Jersey where it will operate as a permanent exhibition of sustainable technology and green building design.

06. Suggested Improvements

a. What & Who is the Solar D for? What is the purpose?

The Stevens teams greatly appreciates all the amazing work done by the organizers, and are grateful to have had the privilege to spend many years working on great projects because of it. But we do think that the Solar Decathlon contest has, to an extent, lost some of its focus over the past couple cycles and this has impacted the quality of the houses, the number of students willing to participate, the number of faculty interested in engaging with the project, and the number of sponsors willing to contribute funds. I think that the latest round (2015), with 6 teams dropping out and several other teams having serious difficulties on-site, should clearly illustrate the trouble the contest is having at this point.

Quite simply, the contest hasn't kept up with the markets it helped to create, whether in terms of the current solar market (no demand response contest, no batteries, no vehicle-to-grid, etc...) or in terms of building science (no air-sealing contest, no IAQ contest, no thermal bridging, vapor profile or Energy Modeling contest) which means that it just isn't as interesting to faculty or sponsors looking to push the boundaries of the green-building sector.

If the contest is able to re-focus itself as a vital reservoir of data and experimentation for the building-science community, it could re-establish itself as a premier venue for those interested in this kind of work.

In general though, we think it is vital to move away from a focus on the general public (the public exhibit) and the 'home-show', and towards a focus on the building science community of architects, builders, companies, policy-makers and engineers if the contest is to continue to be relevant and successful.

b. Remove the huge risks of transportation and on-site erection. This should not be a 'Pre-Fab' contest.

Stevens has, over three cycles, experienced first hand the challenges and issues with the rapid deployment (and then deconstruction) of these homes. Both from a logistics, financial, and site-safety perspective - I think this part of the contest is an unneeded burden on team management and student participants.

This contest should not be about pre-fab buildings, it should be about designing quality built, energy-efficient buildings: whether the building can be erected in 8 days shouldn't have any impact on a team's performance or score.

c. Correct the Misalignment with University Schedules

One of the consistent difficulties with the Solar Decathlon is the schedule and its misalignment with the academic schedule:

i. Misalignment of the notification: Feb notification of acceptance into the contest is too late to form a 'class' for the spring semester as most students and faculty already have their schedules set far in advance. In addition, most classes begin late Jan - so even scheduling of university space is difficult when notification comes in Feb. An earlier notification period (even if it means an earlier submittal period) is critical to integrating the Solar Decathlon into curriculum and getting the best students involved. The only way to get the best students is to make Solar Decathlon part of the curriculum and this requires more advance planning.

ii. 'Exhibit' timeframe is particularly difficult as students have only been in a few weeks of class before they have to leave. Exhibit really should align to semester breaks (Summer or Winter)

iii. One additional challenge is that without the certainty of a project, developing curriculum around building-science issues re: houses is very hard. Shifting to a longer time-frame where acceptance into the contest is known earlier would allow for more 'prep' classes teaching fundamentals, history and theory, etc...

d. Allow for 'Renovation' projects, 'Urban' projects, etc..

While the suburban single-family home model is certainly critical to address (esp. in this country), a wider variety of project types should be allowed which would lead to more interest from schools and students.

Urban projects would require some modification to the visualization and Architecture Jury rules to allow for visuals that demonstrate the project in context and as a part of an urban fabric (right now the rendering rules require a flat, featureless buffer zone around the home....). We fully agree that teams should **NOT** be allowed to show alternate (un-built) versions of the home - but the home in context should absolutely be a part of the Architecture contest and would lead to better buildings.

As for renovations, esp. here in the northeast, new-builds are a very small part of the problem - we need to look much more closely at how we rehabilitate our poorer performing and unhealthy buildings long before we focus more attention on bespoke, single-family, architectural projects.

e. Allow Batteries, judge 'Demand Response'

A difficulty, as of late, is getting solar and utility companies to get excited about the contest since the questions of solar deployment ("*how do we put solar panels on houses?*") has been largely solved at this point (thanks in large part to the work of folks in the Solar Decathlon). The more pressing questions now regard the use of batteries to reduce homeowner costs and increase reliability, vehicle-to-grid connections and demand-response controls among other issues. Solar Decathlon Europe is an interesting model for the Demand Response contest esp.

We think including contests along this vein would help push research dollars towards the projects and get Solar companies excited about the work again. Solar Decathlon teams should be asking questions we don't know the answer to, not simply deploying technology we already know works well.

f. Change Energy Use category to be judged on a kWh / SF basis.

Almost every energy efficiency standard (Passive House, HERS, etc) uses a '**energy-consumed-per-square-foot**' metric to judge buildings on. This makes it possible to compare the efficiency of very different size projects. The Energy use contest should shift to this model rather than using a simple gross 'energy used' figure as a limit. This figure should be carefully calibrated to align with the most stringent energy standards used today (Passive House, Living Buildings, Energy Star, etc..) in order to encourage teams to take energy use seriously and in a repeatable manner.

The Energy Use contest should also **REQUIRE** branch-circuit energy monitoring and open public data sets for all houses. It isn't enough to simply show the total house consumption - individual equipment and component level data needs to be demonstrated and shared in order to effectively develop low-energy buildings.

g. **Include an 'Energy Modeling' task inside the Energy Use category (allow PHPP, TrnSys, HERS, Energy+, WUFI, etc....)**

Increasingly, energy modeling is being used by professionals to drive design decisions from the beginning of projects, and these student projects should be no different. Teams should be allowed to use any tool of their choosing, but SOME form of energy model should be posted online or made available for review and judging. This should include Thermal-Bridge (2D heat flow) analysis of critical details as well as an overall Heating, Cooling, Hot Water, Plug-Load and appliance use as well as full Primary (Source) Energy limits. The contest points should also be re-structured to allow for minimal point loss for going slightly over the limit, with increasing point loss for drastic over-limit consumption (similar to how the Affordability contest is judged now)

h. **Include IAQ in the comfort zone contest, as well as surface temps (esp. at glass or temp. asymmetry contest). Possibly include Airtightness contest? Blower-Door test requirement? Vapor Profile assembly testing (WUFI)**

In our experience, professionals in the building science community are increasingly interested in questions of IAQ, thermal comfort and durability in these new super-insulated and air sealed envelopes people are building. These questions should absolutely be part of the new Solar D.

IAQ can be simply measured via CO^2 PPM monitors, and would incentivize teams to include ERV or HRV technology (and then, when installed, to actually RUN them during the competition measured portion)

Surface temps should also be part of the 'comfort' contest as these have a large effect on perceived comfort in a space - this is particularly important at glass faces and reducing temp. asymmetry should be a focus for the student design team in addition to careful control of temp. and RH.

We would also like to see a Blower-Door test added and an 'air-tightness' contest. This would NOT preclude manual ventilation schemes (as some argue) during the measured portion, as the tests are conducted with all openings closed but this does NOT mean you can't open fenestration later (windows, louvers, etc...) as part of a thermal-comfort strategy. But all building codes are moving towards much more strict Airtightness levels. The limits could be either gross (ACH) or more envelope-specific (CFM/SF-Envelope) as either are effective ways to measure airtightness. This would force teams to think carefully about this critical layer and test throughout construction. Points could be awarded on a sliding scale down to 0.6 ACH@50 or something similar as a target value (perhaps something more appropriate to small buildings - 0.6 is a VERY aggressive target for 1,000sf buildings....)

i. **Do not eliminate the affordability contest.**

While we do understand the issues with the affordability contest limiting 'innovation' from teams - We think it is very, very important to incentivize teams to work to reduce their costs. I think that this 'dampening' effect could be counteracted by requiring teams to include coherent, complete business plans or proposals which model the long-term price of any of their 'innovations' if they were deployed at scale or as real businesses. In this way, teams could, if they put in the hard work, continue to experiment and develop novel mechanical / electrical / solar systems but only if they justify and prove that their projects could work.

07. Note from Faculty Construction Manager:

a. Professional background

Many years in "environmentally conscious" design/build projects with a focus on alternative material applications. In other words, I'm used to challenging one-off projects.

b. Solar decathlon background

Two start to finish Solar Decathlons. First as student project manager on the UNCC 2013 team and then as the faculty construction manager on the 2015 Stevens entry. I've experienced the full process both as a decathlete and faculty advisor.

c. Conclusion based on my experience: Separate design from implementation

After four years in the trenches of the Solar Decathlon, I have a lot of opinions, rants, anecdotes, jokes, epiphanies, hallucinations, and all manner of passion-and-moral infused stories that I could share. But rather than present a list of specifics, I thought it would be more helpful to self-analyze and collate all of that material into a simple suggested course of action. My feeling is that the Solar Decathlon should be divided into separate design and implementation competitions.

As it stands, most schools see the Solar Decathlon as a one-off project. Of course, some schools enter more than one competition, but still I venture that they generally consider each Solar D. as a stand-alone project. However, a necessary component of success both as a competition entry and as an educational exercise is to build a core team of dedicated students and faculty in multiple departments involved for the full project cycle. This goal can truly only be fully realized if the Solar Decathlon is integrated into the school's curriculum. However, the short cycle of the competition doesn't encourage this. By the time a school is told they are accepted into the competition, they need to immediately be in the thick of project development. At this point, it's simply too late to adjust curriculums, especially on an interdisciplinary level such as demanded by the project, and so generally some sort of ad hoc process has to be put into effect. The result for most schools I am confident is less sustained student involvement, less cross-department cooperation, less educational focus, and frankly much more stress and worse project outcomes.

That is a real shame because the Solar Decathlon embodies a great undergraduate design project infrastructure whether or not an actual constructed building is the outcome. Though architects and engineers work together closely in the "real world", they almost never do so in school. Even on the rare occasion when they might, practical realities of marketing, affordability, and public relations won't be part of the process. The Solar Decathlon competition mandates that all of these professional perspectives be integrated into a student design project. The problem is that most universities are not set up to offer such a holistic educational experience. The Solar Decathlon could help change this fact by creating a separate design competition that generated entries for an implementation competition.

The underlying goal of the design competition would be to help interested schools create the curriculum and interdepartmental cooperation to support an ongoing integrated design studio and related coursework dedicated to the design goals embodied within the Solar Decathlon. A school could experiment with the project of designing a solar decathlon entry without committing the huge financial and advanced technical resources required to realize the design. Multiple designs could be generated, more chances taken, and a lot more teaching and long-term interdepartmental partner-building could take place. In a yearly cycle, schools could keep running the related courses, generating designs and entering them in the competition. Even if a school never built anything related to the project, they would have added to their curriculum an interdisciplinary design studio that would serve many students in a long-term trajectory.

Winners of the this leg of the competition would be those that not only developed an excellent design but that also had clearly demonstrated their ability to realize said design through a clear construction/operation scheme including a real business plan with all funding sources in place. If a team could not muster this level of sophistication, they still got all the benefits of the design process, and a better infrastructure and understanding to try again next year. Conversely, teams that won the design competition would have met guidelines that put them in a good position to successfully shift gears to the completely different process of carrying a complex, nuanced, state of the art design through the construction process.

The implementation competition would then be a very elite event, as in my opinion it should be. To be frank, a number of the projects at recent decathlons simply should not have been built. The schools unwittingly bit off more than they could chew and were really led down a path of pain and sorrow by the competition. I believe that only projects that offer some real innovation, opportunity for quantitative research outcomes, or fulfill a specific community need should be built as part of the competition. What's more, a separate design competition would do a much better job of gestating those designs.

Design is a victimless crime, but construction uses real resources and has lasting effects. As the most internationally renowned competition for high performance housing development, the

Solar Decathlon should encourage design innovation while supporting rigor and quality in implementation. I believe the two competition scheme would be a better way to serve both goals.