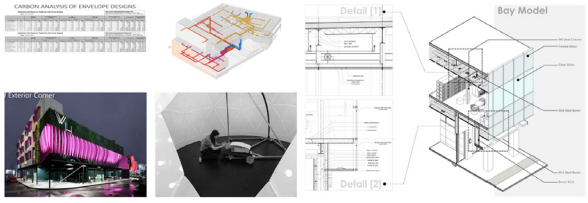
Architecture Climate Change & Society

Buell Center
2020 Course Development Prize



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DESIGN BASED ON ESTIMATING RIPPLE EFFECTS OF CARBON FOOTPRINT

We are a group of faculty seeking the integration of climate action goal of decarbonization into the design studio. We co-teach our school's comprehensive design studio (required 4th year studio) in which performance is emphasized as a principal driving force for design development. Students are challenged with the task of making their buildings as resource-efficient as possible. Students are required to seek evidence-based feedbacks to improve the performance of their design, i.e., the structural, energy, and financial performance. Our endeavor is to redefine the educational goals of studio to integrate carbon footprint as the primary measure of performance, which should open the door for students' creativity in finding innovative ways to minimize carbon emissions due to both operational and embodied energy. The current content and scope of studio enable students to develop the understanding and ability to generate all of the evidence-based data required to evaluate building performance, but this data stops short of estimating the building's carbon footprint. The next step is to explore ways to develop the studio further, pushing the envelope towards making it possible to estimate the ripple effects of carbon footprint and the (direct and indirect) impact of buildings on climate change.

School of Architecture, Oklahoma State University

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Syllabus Attachment

Design Based on Estimating Ripple Effects of Carbon Footprint

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A meaningful quote:

"You must be the change you wish to see in the world", Mohandas Gandhi

Scope & challenge

While it is now well within architects' grasp to achieve the enviable goal of *operational* carbon neutrality in their building designs, when a building is considered in the greater context of its role in society, there is no such thing as a carbon-neutral building. All modern buildings have embodied carbon in their construction. They all are used by people that expend carbon getting to them (as of 2016 the GHGs generated by the transportation sector exceeded those created by the electricity sector. They create opportunity costs and enable any number of events external to the building itself (e.g. the heat island effect, infrastructure impacts, contribution to urban density, tendency for more affluent people to use more energy, blocking or magnifying sunshine to other buildings) that may have carbon impacts. For a complete picture of a building's carbon impact to emerge, its carbon contribution in operation must be weighed against these other sources. Furthermore, these non-operational sources of carbon will become more prominent components of the overall equation as fossil fuel use for electricity generation becomes a thing of the past. When we address carbon impact of buildings, however, we tend to isolate inquiry to such building technics as optimizing the building envelope, local-sourcing materials, daylighting and natural ventilation while we ignore the ripple effects of reducing the carbon footprint of buildings simply because they can be difficult to measure and less under architects' control. This emphasis on building technics can create myopia concerning the architect's influence over the climate change impact of buildings. This measurement problem is starting to receive national attention in the architectural press, as reflected in Fred Bernstein's recent criticism of architects' unsubstantiated claims of carbon neutrality in a recent *Architect Magazine* "Why Architecture Critics Should Ask about Embodied Energy," (April 11th, 2019).

Design Goals

This module is an investigation into how to fulfill the ethical responsibility of architects regarding climate action. Most recently, in June 2019, AIA approved the *AIA Resolution for Urgent and Sustained Climate Action*, in which it adopted three actions:

- Declare an urgent climate imperative for carbon reduction.
- Transform the day-to-day practice of architects to achieve a zero-carbon, equitable, resilient and healthy built environment.
- Leverage support of our peers, clients, policy makers, and the public at large.

In order to achieve the goals of this newly-adopted AIA resolution, acceleration of the decarbonization of buildings is essential. Our ultimate target is to move towards zero carbon, both operational and embodied. However, it is impossible to address all cradle-to-cradle phases of buildings in the design studio. On the

other hand, it is essential and still possible to integrate carbon footprint of both operational and embodied energy into the design process as a holistic measure of environmental impact during the design development phase since this is when design becomes detailed enough to accurately calculate operational energy and when materials are selected, which enables the calculations of embodied energy. Despite the current limitations, a simplified analysis is sufficient to generate meaningful results that help students make informed design decisions in order to reduce the carbon footprint of their buildings.

Schematic Design

Throughout the schematic design phase (SD), we will keep track of the building's utilization of daylight, its operational energy in terms of its predicted Site Energy Use Index (Site EUI), and its carbon footprint (due to operational energy only at this point). Every student (or team of students), is expected to perform energy simulation of his/her design to inform form-finding and the big design decisions. We will also establish a benchmark (for the entire studio) in order to evaluate building performance in terms of both daylight performance and overall Site EUI.

For the SD final submission, students should submit the documentation of complete environmental assessment of at least two design iterations, including the code-compliant reference design (according to IECC 2018) and the predicted EUI according to the Zero Code Energy Calculator.

Design Development

At the beginning of the design development phase (DD), we will finalize the overall design of the building and then look into the detailed design of the focus space. At this level of study we will refine building performance and verify its predicted EUI. In addition, we will also estimate the building's carbon footprint (operational and embodied) and its global warming potential customized to the electric grid (CO_2e) and material selection and sourcing. Students will input the predicted EUI into the life cycle analysis using *Athena, the Impact Estimator for Buildings,* in order to estimate the total carbon footprint due to both operational and embodied energy. Students are expected to guide the development of their envelope design based on the total carbon footprint (operational + embodied) and not only one of them regardless of the other.

For the DD final submission, every student is expected to submit a documentation of a complete estimate of the carbon footprint of his/her building (operational + embodied) and compare to the benchmark established to the entire class.

Selected Readings

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