2011

Solar hot water, Daylighting

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Solar hot water

Three times the performance and one tenth the cost of PV

There are three general types of solar water heaters. Integral or passive solar water heaters are essentially a simple black tank in an insulated box with a window. They are reliable and inexpensive. Thermosiphon systems use the reduced density of hot water to drive circulation from a flat plate, tube or tank collector to an insulated storage tank set above the collector (or with special valves below it). Active solar systems use a pump and controller to transfer hot water from a collector to a remote well insulated storage tank - highest performance, highest cost, most unreliable. PV pump systems will work even when the power system is down.

In a survey of solar water heaters in New England in 1981 many mistakes were found in installation. Although 31 of 170 were outstanding and 50% were rated good, 12% were unsatisfactory for a variety of reasons. Poor orientation, inadequate or problematic mounting on the roof, lack of pressure relief valves (required by code) and use of inappropriate materials were the most common problems. No integral heaters were included in this sample, but they performed best in a comparison study undertaken by Rodale. Poor pipe insulation is a common problem. Experience helps!

The solar water heater lab

Students will build and test simple solar water heaters. They are always surprised how well they can do with some clear plastic, cardboard, newspaper and a black water container.

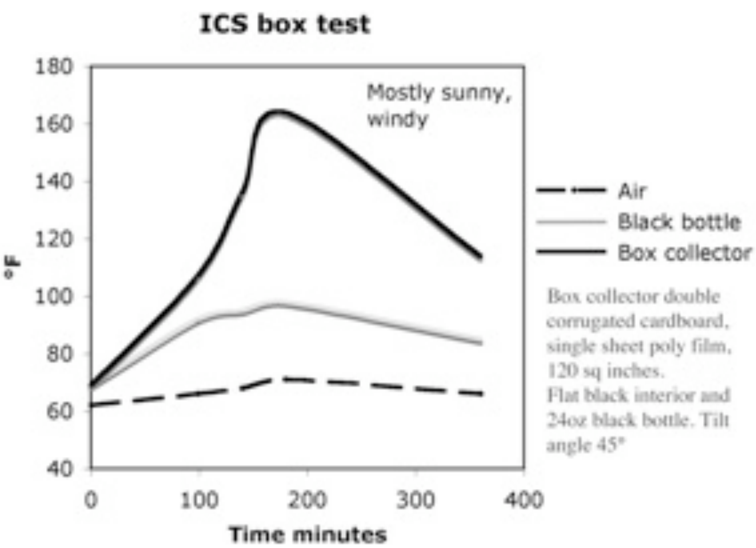
Materials – cardboard boxes of various sizes, newspapers (for insulation), aluminum foil, tape, clear plastic film or bags, assorted sticks and string to help stabilize reflectors, bubble pack, flat black cardstock and/or flat black paint (fast drying), liter bottles prepainted flat black – one per student or per team.

Tools – scissors, razor knives (Band-Aids)

Equipment – IR radiant thermometer or dial type stem thermometers (200°F). If the IR thermometer is used the glazing must be easily removed to read the back of the bottle. The dial type can extend through the collector box into the bottle.

Students are given thirty minutes to create a solar water heater using these simple materials. Temperatures are recorded every fifteen (or thirty) minutes after completion by the designer. After the models are completed and while they heat up students are introduced to copper pipe cutting, soldering and assembly – making pieces for a flat plate collector, selective surface tape, and pipe insulation types.

ICS water heater test



The student or team with the highest temperature wins a prize. All students or teams will turn in a photo and description of their collector and a performance report. Reporting requirements include glazing area and type, tilt angle, sun conditions, insulation type and R value (if known), and water volume. These will be correlated to provide some idea of glazing to water volume ratios and performance.
The instructor monitors air temperature and a black bottle.

Alternative Lab
If more time and shop tools are available it is possible to design and build small ICS systems in a few hours (in more temperate climates). This is a good team activity for 4-6 students. These can installed on campus facilities, raffled, offered as a prize, or provided to a local NGO. For plans see builditsolar.com.

In colder climates a flat plate or evacuated tube system might be assembled. See for example www.facebook.com/video/video.php?v=1055490620753

Working with a licensed solar contractor would offer students important lessons on professionalism and permitting.
For further information on ICS design see: Bainbridge, D.A. 1981. *The Integral Passive Solar Water Heater Book*. Passive Solar Institute, Davis, CA. (free on-line at builditsolar.com). Also recommended: F. A. Brooks. 1936. *Solar Energy and Its Use for Heating Water in California*. UC Extension, Bulletin 602..

Solar cooker

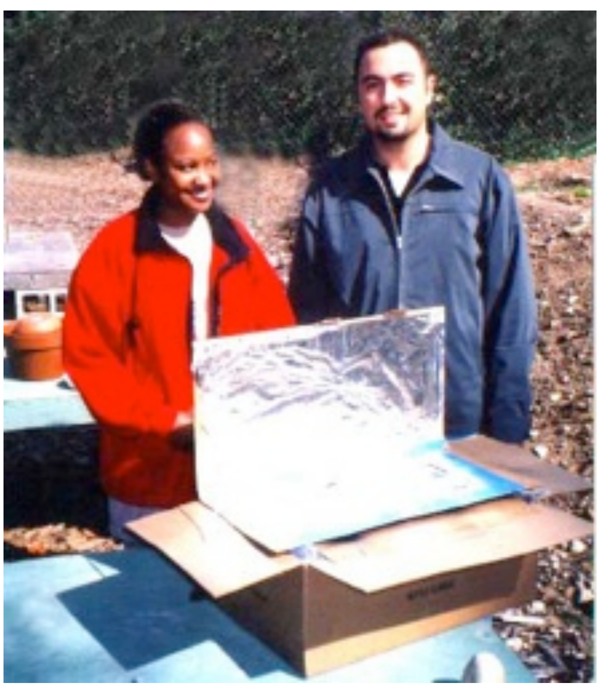
Many foods cannot be eaten without cooking, the sun provides a simple method for cooking in areas with considerable sunshine.

SOLAR ENERGY CAN COOK FOOD, HEAT WATER AND STERILIZE FOOD AND WATER

A simple solar box cooker can be effective in many areas of the world. A glazed insulated box with reflectors may reach 450°F and can cook, bake and prepare almost any food. For improved performance the solar oven should track the sun. Look on the worldwide web for more info on solar box cookers. If there is an active solar cooker group in town they can be invited to bring their solar cookers and to act on a judging panel. The solar ovens are designed and built at home and brought to class (or could be built in the lab).

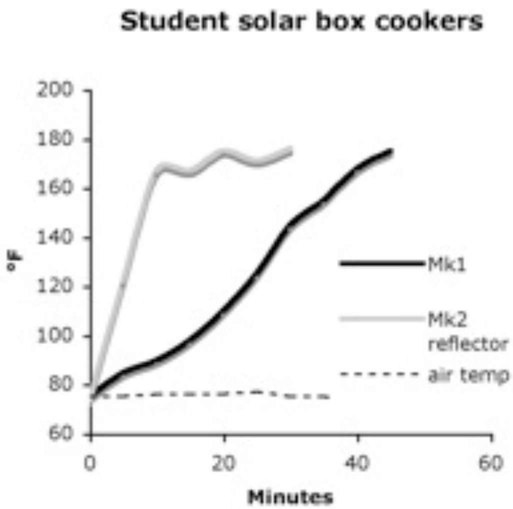
Tools – ruler, pens, scissors, razor knives (bandaids)

Equipment – dial type thermometer or radiant thermometer



Materials include cardboard boxes of various sizes, newspapers (for insulation), aluminum foil, tape, oven proof plastic bags, assorted sticks and string to help stabilize reflectors, bubble pack, flat black cardstock and/or flat black paint (fast drying). (Scraps of foil faced foam from previous building passive building exercises are also useful)

Students are given 15 minutes to set up and orient their solar oven. Temperatures are recorded every fifteen minutes for one hour. The student with the hottest temperature wins a prize. All students will turn in a photo and description of their cooker and a performance report. The grade will reflect the performance of the cooker, ease of use, portability, and durability.



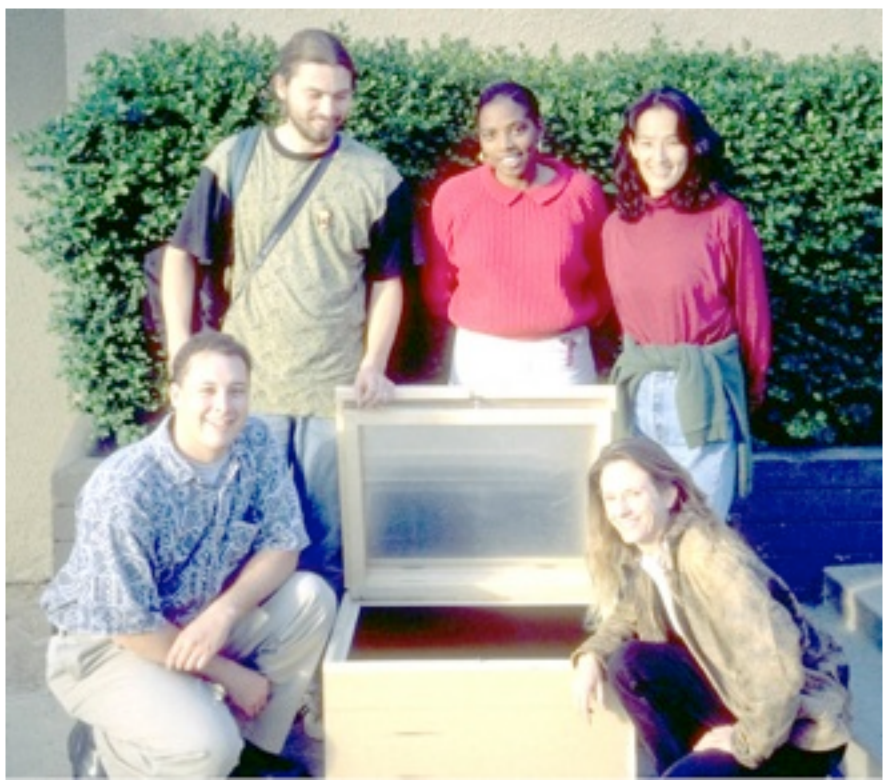
Measure temperature at 5-10 minute intervals, including air temperature.

With a good reflector system and insulation students have melted the polyethylene film covers -- about 220°F.

Alternative lab: If shop tools and supervision are available this can be expanded into a team project building a permanent solar cooker made with metal, plywood or foil faced foam, and glass.

Cost of materials should be included as a factor in design elegance. Teams will turn in a photo and description of their cooker and a performance report.

The team grade will reflect the performance of the cooker, ease of use and access, and durability. The team with the best design wins a prize.



Students can participate in solar cookoffs or invite local solar cooking enthusiasts to campus to judge the student's efforts and to cook a pizza, cookies or a meal.

Solar cooker demonstrations--pizza and cookies are popular with students

Advanced lab: Working with campus microbiology students can add further information on the value of solar disinfection using the near ultra-violet radiation of the sun, 300-400 nm wavelength, to kill pathogens. Water should be prefiltered (use cloth or make a charcoal or sand filter) or allowed to settle if it is cloudy. Place water in a thin-walled vertical transparent container that will transmit a high percentage of uv radiation (PET and clear glass are not ideal but will work) in a location that will receive full sun for several hours.

Students can be asked to research transmissivity of different types of plastics and to explore options for determining when the water has been treated.

Studies on the effectiveness of this treatment have showed complete destruction of *Salmonella enteritis* and S. *typhi* in 60 minutes, *S. flexneri* in just 15 minutes, *Escherichia coli* in 75 minutes, and comparable results against a number of other pathogens.

Daylighting

Before it was destroyed by fire in 1988, the students at the daylit Four Oaks school had California Achievement Test scores 7% higher than the norm within the County. As students were relocated and placed in mobile classrooms after the fire, their performance dropped dramatically. The following year the student's grades went from 7% above to 10% below the norm - a 17% decrease in performance. Michael Nicklas and Gary Bailey. Student Performance in Daylit Schools. www.innovativedesign.net/ studentperformance.htm

A daylit doctors office

For health, productivity, reduced energy and cooling costs, and beauty

Daylighting is one of the easiest and yet most neglected passive solar applications. It has proven benefits of health and productivity, reduces absenteeism and minimizes energy and cooling costs.

The key lessons for this lab are the importance of orientation, solar control, balanced lighting, and glare avoidance.

Students are given a design challenge for daylighting. Three simple examples are presented here, but a many others can be imagined and more complex daylighting assignments are not hard to develop.

Daylighting Techniques Lab: South Facing Classroom

For this assignment students are given the challenge of developing a daylighting strategy for a classroom with a 24 foot wide wall facing South and a 36 foot deep room (and solid sides and rear wall)Using the daylighting design information from pages 148-157 students or teams of students develop a daylighting plan. This is drawn up and heat gain for September 21 is calculated.

The solar simulator being used for a south wall daylighting and solar control evaluation

After review by instructor, TA or other teams the daylighting design is created in foam core. The easiest method is to have the back three walls mounted on the solar simulator - students bring south wall and roof. This can have a digital camera port installed on the side near the front (see photo). The students mount their roof and south wall with clips or painters masking tape. They then take exterior and interior pictures hourly from 9 AM - 3 PM on January 21 and September 21.

Daylighting Techniques Lab: East Facing Classroom

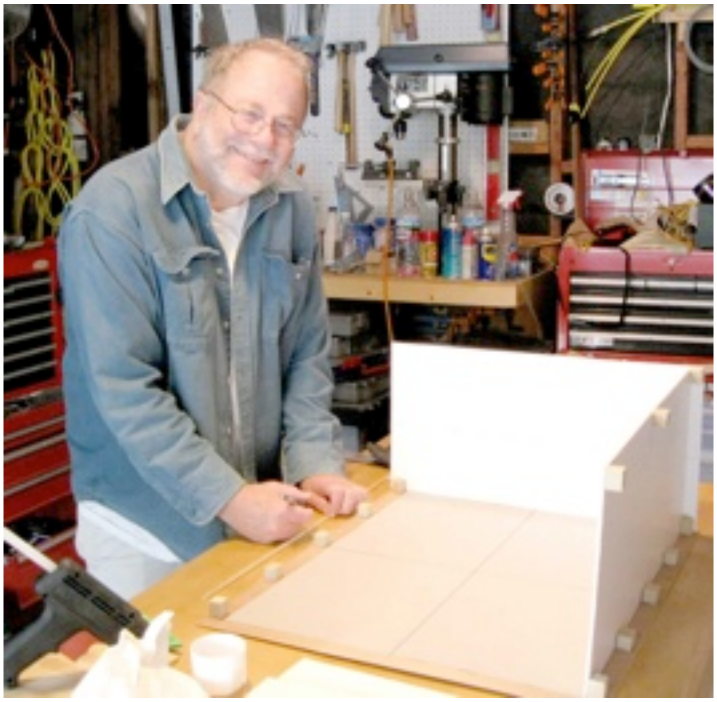
For this assignment students are given the challenge of developing a daylighting strategy for a 24 foot wide wall facing East and a 36 foot deep room. Using the daylighting design information from pages 148-157 students or teams of students develop a daylighting plan. This is drawn up and heat gain for September 21 is calculated.

After review by instructor, TA or other teams the daylighting design is created in foam core. The students then mount their roof and east wall with clips or painters masking tape. They then take exterior and interior pictures hourly from 9 AM - 3 PM on January 21 and September 21.

Daylighting Techniques Lab: Interior classroom with no exterior walls

For this assignment students are given the challenge of developing a daylighting strategy for a 24 foot wide by 36 foot deep interior room. Using the daylighting design information from pages 148-157 students or teams of students develop a daylighting plan using roof monitors, solar tubes and skylights. This is drawn up and heat gain for September 21 is calculated.

After review by instructor, TA or other teams the daylighting design is created in foam core. The students then mount their roof with clips or painters masking tape. They then take exterior (roof) and interior pictures hourly from 9 AM - 3 PM on January 21 and September 21.



Assembling daylight test module

Daylighting: Building evaluation and retrofit design

A more involved lab can assess daylighting performance or potential in campus classrooms, offices, commercial spaces or labs. Potential retrofits can be explored using the simulator table. It is helpful to do not only the lighting evaluation but also a calculation of heat gain. Retrofit light shelves can be very effective in equator facing commercial buildings. They can reduce glare and improve light quality. Interior only shelves can sometimes be tested with lightweight materials and the cooperation of merchants or building owners.

Daylighting computer models can also be used to develop and prepare design performance reports. However, the use of a real physical model is recommended - to compare with calculated models.

Green Materials

Learning is a function of experience, and the best education is one that is sensory rich, emotionally engaging and linked to the real world. Tim Grant and Sarah Littlejohn

Working with green materials is a good activity for students of all ages. Straw bales are an excellent component for building high performance superinsulated passive solar buildings. Mud plasters offer a complex and interesting challenge.

Bales can be shaped to fairly tight curves.

Straw bales are increasingly being used to build homes and institutional and commercial buildings in California and other parts of the world, including a large winery building in the Bay Area, a bus repair facility in Santa Clarita, a synagogue in San Luis Obispo, police station in Visalia, and a café in Norway. This building technology is American born and bred on the treeless plains of Nebraska, but has now spread all over the world to Mexico, Mongolia, China, Japan and Europe.

People like these buildings because they are extremely quiet, fire resistant, low maintenance, energy efficient, strong and attractive.

Straw is the waste material left after grains such as wheat and rice are harvested. It is baled with a machine towed behind a tractor.

The straw bales can be used structurally or as infill between frames or beams. They have been used with wood framing, timber frames, concrete frames, steel frames and on their own. The bales can be used straight, like big bricks, or bent to create more interesting forms.

After the walls are completed and fastened together they are plastered with cement, lime or mud plasters. Designs should include wide eaves and detailing to help keep rain off of and out of the walls.

As the book notes combining straw bales and solar orientation can create very comfortable and extremely efficient buildings. Energy required for heating straw bale homes was 80% less than conventional buildings in Mongolia.

STRAW BALE LAB: The students can explore different ways of assembling straw bale walls using bamboo, string, pins and other materials. Bale cutting and modification can be demonstrated and practiced. Mounting of electrical boxes and window and door frames can be illustrated and practiced. Reinforcing materials (wire mesh, plastic mesh) and a variety of earth, gypsum and cement plasters can be tested and applied.

ALTERNATIVE LAB: Build a straw bale bench. But watch out, students may want to do more -Building a straw bale amphitheater at USIU kept an adjunct professor busy for some time once the students got excited about it.

Straw bale amphitheater and The Good Life Class.
Thanks to adjunct professor Randy Wallin for his assistance.

ALTERNATIVE LAB: A straw bale construction workshop can be held on campus or through an affiliate. A professional SB education group like the Canelo Project can provide supervision and guidance for the construction of a small building or house. Ideal for camps or school field sites.

ALTERNATIVE LAB: Light straw clay construction is also well suited for student activities. This traditional German system is very attractive for some situations.

MUD PLASTER LAB:
Mud plasters are entertaining and challenging. Practice analyzing soils and applying mud plaster to test bales. Compare ease of handling and crack formation with different formulas and straw (or other fiber) additions.

Straw bale resources

Snell, C. and T. Callahan. 2009. **Building Green.** Lark Crafts. 616 p.(good overview well suited for labs)

Steen, A. and B., D. A. Bainbridge, D. Eisenberg. 1994. **The Straw Bale House**. Chelsea Green. 297 p.

Haggard, K. and S. Clark, eds. 1999. **Straw Bale Construction Sourcebook.** California Straw Building Association/San Luis Obispo Sustainability Group. Santa Margarita, CA 37 p.

Steen, A., B. Steen and W. Bingham. 2005. **Small Straw Bale**. Gibbs Smith. 240 p.

Gray, A. T. and A. Hall, eds. 2000. **Strawbale Homebuilding**. Earth Garden Publishing. 156 p. (U.S. dist. Chelsea Green)

Roberts, C. 2003. **A House of Straw**. Chelsea Green. 188 p.

Steen, A. and B. 2001. **The Beauty of Straw Bale Homes**. Chelsea Green. 113 p
Wanek, C. 2003. **The New Straw Bale Home.** Gibbs Smith. 188 p.
Jones, B. 2002. **Building with Straw Bales**. Green Books. 371 p.
Kennedy, J. F., M. G. Smith and C. Wanek, editors. 2002. **The Art of Natural Building**. New Society Publishers. 289 p.
Kennedy, J. F. 2004. **Building Without Borders: Sustainable Construction for the Global Village**. Island Press.
Elizabeth, L. and C. Adams. 2000. **Alternative Construction: Contemporary Natural Building Methods.** Wiley. 392 p.
King, B. 1996. **Buildings of Earth and Straw: Structural Design for Rammed Earth and Straw Bale Houses.** Ecological Design Press 169 p. (dist. by Chelsea Green)
Lacinksi, P. and M. Bergeron. 2000. **Serious Straw Bale.** Chelsea Green, White River Junction, VT. 384 p.
Magwood, C. and P. Mack. 2000. **Straw Bale Building. How to Plan, Design and Build with Straw.** New Society Publishers. 234 p.
Magwood, C. and C. Walker. 2001. **Straw Bale Details: A Manual for Designers and Builders**. New Society Publishers, 59 p.

Earth plasters

Meagan, K. 2002. **Earth Plasters for Straw Bale Homes**. (self publ.), Santa Fe, NM
Guelberth, C.R. and D. Chiras. 2004. **The Natural Plasters Book**. New Society Publishers. 251 p.

Light straw clay

Laporte, R. 1993. **Mooseprints-Light Straw Clay Building**. 35 p.
Volhard, F. 1995 [1983]. **Leichtlehmbau**. CF Muller, GDR 208 p.

Other materials

Stulz, R. and K. Mukerji. 1988. **Appropriate Building Materials: A Catalogue of Potential Solutions**. Swiss Center for Appropriate Technology, IT, GATE. 430 p.
Steen, B. and A. and E. and Y. Komatsu. 2003. **Built By Hand: Vernacular Buildings around the World**. Gibbs Smith, Layton, UT 469 p.

Web resources continue to develop with a wide range of videos and demonstrations now on line. But hands-on experience is critical.

Photovoltaic

Electricity directly from sunlight--its a miracle!

PERFORMANCE WITH ORIENTATION AND SHADE

Photovoltaic cell lab

Materials	PV cells with leads ~$3-15, cardboard or plywood squares 4”x4”, small nails (2”), aiming target sheets
Tools	voltmeter or multimeter capable of low range (digital or analog-as low as $3 up to $30) (bolt to mount aiming tool to tripod if available).

One of the most useful lessons about PV cells is the performance of the cell in relation to solar intensity and orientation. The class is divided into teams. The task is to determine cell performance at different orientations (angle to sun) and shade strength. Students will build a solar aiming tool and use the voltmeter to develop a performance chart for the cell. Each team will develop a chart of cell output.

Teams will then combine data to explore experimental error, performance differences, teamwork/reliability of data, and repeatability. You can stimulate discussion by having students estimate performance before the lab starts.... perhaps just for direct orientation and 45° and 90° tilt angle. You can provide the excel table or have them make their own.

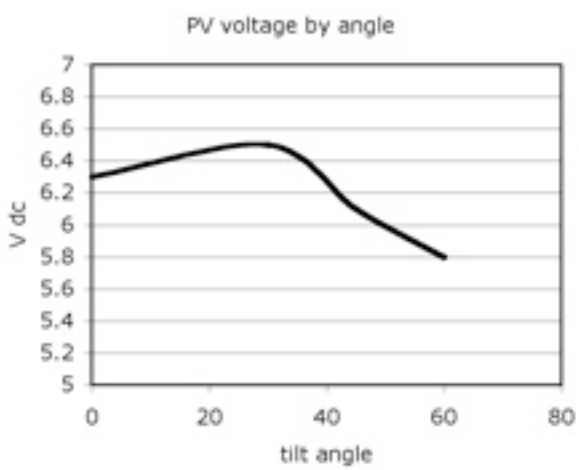
DATE ______ TIME ________ CELL INFO ________________________________
SKY CONDITIONS __________

ORIENTATION	TILT ANGLE direct	30° off	45° off	60° off
direct				
30° off sun				
60° off sun				
90° off sun				

Horizontal orientation ________
Facing solar south, vertical ________
Facing true north, vertical ________
Facing east, vertical ________
Facing west, vertical ________

The effect of shade – determine performance of direct orientation and horizontal position in 3 different types of shade, from trees, bushes or buildings.
Full shade direct ________ Light shade________ Heavy shade________

Full shade horizontal facing up________ Light shade________ Heavy shade________



Or by passing clouds, horizontal facing up Maximum ________ Minimum ___________

ALTERNATIVE LAB: Exploration can also be made of watts or amps instead of just volts. You can compare results from cells with a solar power meter reading to explore efficiency. Depending on time and class experience you may choose to explore the value of reflectors of various types – specular and diffuse, concentrating lenses and different types of cells.

Build and test a ventilation fan using different numbers of cells, motors, gears, propeller types and different gauges and lengths of wire (I^2R). Or build a solar car using trash and a cell and drive system – used for a class race, on land or over water and land, and beauty contest. Or if funds permit, install a PV light on campus at a bulletin board, stairway or walkway.

Supplies available from a variety of sources, Radio Shack, also check classroom packages from
http://sunwindsolar.com/solar_sales_us/products.php?m=a8567ec888

Integrated design

Putting it all together

SUSTAINABLE DESIGN WITH PERFORMANCE YEAR ROUND

Many of the previous exercises deal with specific components and taking measurements to generate site related information. Integrated design is the ultimate goal and this can be more challenging but rewarding to engage in the classroom. Here it becomes important to consider not only quantitative information but also qualitative considerations of pattern, space and flow. Quantitative data provides background and support for design choices but we experience buildings in a much more complex qualitative way. How do they feel? Are they beautiful, healthful and joyful?

Students often prefer to stay quantitative, "more data needed," or totally qualitative. Integrated design requires a more complete consideration of the project. Working with the information and time available to create a building that will perform well and be loved and appreciated is the challenge.

Integrated design uses a series of iterative steps that combine quantitative and qualitative considerations and feedback. After several iterations we should begin to see a solution emerge that answers the data driven questions (radiation gain, thermal mass, solar control) but also the qualitative questions of beauty, flow, and feeling. Providing students with experience and understanding of the integrated design process is critically important, but often neglected. Too often the design challenges are so large that a swoopy, unbuildable design is developed that has not been tested for the quantitative knowns and the equally important qualitative questions.

If sufficient support is available for the lab section of the course many of these labs can be restructured to bear on a design challenge. This can provide the most important lesson of all - synergy matters. It also drives home the point that simplicity and elegance is often complex. This can involve all the lessons of the book -- from programming and meeting climate needs, to research on the site and biome, to passive solar design for heating, cooling, ventilation and daylighting as well as resource capture and community buildings.

This can demand considerable initiative and time and is not well suited for an 8 week course. It can easily make a full time course for a semester. Setting demands for practicality is important as architecture and design students tend to go over-board into fantasy land with this type of assignment. The Internet, Google Earth, Google street view, sketchup and other computer tools can make this go faster--but students will benefit from a quick course in Project Management, perhaps with Gantt Charts.

We have used different design challenges over the years. One year we cooperated on the design for a remote field station for the University of California. This was a great project because it involved a real need, a real client and a very interesting site in the Mojave Desert. Many students also encountered their first off-grid building with pit toilets and no central heating. This type of project takes time but is excellent training for professional practice.

Other design challenges might include a simple 3 bedroom, 2 bath 1400 square foot tract or townhouse home, a 4 plex or small apartment building, a small mixed use residence and retail building, a 600 square foot home for a developing country, or a 400 square foot home for farm workers who now live outside.

It helps to set the site for students rather than letting them choose. A wide range of climate/biome locations can improve learning. One team might be working on a design for Missoula, Montana, another for Yuma, Arizona, and another for Ulan Bator (Mongolia), Aqaba (Jordan), or Ciudad Obregon (Mexico).

Teams work best for this type of challenge. One of the students may pose as the client for home and apartment designs.

Suggested Integrated Design Problems

The goal for the second half or final third of the course should be introducing integrated design problems. These can be offered in a variety of ways. Here are five approaches you might consider. These are also well suited for a full semester or quarter advanced course on integrated design. A summer course or intensive break course could also be developed.

1. Integrated design – off-grid 1000 square foot cottage

The design challenge for this 3 week period is to develop a design outline and calculations for passive heating and cooling as needed (Ch2&3), ventilation, resource harvesting and use (water, energy, etc) and
waste disposal (Ch5) for an off grid self-reliant cottage. This can also be specified as a green material challenge. This could involve setting the criteria as a straw bale building, or rammed earth or ...

Teams of 2 or 3 work well for this assignment but include a inter-team self-grading report to avoid slackers.

The site is provided either by location or Latitude and Longitude (Google Earth is good for this). You might consider using a place you are familiar with from travels, vacation or childhood so you can provide more detail.

If a location such as Yuma, Arizona is provided students could also be asked to pick the most favorable building site. It is possible to select locations with good green buildings – to offer students a comparison with their design decisions after they turn in their assignments. (They may or may not find them doing their workup).

It is a good idea to check availability of solar and microclimate data to avoid student frustration. Nature reserves and research sites are often rich with climate data even in remote sites – see for example http://jornada-www.nmsu.edu/datacat.php. International sites are recommended but check microclimate and solar data availability.

Students may be tasked to prepare a report that includes:

Outline of programming decisions (number of residents, use pattern, etc.)
Solar & microclimate resource profile – solar radiation, temperature, humidity, wind, etc.
Building siting decision
Plan and cross sections – depicting passive system elements (see Ch2, 3).
Orientation, windows, insulation and mass for thermal calculations
Ventilation calculations (see Ch3)

Choice of and calculations of winter and summer design days (see pages ... in this guide)
Material options or selections
Rainwater harvesting and cistern sizing
PV sizing and battery bank
Waste disposal choice or options

2. Integrated design – mixed use light commercial and apartments

The design challenge for this 3 week period is to develop a design outline and calculations for passive heating and cooling as needed (Ch2&3), ventilation, resource harvesting and use (water, energy, etc) and waste disposal (Ch5) for a grid linked mixed use commercial building of 6,000 square feet, with three one bedroom apartments. This can also be specified as a green material challenge.

Teams of 3 or 4 work well for this assignment but include a inter-team self-grading report to avoid slackers.

The location is provided either by location. If a location such as Bozeman, Montana is provided students could also be asked to pick the most favorable building site in the city based on topography and cold air drainage or likely commercial demand. It is possible to select locations with good green buildings – to offer students a comparison with their design decisions. (They may or may not find them doing their workup).

International locations are recommended but it is a good idea to check availability of solar and microclimate data to avoid student frustration. Try Weatherunderground, for example for Lat 27.4 Lon 109.8, Ciudad Obregon, MX or Lat 23.8 Lon 133.9, Alice Springs, AU the data is suitable.

Students may be tasked to prepare a report that includes:

Outline of programming decisions (type of businesses, number of residents in apartments, commercial use pattern, etc.)
Solar and microclimate resources – solar radiation, temperature, humidity, wind, etc.
Building siting decision
Plan and cross sections – depicting passive system elements (see Ch2, 3).
Orientation, windows, daylighting (chapter 4), insulation and mass calculations
Ventilation calculations (see Ch3)
Choice of and calculations of winter and summer design days (see pages ... in this guide)
Material options or selections
Rainwater harvesting and cistern sizing
PV system sizing
Waste disposal choice or options

3. Integrated design – institutional building (school, church, camp, NGO, etc.)

The design challenge for this 3 week period is to develop a design outline and calculations for passive heating and cooling as needed (Ch2&3), ventilation, resource harvesting and use (water, energy, etc) and waste disposal (Ch5) for a grid-linked or off-grid kindergarten school building of 3,500 square feet, with classrooms, office and bathrooms. This should be specified as a green material challenge. Teams of 2 or 3 work well for this assignment but include an inter-team self-grading report to avoid slackers.

The location is provided either by location. If a location such as Bozeman, Montana is provided students could also be asked to pick the most favorable building site in the city based on topography and cold air drainage or likely commercial demand. It is possible to select locations with good green buildings – to offer students a comparison with their design decisions. (They may or may not find them doing their workup).

Design a school for this colonia, Lima Peru

International locations are recommended but it is a good idea to check availability of solar and microclimate data to avoid student frustration.

Students may be tasked to prepare a report that includes:

Outline of programming decisions (type of businesses (retail, office, food), number of residents in apartments, commercial use pattern, etc.)
Solar and microclimate resource profile – solar radiation, temperature, humidity, wind, etc.
Building siting decision
Plan and cross sections – depicting passive system elements (see Ch2, 3).
Orientation, windows, daylighting (chapter 4), insulation and mass for thermal calculations
Ventilation calculations (see Ch3)
Choice of and calculations of winter and summer design days (see pages ... in this guide)
Material options or selections

Rainwater harvesting and cistern sizing
PV system sizing
Waste disposal choice or options
For plans and diagrams start with a big equator (or **True South** in the NH) on the sheet. You might also have a standard for cold wind arrows (purple), cooling breezes (light blue), and approximate winter and summer sun in yellow. Extreme wind direction might be show in red. Doesn't have to be precise, but serves a a good reminder of design issues.

4. *Integrated design – emergency housing*

Emergency housing after the San Francisco Earthquake, 1906

The design challenge for this 3 week period is to develop a design outline and calculations for passive heating and cooling as needed (Ch2&3), ventilation, resource harvesting and use (water, energy, etc) and waste disposal (Ch5, Ch6) for emergency housing for recovery after an environmental disaster (tornado, earthquake, fire, flood, war). Consider making it an assignment linked to a recent, historic, or projected event.

For example the expected big earthquake on the San Andreas fault in Southern California (see http://pubs.usgs.gov/circ/1324/ for details) could be used to set the location in Indio, California. This could focus on a winter or summer event.

This can also be specified as a green material challenge.

Teams of 3 or more work well for this assignment but include an inter-team self-grading report to avoid slackers. The site is provided as a geographic location. Students are asked to pick the most favorable building site in the vicinity (Google Earth helps). You might consider selecting locations with existing sustainable buildings – to offer students a comparison with their design decisions. (They may or may not find them doing their workup).

International locations are recommended but it is a good idea to check availability of solar and microclimate data to avoid student frustration.

Students may be tasked to prepare a report that includes:

Outline of programming decisions (number of residents, use pattern, etc.)
Solar & microclimate resource profile – solar radiation, temperature, humidity, wind, etc.
Building siting decision (unit size, family size)
Circulation diagrams and expectations (pedestrian, bike, car, truck, bus)
Plan and cross sections of typical unit – depicting passive system elements (see Ch2, 3).
Orientation, windows, insulation and mass for thermal calculations
Ventilation calculations (see Ch3)
Choice of and calculations of winter and summer design days (see pages ... in this guide)
Material options or selections
Rainwater harvesting and cistern sizing
PV sizing and battery bank
Waste disposal choice or options

5. Integrated design – retrofit

The design challenge for this 3 week period is to develop a design outline and calculations for passive heating and cooling as needed (Ch2&3), daylighting, ventilation, resource harvesting and use (water, energy, etc) and waste disposal (Ch5) for a commercial, institutional or residential building retrofit.

A redesign of a campus building is often a good project as information is readily available and if the design is appealing – may lead to change. Teams of 3 or 4 work well for this assignment but include an inter-team self-grading report to avoid slackers. The buildings can be assigned or students can select their own projects from the area.

Students may be tasked to prepare a report that includes:

Outline of programming decisions (use, number of residents, etc.)
Solar & microclimate resource profile – solar radiation, temperature, humidity, wind, etc.
Building characteristics
Occupancy survey
Building performance problems – lighting, energy, comfort, health
Energy use profile for year or season
Plan and cross sections – with retrofit passive system elements and daylighting (see Ch 2, 3, 4). Including Orientation, revised window plans, light shelves and roof monitors and other daylighting issues, insulation and mass upgrades as suggested by thermal calculations
Ventilation calculations (see Ch 3) and suggested improvements (windows, vents, solar chimney, etc)
Material options or selections

Optional
Test daylighting retrofit performance upgrades - light shelves
Rainwater harvesting and cistern sizing
PV sizing and battery bank
Waste disposal choice or options
Alternative transportation issues = pedestrian, bicycle
ADA access