SOCIETY OF ARCHITECTURAL HISTORIANS
SAH ARCHIPEDIA

TITLE: ARCHITECTURE AND THE ENVIRONMENT
SUBJECTS/TOPICS: ARCHITECTURE, GEOGRAPHY, HISTORY, SOCIAL STUDIES
GRADE LEVEL: 9-12 (2-3 CLASS PERIODS)
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LESSON OVERVIEW

In this lesson we will explore how environmental factors influence design and building performance, what makes a piece of historic architecture "green," and how some contemporary architects are dedicated to creating sustainable structures that beneficially impact the natural environment and the experiences of their users.

BACKGROUND

Read the following sections on the SAH Archipedia webpage: History and FAQ. Students will be using the database for research, so it is important to familiarize them with the resource and why it is valuable as an online tool.

In order to understand certain elements of architecture and its connection to the environment, students must become familiar with new vocabulary. An abbreviated vocabulary lesson is included at the end of this document.

Review the list of green architecture in SAH Archipedia. This will be a useful guide for some of the activities, especially if students are having trouble finding examples of certain environmental systems or project strategies. If students find additional projects, especially as the SAH Archipedia continues to undergo regular updates, it would be a beneficial class endeavor to update or customize the list.

Many of the exercises within this Unit are designed as a scaffolded curriculum, so it may be beneficial to consult content from the grades 6-8 lesson to see if activities could be modified and implemented for older students.

LEARNING OBJECTIVES

Assess passive and active systems that bolster sustainable practices in the built environment.

Research, present, and debate the validity and application of "green" architecture.

Differentiate between truly sustainable practices and greenwashing. In order to be green, buildings do not have to use the latest, most expensive technology: there are simple practices that can be implemented into almost any existing building to improve efficiency.

In many senses, the "greenest" building is the one already built so the field of adaptive reuse is extremely important to the future of architecture.

Explore several, contemporary rating systems used to assess the effectiveness of architectural projects (i.e., BREEAM, Green Globes, LEED, and the Living Building Challenge).

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PREPARATION

There are many definitions of sustainable design and in these lessons, we will focus on the components of sustainable design that directly relate to the built environment: architecture. As you will learn, the design and implementation of “green architecture” is much more than adding a few solar panels, wind turbines, and green walls to a project. Therefore, it is helpful to look at pre-modern and vernacular architecture to see how passive and low-tech solutions were used to harness and mediate the impact of the sun and natural forces such as wind and rain. In many senses, historic architecture forms the basis for green design: buildings were constructed with local materials and labor because advanced technologies and transportation systems were not available.

Overall, it is estimated that buildings consume 40% of the world's energy. Although that is a huge number, we have to be careful that we do not automatically associate architecture, or industry, with bad environmental practices. Energy usage is shaped more by the choices made by people using buildings rather than the buildings themselves. This is compounded by the fact that in America, we spend about 90% of our time indoors. Therefore, the environmental quality of our buildings, their immediate surroundings, and how we manage energy use in the built environment are extremely important. The proper siting of a building (e.g. location) can dramatically improve an occupant’s quality of life. Responsible energy management around and within a building also can enhance the structure’s lifecycle, reduce the environmental footprints of occupants, and, consequentially, save both owners and occupants money (approximately 5-30%).

You will be conducting visual and textual research using SAH Archipedia. Read the following sections to familiarize yourself with the project as a whole and how to navigate the database: History and FAQ.

GUIDING QUESTIONS

Can you design a building without knowing the site? What are the factors that need to be considered in site assessment?

What is the value of sustainable architecture?

What are the components of the “triple bottom line” in sustainable design?

Why is the concept of conservation critical to both architecture (the built environment) and the natural environment?

We can find examples of “green” architecture in many pre-modern and vernacular buildings, so why did we move away from a more sustainable approach to architectural design during the late 19th and 20th centuries?

CONTENT STANDARDS

Grade 9:

Key Ideas and Details
- CCSS.ELA-Literacy.RI.9-10.1

Craft and Structure
- CCSS.ELA-Literacy.RI.9-10.4

Text Types and Purposes
- CCSS.ELA-Literacy.W.9-10.1
- CCSS.ELA-Literacy.W.9-10.2

Research to Build and Present Knowledge
- CCSS.ELA-Literacy.W.9-10.7
- CCSS.ELA-Literacy.W.9-10.8

Grades 11-12:

Key Ideas and Details
- CCSS.ELA-Literacy.RI.1.1

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ACTIVITIES

Activity #1: Building Audit

- When evaluating a building's efficiency in terms of energy usage we have to look at two different forms of energy: expended and embodied. The first type, expended energy, measures how much energy a building uses, and this type of energy is the easier of the two in terms of tracking and monitoring consumption. The second type of energy we need to understand for creating sustainable buildings embodied energy. This is the amount of energy it takes to make the building: from the fabrication of individual materials to the transportation of those materials to the building's site to the labor and construction practices needed to put the building together. As you can imagine, calculating embodied energy can be difficult. If we think about the energy used in a building as an equation, we would get the following formula:
    - Embodied energy (making a building) + Expended energy (using a building) + Post-use= Lifecycle analysis

- With this formula, it is clear that in order to really understand how “green” a building is, we need to look at the entire building process. We also need to do some research on specific elements of the building, such as the materials. If a material comes from nature, or a company markets a product as sustainable, we still need to dig deeper to complete a full assessment about whether it is actually good for the environment:
    - How was it harvested? Was another plant put in its place? How many years does it take for the plant to regenerate?
    - How far did the material travel to get to the site?
    - What does it take to maintain the material, or system?

- Just because a material is advertised as sustainable does not mean it actually is. For example, there are some building materials on the market that are advertised as sustainable because they use recycled elements (i.e. plastic bottles, wood chips), but when these elements are assembled into new, composite materials, they make material systems that do not easily break down. Once that “recycled” material is at the end of its lifecycle, it will simply sit in a landfill for decades or even centuries.

- We also need to think about the social impacts of architecture in our evaluation of sustainability. As architect William McDonough said, buildings cannot just be “less bad” but, instead, they need to actively contribute to the quality of life for humans and the environment as a whole.
    - Does the building beneficially impact its inhabitants?
    - Does it beneficially impact the surrounding community, both in terms of human interaction and ecological systems?

- Complete both the Building and Energy and the Environmental Consideration worksheets for this activity.

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Activity #2: Building Rating Systems

- There are several rating systems for new constructions and renovation projects that encourage a holistic approach to the built environment, such as LEED (Leadership in Energy and Environmental Design) from the United States Green Building Council, Green Globes for North America, and the Living Building Challenge. These system encourage designers to select building technologies and materials that are "green": they use materials that are biodegradable, recyclable, and made from renewable resources and that have been manufactured in a way that have not damaged the environment. Overall, the buildings are made with long-lasting and low-energy use products, such as specialized light bulbs and thermal glazing. These buildings consume less energy than market standards: they use sensors, timers, and motion detectors to control energy use to fixtures and they ask inhabitants to be more active within the manipulation of the environment to reduce energy consumption, such as adjusting shades to block unnecessary light and reduce cooling loads. These buildings have recycling plans for waste: they establish areas for collection of recyclable materials by type (paper, plastic, glass, vegetable matter), and they may use composting for gardening and the surrounding grounds. Rainwater may be captured and collected for irrigation and there may be options for the use of gray water from non-contaminated sources in the building, such as toilet flushing.

- Read about these different systems and take notes about their overall goals: how are they similar, and how are they different? Create a bubble diagram that illustrates the main assessment categories for these three building rating systems. Some of the categories may have different names, but their goals are similar; identity these rating systems' "synonyms" graphically, such as using similar text bubble shapes or colors.

- Write a brief reflection addressing the following elements:
    - Does it cost more money to design or renovate a project to a building system's standards?
    - Do you think adherence to a building rating system should be mandatory in the US for all new constructions and adaptive reuse projects? Why or why not? Support your position with direct evidence.

- Now, take a deeper look into a specific LEED project and prepare a digital presentation for your classmates.
    - Select a LEED project from SAH Archipedia.
    - Research the project using sites such as the architect or engineer's website, as well as online architecture journals. The questions and worksheet from the Building Audit activity may help guide your work.
    - Find the LEED scorecard for the project. For example, the Tioga Library Building scorecard can be found here.

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Activity #2, continued

- For your project, answer the following:
    - What LEED rating system was used and, if necessary, explain the system? You will see there are several LEED categories, depending on the system: NC, BD+C, EB O+M, C+S, ID+C, Homes, multifamily mid-rise, ND, Schools, Campus, and Volume.
    - What level of certification did the building achieve and how did it earn points?

- Make an original annotated image that explains the building and its approach to sustainable design. Use graphic presentation software such as Adobe CC, GIMP, or an interactive ThingLink.

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Activity #3 Usonian Visions

- In 2019, eight of Frank Lloyd Wright's 20th-century projects in the US were elevated to the UNESCO World Heritage List under a thematic nomination. With more than 500 built projects to his credit, it is significant that one of the projects cited in the UNESCO nomination is one of his "Usonian Houses": the Herbert and Katherine Jacobs House (1936). Responding to rising housing needs for the middle class, Wright designed a series of modern houses for the typical American family. Criticizing the work of his architectural contemporaries abroad, such as Le Corbusier (1887-1965), who embraced an industrialized and austere form of modernism and said that the house was a "machine for living in," Wright wanted to construct modest but well-detailed houses. Reminiscent of some of the earliest known forms of architecture, Wright typically placed the hearth at the center of his Usonian residences. This could be a fireplace, or another essential space that featured the essence of the hearth in terms of a gathering place, but with more advanced tools for cooking: the kitchen. The Usonian houses were intended to cost only $5,000 and they were efficiently designed structures: to conserve space within the small footprint, the houses typically featured built-in furniture and lighting fixtures. Abandoning plaster or other surfaces that would need to be embellished with decorative wallpaper or paint, Wright used a more natural material palette of wood and brick. Built on concrete slabs, the simple foundation system was more weather-resistant and radiant heat coils were embedded into the core to generate an effective heating system.

- Using the UNESCO report, the Jacob House SAH Archipedia entry, and other independent research, make a list of the characteristics of a Usonian project.

- Now, research a specific Usonian project on SAH Archipedia.
    - You can search on SAH Archipedia a few different ways:
        - Search for "Wright" then Filter by Type on the left side of the screen; select "dwellings." There are a number of Wright projects on the SAH Archipedia. Some of these projects fall within Wright's *oeuvre* of Usonian and organic architecture, yet they are not tagged with the metadata "usonian." Also, try using "usonian" in the search bar then filtering the search through the "Building Entry" option on the left menu. Are there additional projects that should have the "usonian" metadata tag? If so, which ones, and why?
    - Find essential information about the project date, location, regional climate, clients, and current condition using other online architecture sources, such as the Frank Lloyd Wright Foundation, the PBS Usonian House resource, individual websites for Usonian projects if they have been converted into museum, printed sources such as *Wright's on Architecture: Selected Writings 1894–1940,* and others.
    - Craft an original summary of the project, citing relevant sources and pair this textual synthesis with an original annotated image that illustrates the building's main features and how the project interacts with the environment.

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Activity #3, continued

- As a class, create a graphic record of Wright's various Usonian projects from SAH Archipedia.
    - Create network diagram of the Usonian projects and architects (not just Wright), mapping how the architects were interconnected (e.g., master to apprentice, design to builder, etc.). In terms of mapping the projects, notice how there are a few clients with multiple projects.
    - Use Google Maps to create a map. Change the icons and associated colors to illustrate different aspects of the projects. Create a key for your map's visitors. Generate a virtual tour with embedded links.
    - In the map, what geographic trends do you notice? Are there any specific climate regions without Usonian houses?

- Push your explorations beyond Wright's work. Many architects have taken on Wright's challenge to build modest, well-design, and affordable residences. These projects are often constructed using different building systems and materials, and in challenging locations. Like Wright's Usonian projects, these buildings are experiments. For example, explore the design-build student project for the Rosie Joe House (2004) in Bluff, Utah, by DesignBuildBLUFF. Is this a 21st-century example of a Usonian house? Why or why not?

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Assessments:

All of the activities could easily be a longer-term research and reflection projects, consisting of work time both in and out of the classroom.

General Comprehension Quiz:

- [Short Answer] What are the associated components of the acronym LEED?
  Answer: Leadership in Energy and Environmental Design

- [Fill in the blank] The greenest building is the ____ ____ ____ .
  Answer: one already built

- [Essay] Explain the difference between passive and active systems in sustainable design in the built environment. Provide two examples of each.
  - Passive: daylighting with windows, sunshade to reduce solar gain, operable windows to allow for air circulation, rainwater collection
  - Active: PV panels for solar energy collection, wind turbines for energy collection, low-flow fixtures in bathrooms, waterless urinals
  - This could be administered as an illustrated essay and students could find project examples from SAH Archipedia, bolstered by information from the affiliated architect's website.

Activity #1 Building Audit

- With research using various tools, student should create rich, interrogative projects. Encourage them to ask questions about the design and its response to the site and climate. Their presentations should not just be explanatory but also critical of the building and its resultant impact on the environment: is it truly "green"? What is the predicted lifecycle? How can we assess the value of the building for inhabitants and the community?

Activity #2 Building Rating Systems

- It is estimated the 75% of the built environment will be newly constructed or renovated by 2035. For an extra challenge, complete this activity using an adaptive reuse project.

- For a broader discussion of architecture and the environment at a global scale, with direct connections to policy, explore the UN's Global Sustainable Development Goals. How is this initiative different than building rating systems? What elements of the goals directly relate to the building environment; how and why?

Activity #3 Usonian Visions

- This is project that can be used as an example to search SAH Archipedia as a class: Weltzheimer-Johnson House (1948-1949) in Oberlin, Ohio, by Frank Lloyd Wright
- Students may find Usonian-inspired houses by other architects. For example:
  - William L. Copeland house (1960-1962) in Atlanta, Georgia, by Robert Green (Wright's former student)
  - Rush Creek Village (1954-1976) in Worthington, Ohio, by Theodore van Fossen (who made furniture for several of Wright's projects) and Richard and Martha Wakefiel

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Lesson Extensions and Resources:

- See the Architecture and the Environment Bibliography

- Era of the Anthropocene from the Smithsonian Magazine

- In terms of visualizing information, Information is Beautiful is an incredible site with a wealth of topics. To explore the process, watch Making Data into Art. The following are of interest for architecture and environment:
    - When Sea Levels Attack
    - How Do We Get to Zero Greenhouse Gas Emissions?
    - Methane

- If you would like to see some inspiring TED Talks about architecture and forwarding-thinking design:
    - William McDonough speaking on his concept of 'cradle to cradle' design
    - "Norman Foster: Building the Green Agenda"

- One of the best ways to improve the energy performance of new buildings is to understand how we use energy within existing buildings. Check out this great series of infographics on energy use in New York City.

- Additional student design/build programs:
    - Auburn University's Rural Studio
    - University of New Mexico's ecoMOD
    - Tulane University URBANbuild + Small Center for Collaborative Design
    - Yestermorrow Design/Build School

- Additional online architecture and sustainable design resources:

  Arch Daily
  Architectural Record
  Architect
  Architizer
  Bustler
  Detail
  e-architect
  Harvard Green Building Resource
  Journal of Architecture
  Journal of Architectural Education
  Journal of Green Building
  Places
  Treehugger

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General Architectural Reference (with an American focus)

The Buildings of the United States series from the Society of Architectural Historians and the University of Virginia Press.

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ARCHITECTURE AND THE ENVIRONMENT: BUILDING AND ENERGY WORKSHEET

Part 1. Location and Transportation

Question	Yes/No
Does your residence have access to public transportation (e.g. bus, ride share)?	
Is your residence located within walking/public transportation access to: …a grocery store?	
…. to community resources (e.g. convenience store, farmer's market, pharmacy)?	
…. to services (e.g. gym, bank, laundry)?	
…. to civic/community resources (e.g. library, park, post office, worship, police/fire)?	
Is your residence in what the USGBC calls a "high priority area" [and for what]? [e.g. historic district, brownfield redevelopment (formerly polluted site)]	
Is your residence built on environmentally sensitive land (e.g. prime farmland, flood plain, threatened natural habitat, < 50 feet from wetlands, or < 100 feet from a body of water)?	
Does your residence have access to a bike share or bike parking?	

Reflection Questions – Part 1

1. In what ways does your residence's *location* affect your environmental footprint, and your relationship to the neighborhood and greater area?

2. Identify at least two things you could do right now to increase your use of public or green (e.g. a bike) transportation systems.

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Part 2. Sustainable Sites

Question	Yes/No
Does your residence have aesthetically pleasing views to the exterior?	
Does your residence have dedicated outdoor space (e.g.: adjacent outdoor areas for use)?	
If yes, does your outdoor space have pedestrian-oriented paving or space for social activities?	
If yes, is there a garden with a diversity of vegetation?	
If yes, are there signs of a healthy natural habitat?	
Does your residence have on-site rainwater management (e.g.: bioswale, rain garden, rain barrel)?	
Does your residence's site have natural shade (e.g. trees or vines)?	
Does your residence's site have built shade devices (e.g. trellis, porch, awnings)?	

Reflection Questions – Part 2

1. To what extent does your residence's site (immediate surroundings) contribute to your sense of community, and your relationship to the natural environment?

2. Identify at least two things you could do right now to enhance your residence's site.

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Part 3a. Energy Assessment

In evaluating your residence, inspect only locations that: (1) are SAFE and (2) you have PERMISSION to enter. Complete this exercise with caution; if you are unsure about safety or whether you should be in a given location to answer any of the below questions, please write "N/A" in the answer box.

Check for air leaks: hold a feather or lightweight piece of string in front of the areas noted below; if the feather or string moves [even slightly] there is airflow. Answer whether there is air flow at:

Item	Yes/No
Electrical outlets	
Switch plates (light switch covers)	
Window frames	
Baseboards (where walls meet floors)	
Weather stripping around doors	
Fireplace dampers - are they closed when not in use?	
Wall – or window – mounted air conditioners	

Lightbulbs: Number of incandescent (old-fashioned) light bulbs? _________
Number of compact fluorescent lights or LED's? ____________ (much more efficient)

Item	Enter a number
Number of electronics/appliances plugged in when not in use	
Number of electronics/appliances unplugged when not in use or attached to a power strips to eliminate phantom power	

Building apertures: daylight, shade, and insulation	Enter a number
Number of windows in your residence	
• North facing (diffused light; can cause significant winter heat loss if not properly insulated)	
• East facing (morning light)	
• South facing (strongest/longest light; can cause significant heat gains in the summer)	
• West facing (afternoon light)	
Number of doors	
Number of windows with exterior shading devices (e.g. awnings, overhangs, operable shutters).	
Number of windows with interior shading devices (e.g. blinds, curtains, interior shutters).	

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Part 3b. Appliance Assessment
Go to: https://energy.gov/energysaver/estimating-appliance-and-home-electronic-energy-use. Once there, scroll through the list and identify at least five appliances that you use frequently. Then find their wattage information here: http://hes-documentation.lbl.gov/calculation-methodology/calculation-of-energy-consumption/major-appliances/miscellaneous-equipment-energy-consumption/default-energy-consumption-of-mels.

Complete the following table:

Appliance	Energy use (annual)	Estimated cost (annual)
1.		
2.		
3.		
4.		
5.		

Reflection Questions – Part 3

1. Which energy efficiency issues did you discover in your residence that surprised or concerned you? Why?

2. How does your residential energy use relate to both your budget and your environmental footprint?

3. Identify at least two things you could do right now to improve your residential energy efficiency:

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ARCHITECTURE AND THE ENVIRONMENT: ENVIRONMENTAL CONSIDERATION WORKSHEET

Environmental consideration	Description + source(s)
Geomorphology + Topography (e.g.: What are the geological and hydrological conditions? How does the altitude impact temperatures and air pressure?)	
Latitude + Longitude (e.g.: What is the relationship to the sun, prevailing winds, and climate zones?)	
Flora + Fauna (e.g.: How do the plants contribute to shading, wind breaks, or create precarious situations within soil? What animals are in the area and how are they impacted/how can they impact the built environment? Are there any rare, invasive, and/or predatory species?)	
Water (e.g.: Is there scarcity or overabundance, such as floods? What type of water – salt, freshwater, brackish?)	
Materials (e.g.: What is available, scarce, or overabundant in the area? How are materials brought to the site, how are they assembled, and how are they maintained?)	
Culture (e.g.: Who lives, works, and/or plays here? Is it urban, suburban, or rural? What are the major human needs and wants for the area?)	

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Green Architecture on SAH Archipedia

The following "green" projects can be found on SAH Archipedia; this is just a sampling and there are many more to explore. For the more contemporary projects, it would be useful for the students to explore affiliated websites for the architects, engineers, and builders in order to learn more about the sustainable systems and building's overall intensions (ex. William McDonough + Partners project)

- Alta Vista Elementary School Addition (1957)
- Aqua Tower (2007-2010)
- Atlantic Station (1995-2006)
- Atwood-Higgins House (1730; 1919-1962)
- Austin Resource Center for the Homeless (2004)
- Baer House (1971-1972)
- Bateson Building (1977-1981)
- Benewah Medical Center (2012)
- Berry College (1850-present)
- Bogue Supply Building (1904; 2001)
- Borden Building (1907-1908; 2007-2009)
- Bowersock North Shore Power Plant (2011-2013)
- California Academy of Sciences (2000-2008)
- Cass Technical High School (2005)
- Cedar Street Bridge Public Market (1893-c.1926; 1983-2005)
- Center for Advanced Energy Studies (2005-2008)
- Cherokee Mountainside Theatre (1949-1950)
- Cordova House (1848)
- Cosanti (1956-1974)
- Dam no. 4, Hydroelectric Plan (1909)
- Detroit School for the Fine and Performing Arts (2005)
- Ford River Rouge Center (1917-1938; 2004)
- Frey House II (1963-1964; 1972)
- Eagle Sanctuary (1995-1999)
- Eli and Edythe Broad Art Museum (2010-2012)
- Equitable Building (1944-1948)
- Georgetown University (1792-present)
- Googleplex (2004; 2013)
- Greater World Earthship Community (1994-present)
- Greensburg City Hall (2008)
- Harley-Davidson Museum (2008)
- Herman Miller Greenhouse (1995)
- Intermountain Gas Company HQ (1965)
- International Quilt Study Center and Museum (2004-2008; 2012-2015)
- Islandwood (2002)
- Kauffman Farm (18th and 19th c.)
- Laboratory House (1950s; 2003)
- Lady Bird Johnson Wildflower Center (1995)
- Lone Mountain Ranch House (2010-2012)
- Massachusetts Museum of Contemporary Arts (1872; 1999)
- Mattress Factory Building (1907-1912; 2002-2003)
- McLauthlin Building (1856-1864; 1979)
- Monticello (1768-1826; 1934-1941; 1979-1994; 1993-2002)
- Mystic River Restoration (1893; 2009)
- National Museum of American History (1955-1964)
- Nature Conservancy HQ (2010)
- Paccar Environmental Technology Building (2014-2016)
- Park East District (2008)
- Rapid Central Station (2004-2005)
- Richard E. Dill House (1936)
- Rosie Joe House (2004)
- Simmons Hall (2002)
- Sky City Cultural Center and Haak'u Museum (2000-2006)
- Solar Building (1955-1956)
- Sunset Magazine Demonstration Desert Garden (1963, 1971)
- Target Field (2007-2010)
- University of Arizona Poetry Center (2007)
- Wayne Clough Undergraduate Learning Commons (2002-2011)
- Wells Fargo Center (1972-1976)
- Wetland Discovery Point (2009)
- Whitney Water Purification Facility and Park (1997-2005)

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Architecture and the Environment Vocabulary

There are several important vocabulary words we need to understand in order to proceed with our lessons on sustainable design. Read the definitions below.

- **active environmental system:** any element or system of elements that function with moving parts and require regular user input. For example, a solar photovoltaic panel (PV) is an active solar device. The opposite of a passive system, but they often work together effectively.
- **adaptive reuse:** the conversion of a building, structure or area into a use other than that for which it was originally designed; this can often a 'green' practice since it saves existing structures and their associated embodied energy instead of completely demolishing a site
- **adobe:** thick earthen walls, effective thermal mass
- **apertures**: openings in a building, such as doors, windows, and skylights
- **brownfield:** a property that has or may have hazardous pollutants or contaminants; these need to be remediated (restore the soil, water, etc. to prevent further environmental damage) before redevelopment happens
- **building envelope:** the elements of a building that enclose conditioned spaces through which thermal energy may be transferred to or from the exterior or to or from unconditioned spaces. The major elements of the building envelop are the walls, windows and doors, the roof, and the floor or foundation.
- **cladding:** the exterior, protective and decorative layer of the building; this is separate from the structure
- **conditioned spaces:** the portions of a building that are mechanically heated or cooled; examples are rooms that have air conditioning
- **daylighting:** the use of the sun, instead of candles or electrical lighting, to illuminate interior spaces
- **ecology:** the interrelationships of living things to one another and to their environment, and the study of these interrelationships
- **embodied energy:** the amount of energy associated with extracting, processing, manufacturing, transporting and assembling building materials; a completed building has embodied energy
- **energy:** the potential to do work; power
- **energy flow:** the movement of potential/power from one part of a system to another
- **energy auditing:** the examination of the energy systems in a house as used by the current residents
- **energy ratings:** comparing existing houses to standard prototype residences
- **entropy:** the tendency for energy/matter to erode or become less organized over time in a system.
- **existing conditions:** the state of a site previous to the action of the designer. This includes all elements in the landscape and their arrangement. An existing conditions map, often call a base or index map, identifies and communicates these elements and often notes any particular challenges or opportunities. For design process purposes, it is essential that an architect fully study the existing conditions to understand key elements such as the environmental factors that may impact the site and the available, local material resources
- **feedback:** outputs of information, materials, or energy from a system. Positive feedback means that things are working well in the system; negative feedback means that one or more things need to be optimized in the system. Continually monitoring and management of feedback is important for getting the most beneficial and efficient results for a system.
- **glazing:** the use of glass in a building; to reduce solar gain and maintain indoor temperature balances, glass systems can be doubled, insulated and/or tinted
- **greywater:** water from bathroom sinks, showers, and any other non-kitchen and toilet fixtures. In terms of sustainable design practices, harvesting and reusing greywater can be a particularly valuable resource on a site.
- **infiltration:** accidental leakage of outside air into the building; major source of convective heat transfer through the building envelope

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- **insulation:** a material that helps maintain temperature consistencies (heating or cooling) for parts of a building
- **lifecycle analysis (or assessment):** tracking the environmental consequences and energy needs of material systems from resource extraction, through manufacturing and construction, to service-life performance, providing a powerful tool for measuring resource and energy efficiency
- **Life Cycle Cost Analysis (LCCA):** a method for assessing the total cost of facility ownership. It takes into account all costs of acquiring, owning, and disposing of a building or building system
- **microclimate:** a small-scale climate usually resulting from a variation in solar gain (exposure vs. shade), wind patterns (still vs. calm), water flows (still vs. moving), and/or human-derived heat sources.
- **passive environmental system:** any element or system of elements which function without moving parts or regular user input. For example, a south facing wall of glass is a passive solar device since it naturally adds heat to a space. The opposite of an active system, but they often work together effectively.
- **recycled material:** a remade or repurposed item that can be used for building construction
- **renewable:** usually referring to sources of energy or materials that are produced in relatively short timeframes; an element that can be harvested and then replaced, however the amount of time needed for renewal can be variable.
- **solar energy:** photovoltaic (PV) panels collect energy from the sun that can be harvested and distributed for use in building systems. For the maximum annual solar gain, the panels should be tiled to be perpendicular to the sun at its zenith. For optimal tilt, it is important to know the latitute to know the position of the sun; elements that can reduce the effectiveness of PVs are humidity, cloud cover, pollution, and shadows.
- **solar heating:** evacuated tube solar hot water heaters are vacuum glass cylinders filled with water, glycol, and a copper tube that collect heat from the sun and convert it into steam to generate hot water for bathing, kitchen use, or radiant floor system. They work with a closed flow loop and are very efficient since 92% of the thermal energy collected can be used within the system.
- **specific heat:** the heat holding capacity of a material or surface; water and stone can hold heat well, so they have a high specific heat.
- **stack effect:** the buoyancy of warm air
- **thermal mass:** heavy materials with the highest specific heat (ability to hold heat) such as stone, water, or earth that store incoming solar heat (during sunny hours) and then re-radiate the heat when there is little or no solar gain. It is important to get the most sun exposure, so in the northern hemisphere elements using thermal mass are usually found on the southern side of a structure. In the built environment, structures with thermal mass are particularly effective where temperature fluctuations are high, such as the desert.
- **ventilation:** the way air moves through the building; this can be with passive systems (i.e., open windows, cool air entering at a low level then hot air rising and escaping through high windows) or active systems (air conditioning or heating)
- **Venturi:** this is the effect when air or water increases speed through tunnel because of constriction. A Venturi can happen unintentionally in a building or natural condition, but it can also be a designed element in the built environment that effectively generates passive cooling.
- **Volatile Organic Compounds (VOC):** Off gasses from such products as carpet adhesive and paint usually that often cause allergic reactions or can aggravate asthma. Most green buildings employ low-VOC (or no VOC) products.
- **walkability**: a measure of how friendly an area is to walking
- **waste:** a misplaced resource; this is typically an unintentional and unwanted output of a system. Systems that are the most efficient, naturally, or the best designed are able to match inputs with their waste to create a closed loop, or at least one with minimal waste.
- **windbreak:** a natural, biological or built feature that deflects or slows the flow of air.

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