SU+RE: Sustainable + Resilient Design Systems

Introduction
Climate Change is the New Gravity
Clarke Snell

Unsustainability and the Architecture of Efficiency
Graham S. Wright

Resilient Design
‘Systems Thinking’ as a Response to Climate Change
Claire Weisz

High-Performance Enclosures
Designing for Comfort, Durability and Sustainability
Ken Levenson

Global Responses to Local Conditions
Sustainability and Resilience are Nowhere the Same
Alexandros Washburn

‘Global Warming is Real’
Superstorm Sandy, Stevens and the SU+RE House
John Nastasi

Practical Resilience
Low-Tech Plug-and-Play Innovation in the SU+RE House
Clarke Snell

Modelling to Drive Design
Honing the SU+RE House through Performance Simulations
Ed May

SU+RE Power
Energy Independence and the Sustainable Resilient Sun
Clarke Snell and Alex Carpenter
Defining Environments
Understanding Architectural Performance through Modelling, Simulation and Visualisation
Brady Peters

Data Buildings
Sensor Feedback in Sustainable Design Workflows
Terri Peters

Building Physics, Design, and the Collaborative Build
Sustainability and Resilience in Architectural Education
Karin Stieldorf

Climate Change and the Bottom Line
Delivering Sustainable Buildings at Market Rate
Adam Cohen and Clarke Snell

Energy and Design Criticism
Is It Time for a New Measure of Beauty?
Bronwyn Barry

The Design of Public Policy
Sustainability and Resilience at the City Scale
Ann Holtzman

Counterpoint
Aim High
Pressing for a Radical and Global Approach to Sustainable Design
Craig Robertson
Guest-Editors John Nastasi, Ed May and Clarke Snell collaborated as faculty leaders on the Hoboken, New Jersey-based Stevens Institute of Technology’s winning entry for the 2015 Solar Decathlon: the SU+RE House. John Nastasi has led three entries (2011, 2013 and 2015) into the US Department of Energy's Solar Decathlon as part of his work at Stevens Institute, with Ed May joining the 2011 and 2015 teams. Clarke Snell was part of the 2013 University of North Carolina Solar Decathlon team and joined the Stevens leadership group for the 2015 cycle. This issue focuses on some of the issues and ideas at the heart of this research work, and in particular the intersection of sustainability and resiliency within a context of climate change.

Student design-build research projects such as the Solar Decathlon are unique opportunities for students to engage with complex design problems while also learning valuable collaborative and communications skills. It is becoming crucial to cultivate these skills in students as the design community begins to wrestle with the realities of building in an ever-more extreme environment. The articles in the issue take an in-depth focus not only on the SU+RE House, but also on the larger questions of how designers must adapt to the demands of practice within this new context.

John Nastasi is both an architect and a design educator. As principal of his own design practice in Hoboken, New Jersey, he has built a diverse body of work that is distinguished by a consistency of process, a rigorous detailed investigation of real and theoretical issues, and a high level of craftsmanship that accompanies the art of making. His work has received the prestigious Young Architects Award from the Architectural League of New York. He is an alumnus of Harvard’s Graduate School of Design (GSD), and a recipient of the university’s Rice Prize in Architecture and Engineering. He has also held the position of Director of the Materials and Fabrication Lab at Harvard GSD. In 2004 he founded the Graduate Program in Product-Architecture at Stevens Institute of Technology.

Ed May is a partner with the design and consulting firm BLDGtyp based in Brooklyn. He is a licensed architect and an expert in the use of energy modelling to drive design. He received a Bachelor’s of Fine Arts from the University of Massachusetts at Amherst in 2001, and a Master’s of Architecture from Parsons The New School in New York City in 2009, where he was previously an Adjunct Professor. He was also an Industry Professor at Stevens Institute where he was the Faculty Project Manager for the SU+RE House Solar Decathlon entry. He currently teaches with the Passive House Academy (PHA) and the North American Passive House Network (NAPHN), and has earned the Certified Passive House Consultant designation from both the Passive House Institute (PHI) in Germany and the Passive House Institute of the US (PHIUS).

Clarke Snell's professional focus is the development and application of sustainable and resilient building systems towards a zero-resource architecture. Specifically, he applies research into low-tech, high-performance materials, assemblies and systems to the design and construction of small buildings and their microclimates with the goal of repeatable and quantifiable reductions in project carbon footprint. He holds a Master’s of Architecture from the University of North Carolina at Charlotte, and has experience in construction as a builder, and in design as the principal of his own residential design and consulting firm. He has written two books and numerous articles on alternatives to currently standard construction methodologies. He is currently an Industry Associate Professor on the Design Faculty at Stevens Institute where he was the Faculty Construction Manager on the SU+RE House project.
Climate Change is the New Gravity
Sustainability and Resilience as Architectural Design Constraints

An increase in carbon emissions is initially causing a global increase in temperature that in turn will trigger other climatic changes. Many of these predicted outcomes, including increased polar ice melts and more frequent and intense storms such as Hurricane Sandy, are already being observed.
In October 2012, Superstorm Sandy, the largest Atlantic hurricane on record, pummelled the East Coast of the United States. In New Jersey alone, Sandy caused US$30 billion in damages, killed 39 people and left 2.7 million homes and businesses without power, 350,000 of those needing repair or reconstruction.¹ The Federal Emergency Management Agency (FEMA) responded with regulations that mandated construction above the floodplain. This was a sensible technical solution, but disastrous from an architectural and social standpoint in that it would lift many buildings well above street level, disrupting longstanding existing neighbourhoods with entrenched and vibrant living patterns.

A small group of architecture and engineering students led by faculty from Stevens Institute of Technology in Hoboken, New Jersey, countered with the SU+RE House, a new paradigm for coastal housing and the winning entry in the US Department of Energy’s 2015 Solar Decathlon competition. Hoboken sits on the Hudson River across from Manhattan, and in 2012 Sandy had flooded the city. Just months later Ecohabit, Stevens’ entry in the 2013 Solar Decathlon, was being built by students in a parking lot adjacent to the Hudson as a storm threatened to flood the river again. As an emergency measure, the building had to be craned out of the danger zone. When Stevens decided to enter the 2015 Decathlon and utilise the same parking lot for construction of the SU+RE House, it seemed clear that the design challenge had to be an intelligent, replicable response to Sandy. The result was the development of a building system that allows for construction in the floodplain, thereby reclaiming a densely populated site condition currently being lost worldwide to more frequent and severe flooding. Through conscious envelope design, the house also requires only a fraction of the energy to run compared to its conventional counterparts, its roof-mounted photovoltaic system producing considerably more power than the building requires. During a storm-induced grid failure, the system ‘islands’ itself to continue producing power, becoming an oasis of energy to supply standby electricity to the neighbourhood.

The SU+RE House is a good touchstone for this issue of disaster because it is a very straightforward example of a specific act of design that in order to succeed needed to be generally applicable to a problem of ecological scale. This is the essence of sustainable and resilient design.

A Complex Problem with a Simple Solution
Superstorm Sandy is part of a clear trend, as over the past 50 years extreme weather events are definitely on the rise. According to the Emergency Events Database, in 1960 there were fewer than 50 natural disasters worldwide, while in 2014 there were 400.² In the Atlantic, massive storms seem to be becoming more commonplace, with Katrina in 2005 and Sandy in 2012. In 2017, for the first time three hurricanes in a season (Irma, Jose and Maria) had an accumulated cyclone energy (ACE) over 40, while Harvey set flooding records in Texas. We do not have enough data to determine a generalised cause for these specific weather events, but we can say confidently that from a design standpoint the particular ‘problem of ecological scale’ for extreme weather is climate change.

Human-induced climate change is very real, ravenous, and happening faster than anyone initially predicted. Though projecting the intricacies of its course is a complex modelling exercise, the causes are mechanistic and well understood. We are introducing materials into the air (collectively called greenhouse gases) that are intensifying the mechanism through which solar heat is trapped by our atmosphere, thereby altering the process responsible for creating the delicate temperature range that has engendered and supported life on earth for the last 3.5 billion years. The main culprit is carbon dioxide produced from the combustion of fossil fuels. The initial result is a general warming trend, the infamous ‘global warming’, which has already begun to trigger a domino effect of changes to other environmental variables such as global ocean and air currents, carbon sinks and precipitation patterns, to name a few. As a result we are moving into uncharted climatic waters.
Predicted results that will drastically affect human society are already being observed. Global ice-melts leading to sea-level rise will threaten the coastal communities where a majority of the most populated human cities are situated. Extreme weather, including more frequent and furious storms, droughts and floods as well as general warming, will cause species migrations and degrade agriculture in ways that will deeply impact human development all over the world. Though no one knows the exact trajectory, generally accepted projections conclude that there will come a point when a feedback loop will be triggered, after which our actions will not be able to affect the outcome.¹

Remember, this is not the plot of a dystopian Hollywood blockbuster. These conclusions are derived from observation, study and modelling, all tested and refined through the scientific method to the point where there is almost unanimous agreement on the veracity of the core conclusions from climate scientists worldwide.² Facts are slippery, but the reality of human-induced climate change is about as factual as facts get. The summary is that it is happening, it is serious, and we have to deal with it collectively and rapidly.

The good news is that climate change is a complex problem with a very simple solution: stop burning fossil fuels. We are after all the big-brained mammals that learned to fly, tamed the atom and invented chocolate. This should be an easy one. Of course our industrial society is built on fossil fuels so we cannot just turn off the gas and keep on trucking. We need some time to rethink and retool, but we must not hesitate. Projections based on the same science that uncovered the problem give us good benchmarks to work with in terms of how much carbon we can still afford to emit and over what period of time.³ Such theorising is admittedly inexact. Outputs vary and are constantly under revision. Still, even a conservative analysis points to the need for swift and profound reductions in carbon emissions, so much so that the synopsis ‘as much as possible as quickly as possible’ is almost exactly accurate.

The Mandate for Quantitative Sustainable and Resilient Design Systems
This is where architects and building engineers enter the picture. Buildings are a big part of the equation with their operation alone making up 30 to 40 per cent of industrial society’s worldwide carbon footprint (see Graham S Wright’s article on pp 16–23 of this issue). And this brings us into familiar territory: the discussion of the complex intersection between the built and natural environments. What should we call it in this case? Definitely our subject falls under the broader mantle of sustainable design, but if you have been to a conference on that topic, chances are you did not come away with a clear definition of what it is or how to do it. Sustainability is often a vague concept deployed as everything from a moral argument to an emotional plea to a marketing strategy. In fact sustainability is easily defined. It is the process of maintaining something at a given level. If we can agree that in this case the thing is life on earth and the level is industrial human society, then at least for now sustainability becomes quantifiable and the metric is carbon. Design on the other hand is simply to devise for a purpose. It does not seem controversial that we need to design such that advanced industrial society can continue. Clarified with these simple definitions, sustainable design becomes a mandate, and a project’s success or failure can be quantified through carbon emissions.
And this is where many architects start to chafe because they interpret this discussion as constraining to freedom of expression. But in fact as designers we know that it is the constraints that generate the beauty. If we were not small animals glued to the ground, what would be the interest in building up and out and over? Would there be Gothic sanctuaries built of stone but made of light? Or the frantic, graceful race to scrape the sky of the 20th-century skyscraper? Or the contemporary penchant for massive cantilevers, voids and structurally counterintuitive forms riffing again and again on the groove: ‘I’ll bet you didn’t think this could stand up?’

The challenge of gravity has not mandated limits but created opportunities. It has generated beauty. Climate change must become the new gravity. We simply have to accept that climate change is the new normative baseline design constraint for the built environment. As with the last 5,000-plus years of gravity-focused architectural design, our grappling with climate change will create beauty, but there is a difference. Gravity as a design constraint guides compliance through immediate feedback. Climate change will not baby us. We have to define its parameters for design and create our own short-term feedback inputs. Carbon as the metric of that feedback will not limit our expression any more than gravity. The only thing that has really changed are the stakes.

But sustainability is not enough. As the climate changes, so does the site. Solar intensity, temperature, wind speed, drought, flood and sea level are just some of the site-specific variables that are changing. As we work to stem the cause, we therefore have to react to the effects. To respond, a design process is required that seeks to integrate resiliency by building-in the capacity to absorb the impacts of these disruptive events and adapt over time to further changes while simultaneously being part of the solution to the problem itself. To build sustainably in a world with a changing climate, we must now integrate resiliency.

Humans have become so adept at dealing with gravity as a design constraint that we are now often just riffling with structural parlour tricks and formal gags. It is time for a new challenge.

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Laboratory for Innovative Housing, Passchalchemical wall system, University of North Carolina at Charlotte, North Carolina, 2013

Carbon reduction as a design constraint has informed new architectural creativity focused less on the façade and more on the volume of the building envelope. Here, by utilising four distinct concrete mixes optimised for specific thermal characteristics, a conventional precast concrete assembly is re-envisioned as a low-energy heat storage and dissipation machine.

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The form and materiality of ubiquitous neomodern office buildings typically come with a high carbon price tag due to building envelopes that require profligate operational energy use to maintain interior comfort. This does not have to be the case: the RHW 2 tower meets the German Passivhaus standard, one of the most rigorous building energy standards in the world.

Quantifiable sustainability in architecture is a collective, worldwide endeavour. This apartment block in China was also built to meet the German Passivhaus standard.

This issue of \( \Delta \) is less about the ‘what’ and more about the ‘how’ of this new synergy of sustainable and resilient design forged by climate change.
The Nuts and Bolts: Energy Demand, Production and the Changing Site

This issue of Δ is less about the ‘what’ and more about the ‘how’ of this new synergy of sustainable and resilient design forged by climate change. Its direct genesis is the SU+RE House, a project the Guest-Editors undertook together as architecture faculty at Stevens Institute of Technology. Stevens has been immersed for three centuries in the science and engineering of its local climate, pioneering steam-ferry technology and transportation in the 1700s, developing competitive yacht design and racing (the New York Yacht Club and America’s Cup) in the 1800s, spearheading military warship prototyping and design during the First and Second World Wars, inventing mechanical wave dynamics modelling in the post-war 20th century, and currently researching real-time monitoring and predictive computational modelling of the physics of the coastal ocean in the 21st century.

When Superstorm Sandy hit Hoboken in 2012, it was in the context of this long history of local climate-driven research/engineering/design/build iterative loops that Stevens decided to respond with the SU+RE House. The project serves as an appropriate poster-child for this issue because it delivers sustainability through measurable carbon reduction, and resilience through a replicable design system.

The issue outlines a practical strategy for this systems approach to sustainable and resilient design. In his article (pp 16–23), Graham S Wright sets the sustainability stage with a more detailed examination of fossil fuels as a context for climate change, and introduces the argument that the sensible response for building designers is to switch focus to operational load reduction. Ken Levenson (pp 48–55) lays out the nuts and bolts of this load-reduction strategy through a primer on passive building design basics, while Bronwyn Barry (pp 116–21) grapples with mainstream architecture’s reluctance to embrace the low-energy envelope as a metric of beauty. Adam Cohen (pp 110–15) outlines a practical approach to delivering low-energy buildings at market rates through increasing the efficiency of the architectural delivery process. Terri Peters (pp 92–101) investigates how post-occupancy feedback provided through integrated building sensoring can improve performance and drive an iterative design process that leads to more sustainable and resilient buildings, using case studies from the international practices Skidmore, Owings & Merrill (SOM), FXFOWLE and 3XN.

To offer a more in-depth case study, the Guest-Editors focus on the SU+RE House by first setting it in an environmental, social and educational context (pp 40–7), then discussing its practical approach to sustainability and resilience as a combination of hybridising existing technologies and a plug-and-play approach to innovation (pp 56–63 and 64–71). At the core is a quantitative feedback loop of multi-platform modelling generating real-time design iteration (pp 72–81). In related articles, Karin Stieldorf (pp 102–9) expands on the educational context while Brady Peters (pp 82–91) considers the architectural representation of building performance simulation with examples from the work of Bjarke Ingels Group (BIG) and BuroHappold.


This low-energy factory was built using the components it produces for use in the construction of low-energy buildings, creating a feedback loop of carbon reduction.