An undergraduate topic studio focused on carbon neutral design. Instruction highlights high-performance design process and integrates Climate Consultant, the 2030 Palette, and multiple tools for energy and daylight modeling.

Course: ARC 402 Topics in Advanced Architectural Design
Winter quarter 2017
DEPARTMENT OF ARCHITECTURE
California State Polytechnic University, Pomona
Instructor: Pablo La Roche PhD

1. Abbreviated course syllabus
This topics studio in the winter quarter of 2017 was the ninth edition of the carbon neutral design studio. The studio is open to fourth year undergraduate students in the Department of Architecture at Cal Poly Pomona and meets 3 times a week for 4 hours each day, for ten weeks (quarter system).

The goal of this studio is to introduce the students to the design process of environmentally responsive, low energy, low carbon buildings. The building's environmental performance is a major focus of this studio and the students must demonstrate that their ideas perform as intended. This course is an opportunity for students to develop strong performance based analysis skills using state of the art digital tools.

The course is organized to support the design process through a combination of exercises, lectures and field trips. In the studio, students balance design issues that involve social, economic, and environmental problems using energy simulation tools to validate performance. The carbon neutral protocol developed by the instructor and discussed in the book "Carbon Neutral Architectural Design" is implemented and the projects had to respond to the requirements of the 2030 challenge.

In this edition of the 2017 studio, the students had to design a high rise multifamily building in downtown Los Angeles with a very small carbon footprint. Precedent studies investigated the relationship between the design concepts, the issues that affect them and the metrics that explain their performance, while at the same time promoting creativity through the exploration of examples of future design ideas and concepts. Metrics for energy, construction, water, waste and greenhouse gas emissions are important in this stage and students explored values in real buildings using different databases. Through this initial combination of lectures and case studies, students learned new concepts such as Energy Use Intensity EUI and Carbon Intensity CI. A visit to buildings, in which these concepts are implemented and discussed, reinforced what they learned, showing how these concepts were implemented in real buildings.

The second exercise is a site investigation to determine potentials and challenges, and generate appropriate design concepts. Students used weather files and climate analysis software combined with additional tools such as the 2030 palette to understand impacts and potential strategies. They also proposed Carbon and Energy Use Intensity goals, generating an architectural design concept that responded to the site and the goals. This means that early on, the student is asked to look at sustainability as a form giver and not as an afterthought. Students are asked to study energy flows through the building and how the building can be first used as the heating and cooling system before implementing mechanical systems.

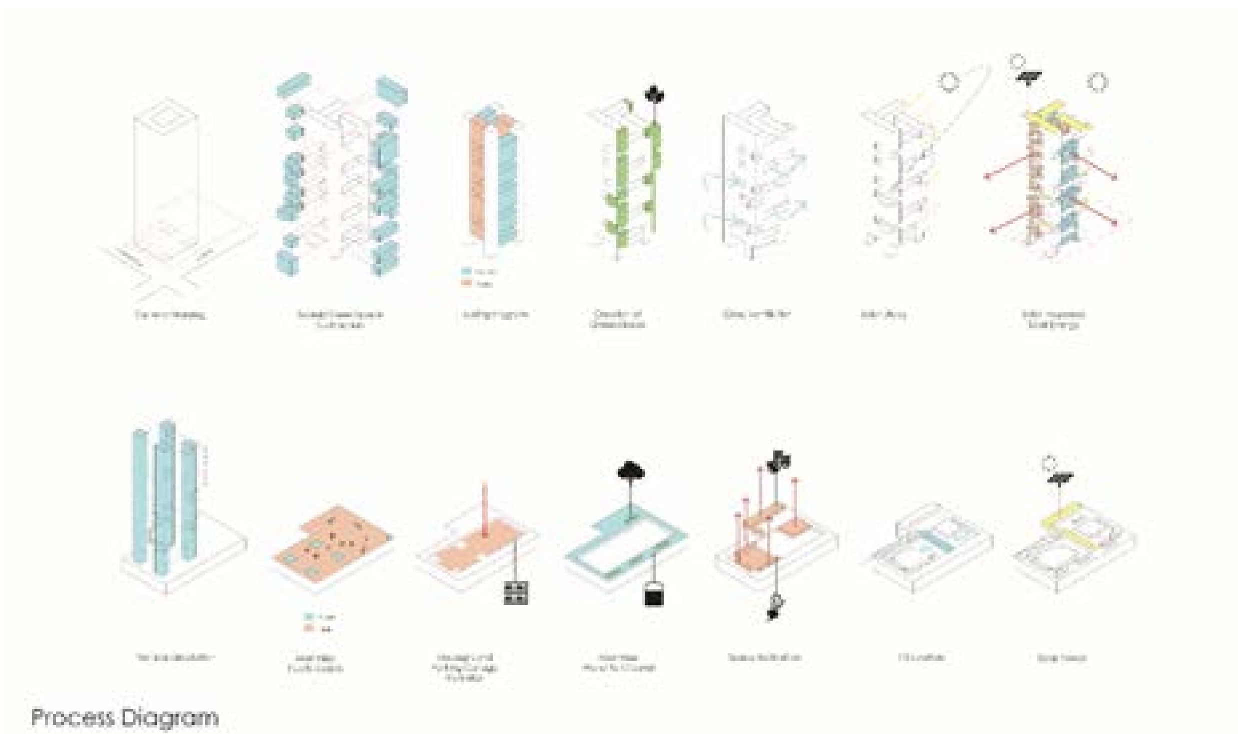
The student project evolves from the site analysis and the performance and design goals. Energy and materials are important, but water, waste, response to site and IAQ also had to be considered. Building projects had to show performance data for energy and carbon and students continuously tracked their emissions as they developed the project.

At the end of the course students have been introduced to a new design process to design low carbon buildings with a new vocabulary and tools. This process combines the generation of climate responsive design concepts with the scientific evaluation of these concepts using state of the art modeling tools. However, this is just the beginning of a necessary learning process for the students that will be the designers of the low carbon buildings of tomorrow.

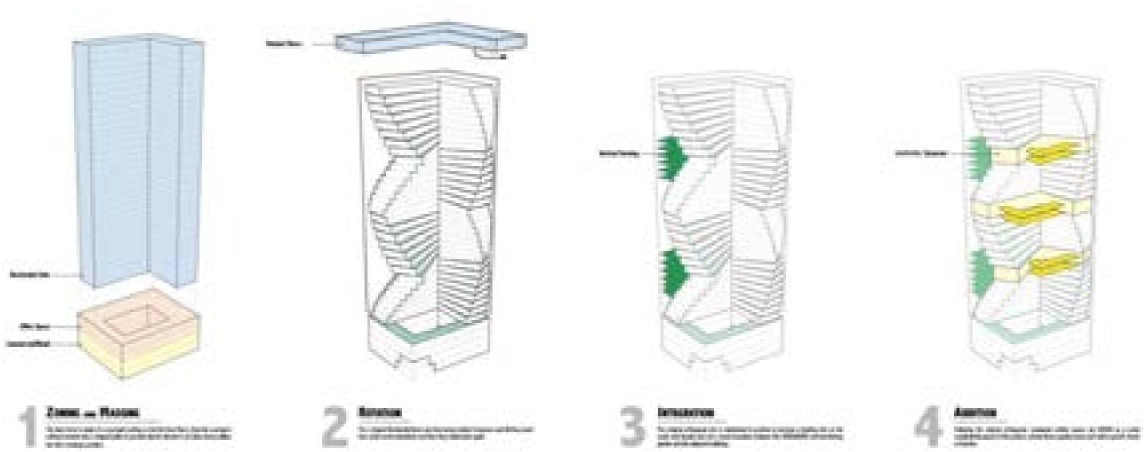
Examples of student work

Concept Diagrams

The following images include some of the concept diagrams developed by Josue Soma and Dannela Valencia to illustrate the ideas that helped shape their project.



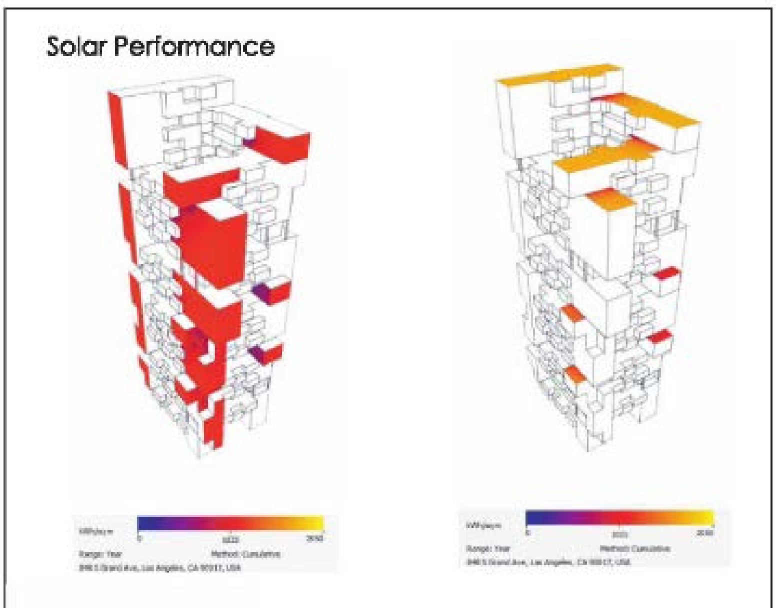
The following concept diagrams from Kayley Ryan and Youstina Yussef emphasize the integration of activities to promote social sustainability and co-op living in vertical housing with shared amenities in the spaces to the south. It is a vertical village.



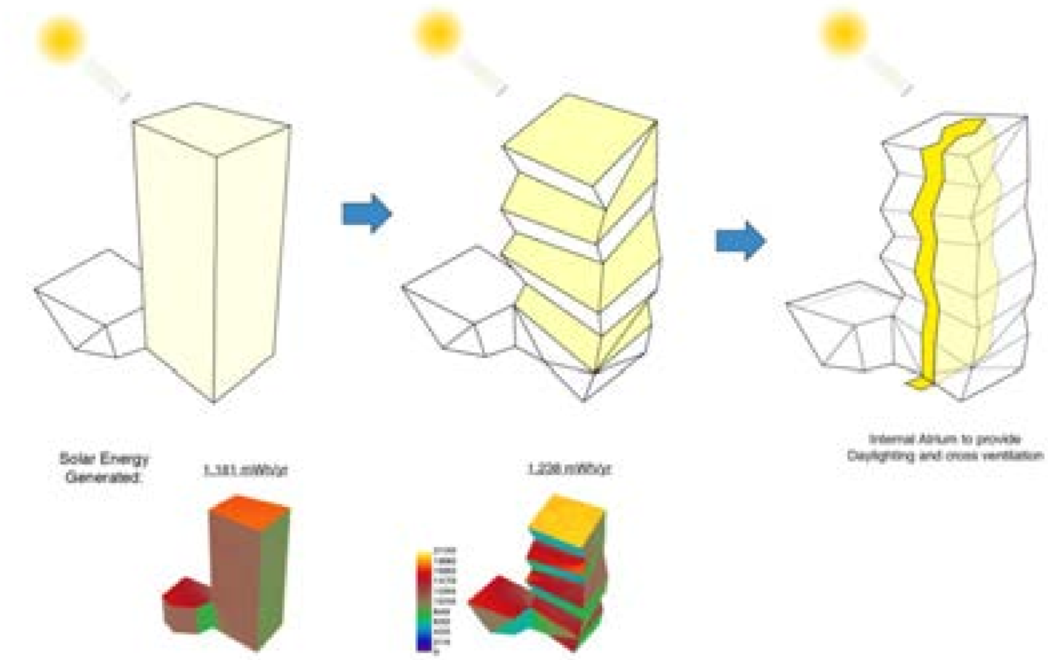
Solar Studies

Solar studies show the amount of energy falling on a surface. These studies can be seasonal, monthly, annual or by specific months and specific hours and were done at different moments in the design process. During the site analysis students the solar study helped indicate over shaded areas in the winter and overheated areas in the summer. Later it was used to evaluate concepts and test façade and shading systems. The building envelope regulates multiple types of interactions between the indoor and outdoor environments, regulating heat gains and losses, providing daylight, controlling glare and providing views when needed. A study of the envelope usually begins with a solar analysis of the facades on different orientations, calculating solar gains during peak cooling and heating hours and for the whole cooling or heating seasons. Students had to understand when and how to do these analysis properly.

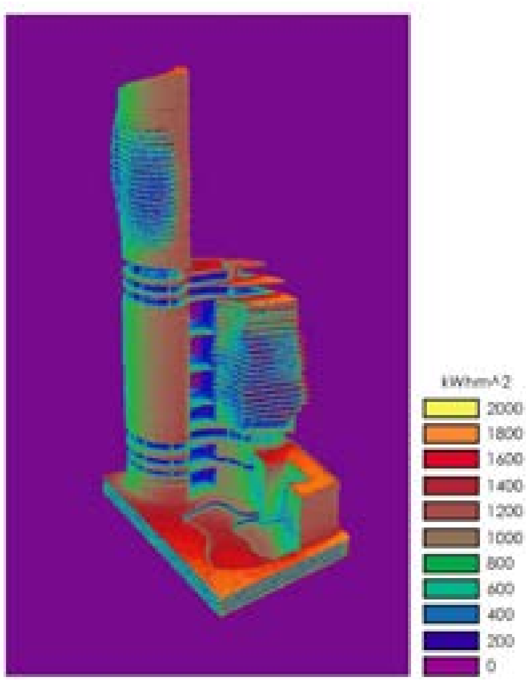
The following image by Josue Soma and Dannela Valencia includes the results to study areas with more potential for vegetation and generation of solar energy.



The following solar study by Mario Barrientos was done to determine a building form that maximized the collection of solar energy.



The following study was done to determine the best location for generation of energy in the curved surface. Students Jad Osseiranand Erick Colobong



The following four images are from a project by Stephanie Cortez and Carmelle Luminarias. Their project integrates a system to reduce smog as indicated in the last diagram. The building then becomes a filter to clean the air in downtown Los Angeles.

ELEVATION

SECTION

- SUSTAINABLE SYSTEMS

- 1. PASSIVE VENTILATION
- 2. BUILDING AIR FILTRATION
- 3. MODULAR UNIT FILTRATION PANEL
- 4. WIND TREE/ TURBINES
- 5. PV WALL CLADDING
- 6. PV PANELS/ TRANSPARENT PANELS
- 7. OPERABLE SUN SHADING
- 8. REUSABLE WATER
- 8. MODULAR WOOD UNITS
- 9. CARBON ABSORPTION WOOD/ BRISE SOLEIL
- 10. TITANIUM DIOXIDE COATING
- 12. INTENSIVE GARDEN/ GREENSPACE
- 13. EXTENSIVE GARDEN/ GREENSPACE
- 14. LIVING/ ACTIVE GREEN WALL
- 15. GREEN WALL/ HANGING GARDEN

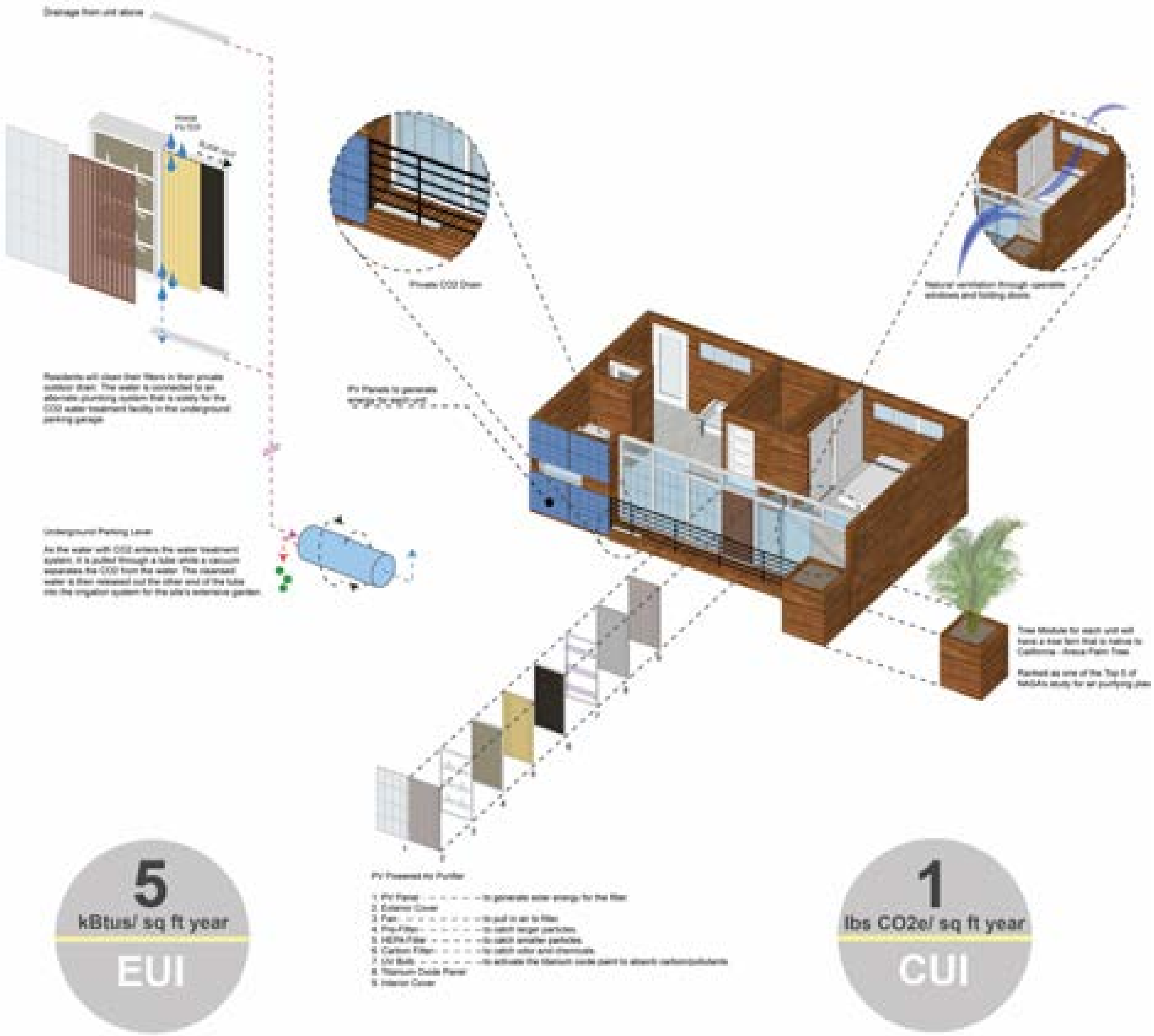
4

7

10

15

SUSTAINABLE SYSTEM
AIR PURIFYING COMPONENTS | MODULAR

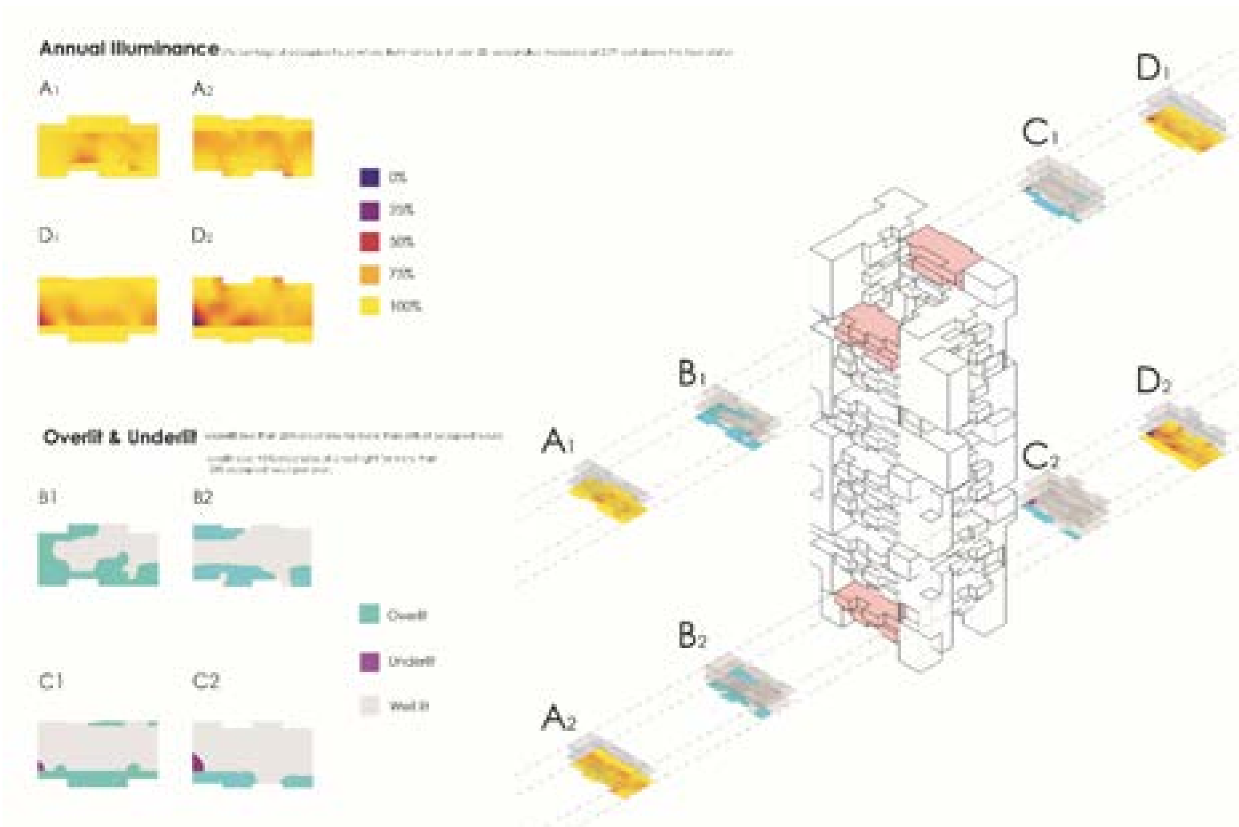


The following images from Kayley Ryan and Youstina Yussef show the development of the social sustainability and co-op living in vertical housing with shared amenities in the spaces to the south.

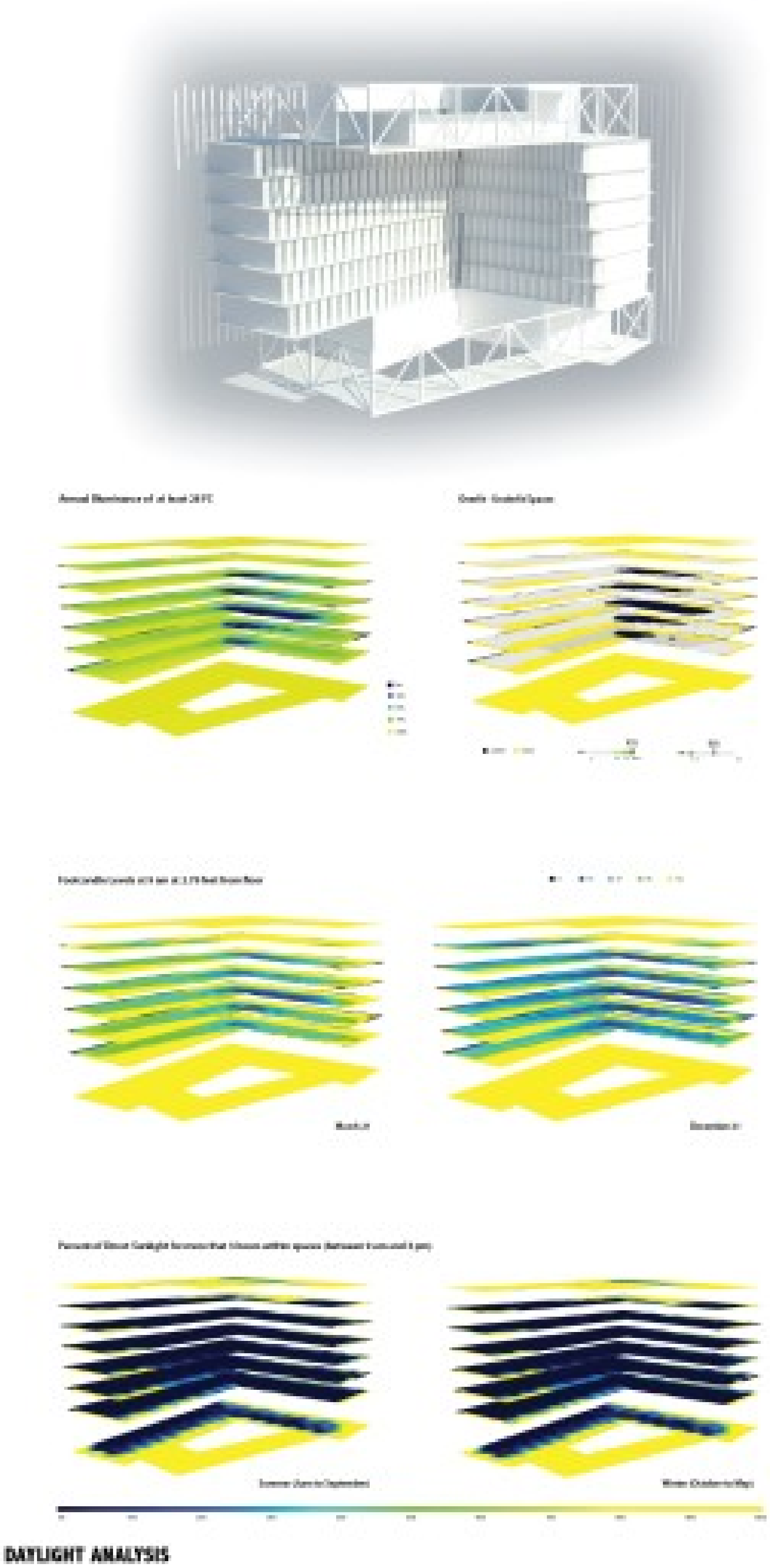

ZEN FIN
HEALTH FIN
COMMUNAL FIN
COMMERCIAL/RETAIL/OFFICE
PROGRAM

Daylight studies:

Daylight analysis is an area of building simulations in which easy to use software is now available. Daylight design typically aims to achieve required illuminance levels, avoid glare, control solar heat gain and reduce undesirable heat losses through the windows during cooler seasons, all of this while providing visual balance and an enjoyable environment. The daylit area is that part of the building in which there is sufficient daylight to provide the required illuminance levels so that electric lights can be turned off or dimmed. Performance simulations allow to quickly compare options and test the effect of different design moves on daylighting strategies. Students used daylight analysis to test envelope ideas and provide required illuminance levels.



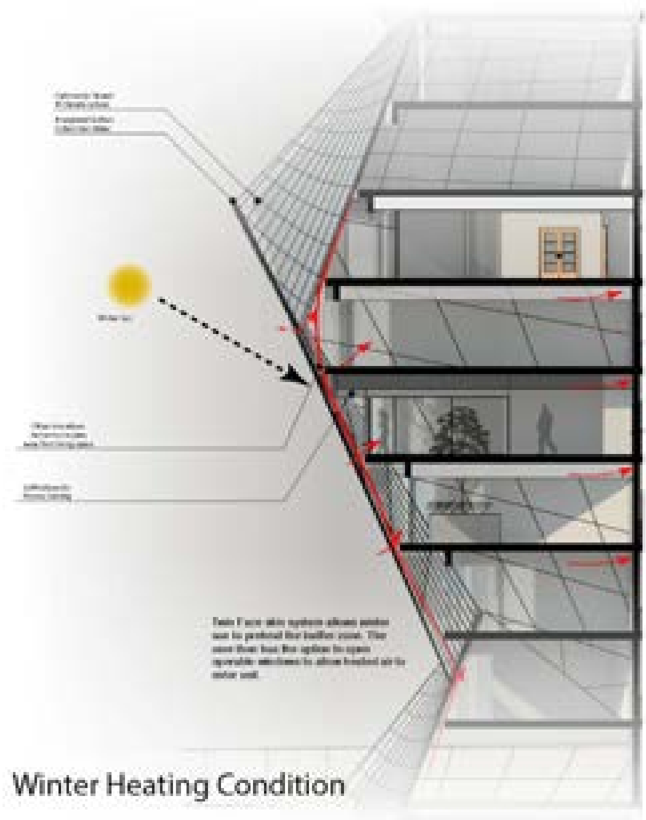
The following daylight studies are from Kayley Ryan and Youstina Yussef with the goal of providing daylight from both sides of the building.



Passive Strategies

A passive cooling system is capable of transferring heat from a building to various natural heat sinks. To achieve this, the building must have special design details, generally in some part of the envelope. Passive cooling systems provide cooling through the use of passive processes, which often use heat flow paths that do not exist in conventional or bioclimatic buildings. Passive strategies are taught as an important step in the process to achieve carbon neutrality. Students implemented many passive cooling and heating strategies that included buoyancy driven solar chimneys, natural ventilation, evaporative cooling and of course shade as a precondition.

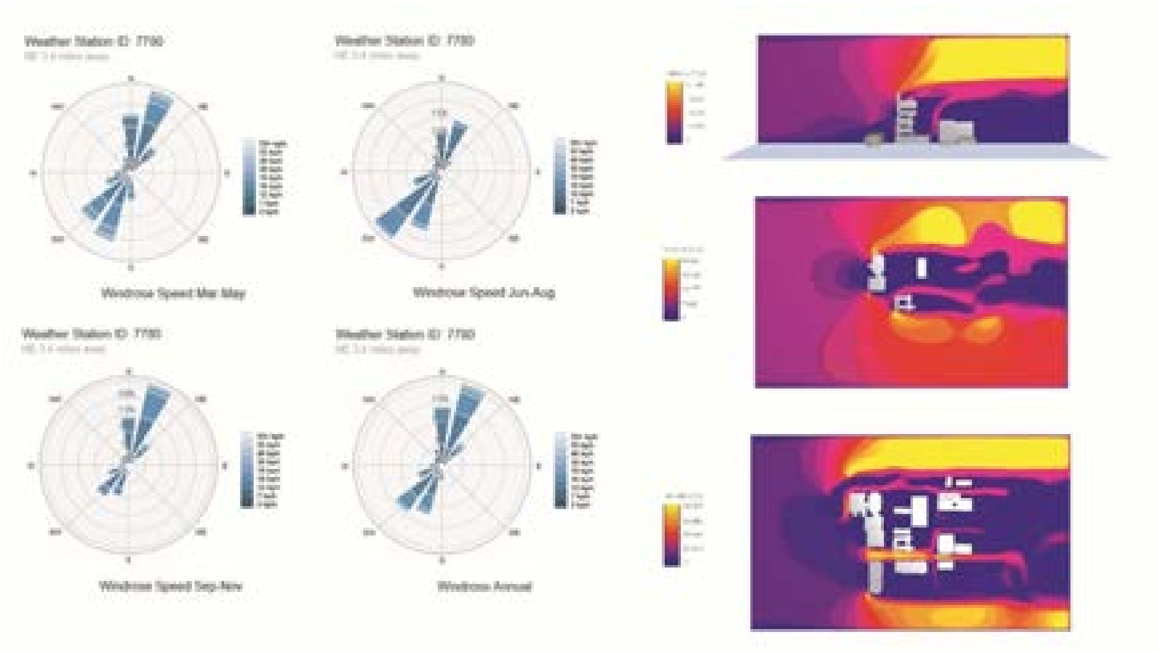
Passive heating was also implemented and the simplest method to passively heat a building is to increase solar gains to the interior of the building through direct gain systems.

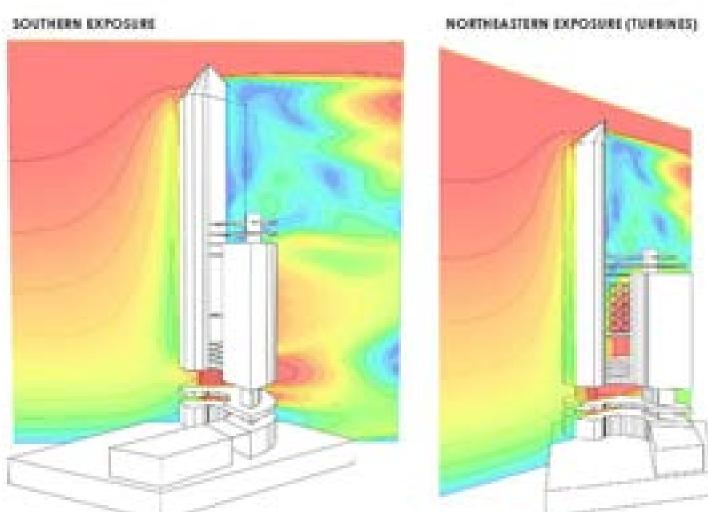


Project by Mario Barrientos

WIND STUDIES

Natural ventilation is an important strategy to increase comfort without increasing energy use. To test natural ventilation students used simple tools. The following are some wind and solar studies by Josue Soma and Dannela Valencia. Students first found wind direction and velocity from the weather file and then tested some of these with different software.





Students Jad Osseiranand Erick Colobong designed a building that maximized flow of air through a series of wind turbines.