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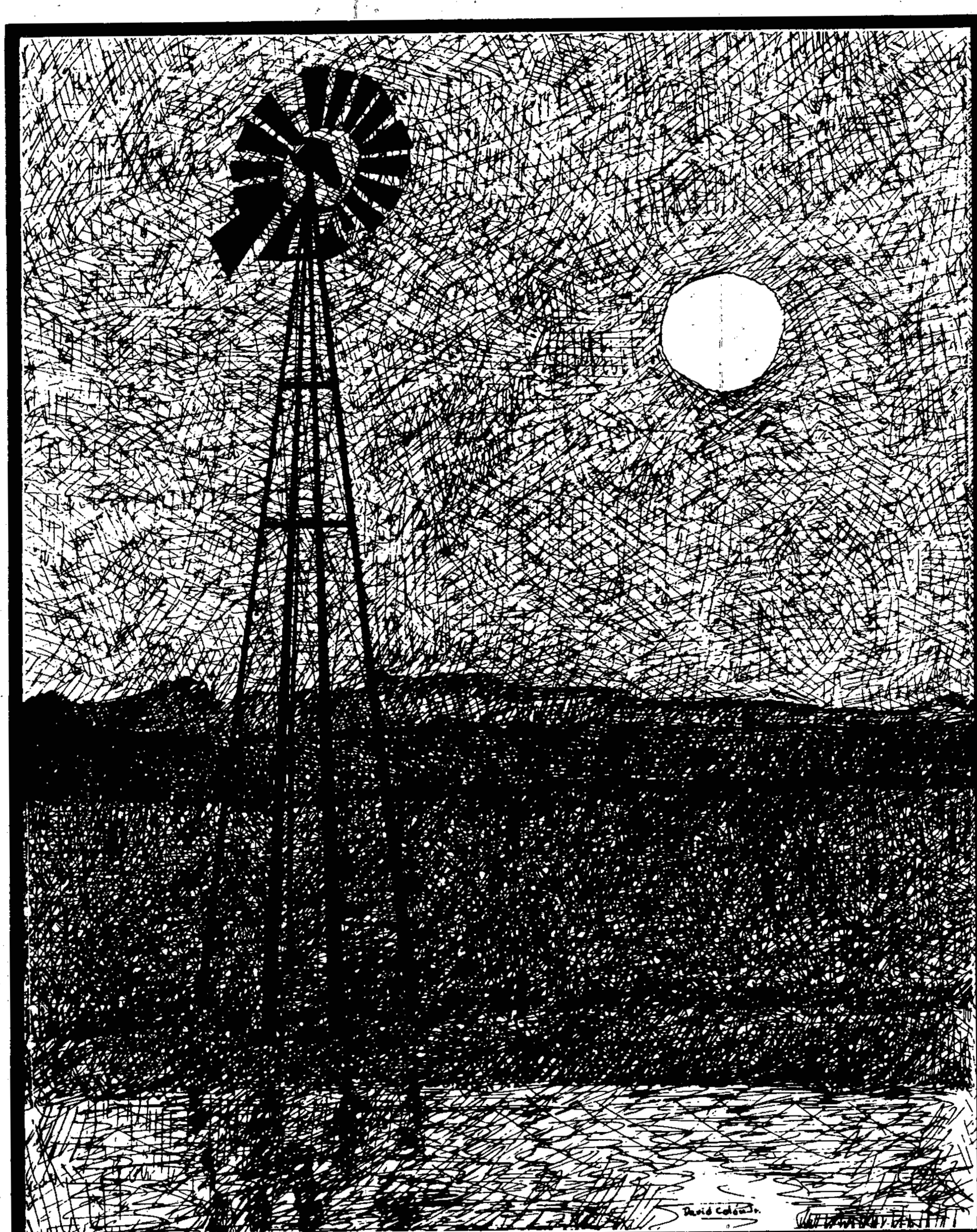
U.S. Department of Energy

Solar Energy Education

May 1981



MASTER

Teacher's Guide

INDUSTRIAL ARTS

Field Test Edition

NOTICE

Information on the Solar Energy Education curriculum may be obtained from:

Solar Energy Project
c/o New York State Education Department
Albany, New York 12234

Your comments on and evaluation of this field-test edition are solicited.

The Solar Energy Education Curriculum

The booklet in your hands is just one part of a series. The Solar Energy Education materials include

a **Solar Energy Text**,

a **Solar Energy Reader** in four parts:

Energy, Society, and the Sun (general),

Sun Story (history and literature),

Solar Solutions (practical applications), and

Sun Schooling (classroom-oriented readings),

Solar Energy Education Activities for

Science,

Industrial Arts,

Home Economics,

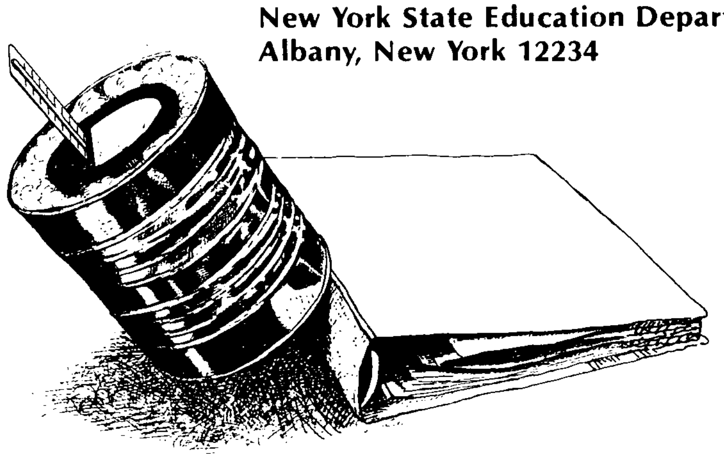
Social Studies, and

Humanities (Art, Music, and English), and

Solar Energy Education Teacher's Guides
to accompany the above activity booklets.

For more information on the Solar Energy Education curriculum, contact

Solar Energy Project
c/o Curriculum Services
New York State Education Department
Albany, New York 12234



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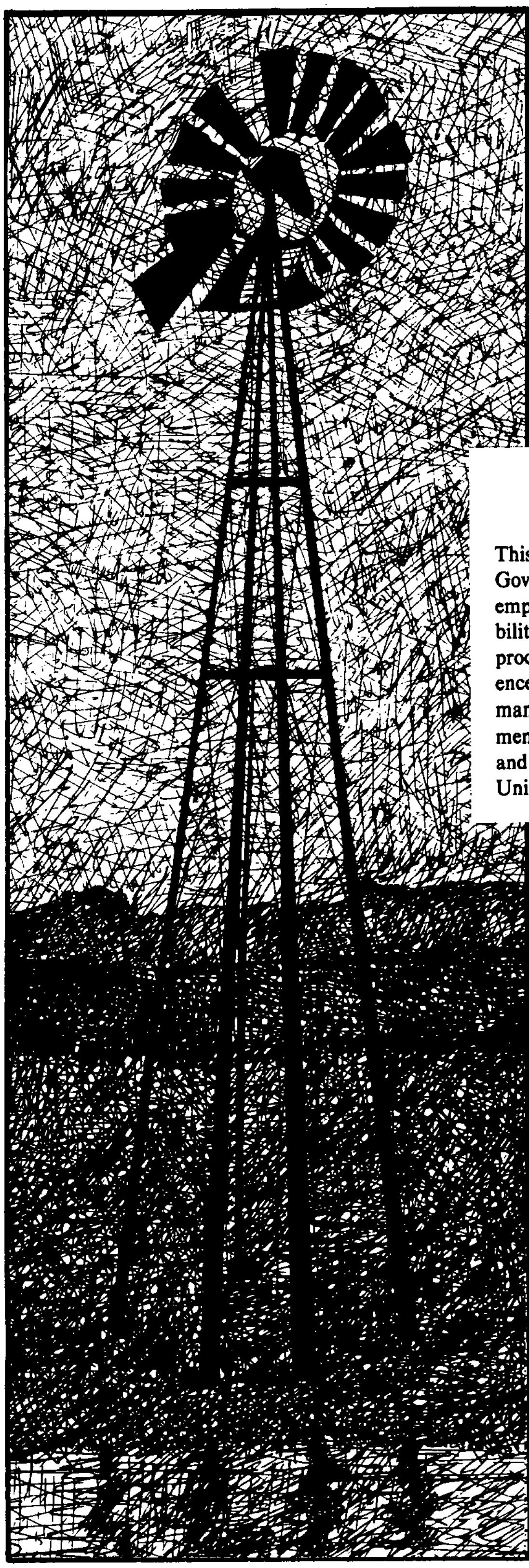

INDUSTRIAL ARTS

Teacher's Guide

Field Test Edition

Prepared For:
U.S. Department of Energy
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Office of Solar Applications for Buildings
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New York State Education Department
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TABLE OF CONTENTS

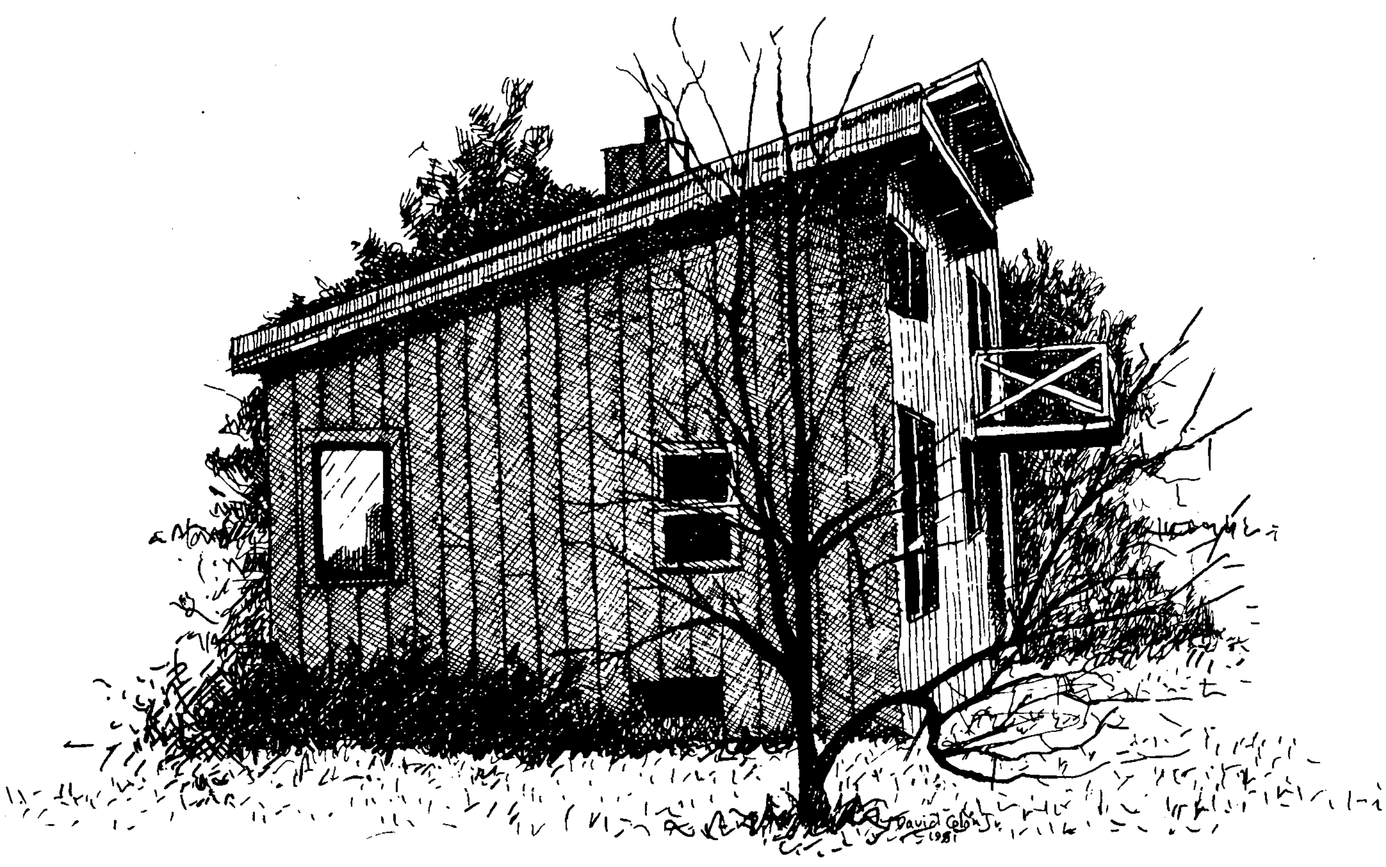
INTRODUCTION

Without the sun's energy life could not exist, but most of the time we take the sun for granted. In winter we think sunshine doesn't warm us much. In reality, if the sun didn't exist, our environment would cool to a molecule-stopping -273°C! Thanks to the sun, we only have to raise our winter temperature about 10° to 30°C to be comfortable.

We've known for many decades that the sun's energy could be used to great advantage but, because "conventional" fuels were cheap and easily obtained, the idea of using sunshine had to wait. It waited for us to demand more and more energy. It waited for us to develop fossil fuel supply problems. It waited until now we have so many inefficient machines that half the energy we use leaks away as wasted heat.

Surveys show that many Americans still believe the "energy crisis" to be contrived. People who seriously study the situation know that it is real. Energy problems are many and complex, and efforts to solve them are hampered by ignorance, confusion, and lack of consensus.

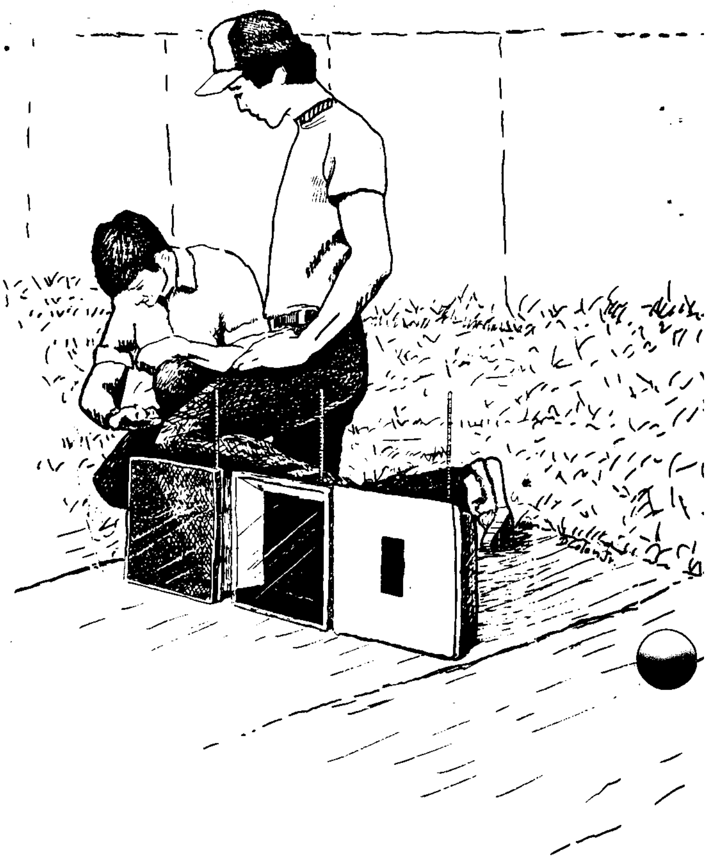
Knowing these things to be true, we in education also know that the solution begins with education. Industrial arts is particularly well suited to this task. Here students can learn the theories, and apply and compare them by designing, building, and testing their own solar energy devices. This kind of problem solving not only affords students great satisfaction, but, best of all, teaches the concepts and values that one day will bring us to an energy consensus. The activities described on the following pages are intended to provide a start in this direction.



Activity 1

Passive Solar Demonstrators

Students construct three passive solar models--direct gain, indirect gain, and isolated gain--and one "average house" model as a control. Each model illustrates the basic design features of a passive solar system.



Activity 2

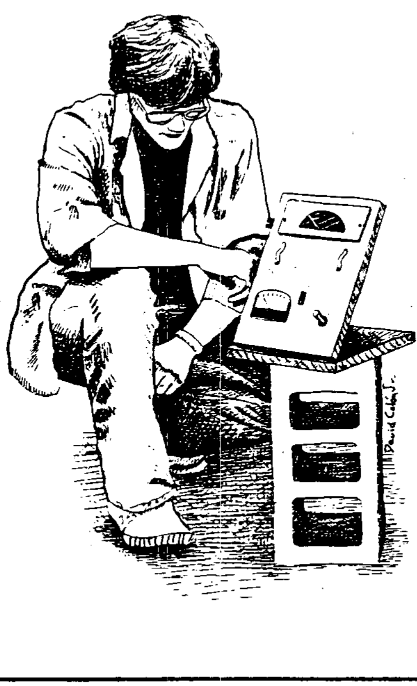
Passive Solar Heating

The four models constructed in the previous activity are fitted with thermometers to demonstrate their passive heating capacities. From heating and cooling temperature data, students determine how each model functions in passive heating.

Activity 3

Passive Solar Cooling

Students adapt the four passive solar models for passive cooling by adding solar chimneys, roof overhangs, and cool air inlet tubes. The models are tested to see which one provides the greatest amount of passive cooling.



Activity 4

A Photovoltaic Demonstrator

Solar cells are used in a test apparatus to determine solar altitude and azimuth, solar intensity, and the transmittance of solar collector glazings.

Activity 5

How to Site a Solar Home

By preparing "bird's-eye view" maps of a potential home site, students learn how to properly site a house for maximum solar gain and energy conservation.

Activity 6

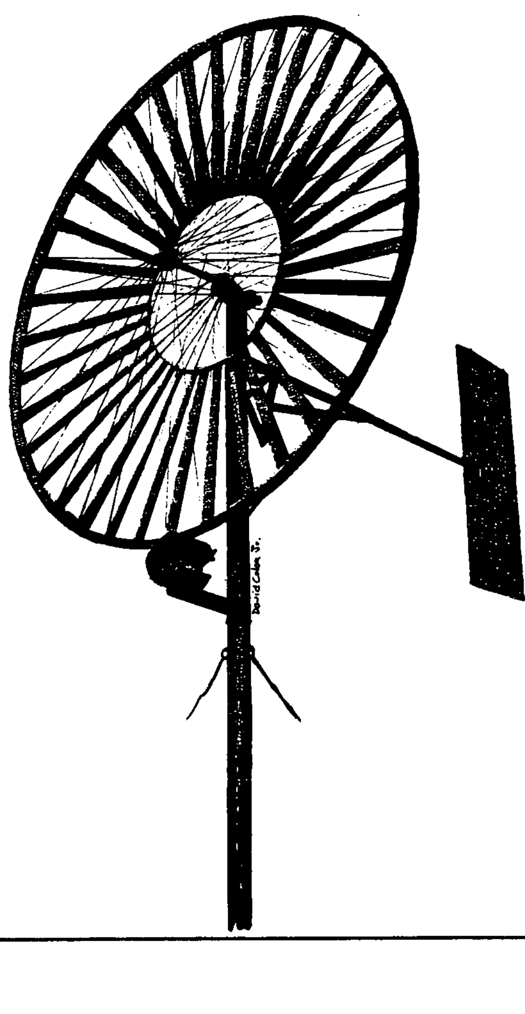
A Thermosiphoning Collector

In this construction project students build a solar collector which employs air as a transfer medium. The collector can be mounted as a window-box or vertical-wall collector, and temperature data can be collected and analyzed to determine how well the collector functions.

Activity 7

A Solar Water Heater in a Tote Tray

Recycled materials are used to build models of solar hot water heaters. By calculating the amount of heat each model delivers, students compare the relative efficiencies of the water heaters and try to account for the differences in results.



Activity 8

A Bicycle Wheel Wind Turbine

A sophisticated wind electric conversion system is constructed from a bicycle wheel. Instrumentation is added so that students can performance test the turbine under actual operating conditions.

Activity 9

Loading the Bicycle Wheel Turbine

The turbine constructed in the previous activity is operated under constant wind speed conditions. Students use a potentiometer to simulate possible loads on the turbine. The resulting data are analyzed to determine the effect of load on a turbine's speed of rotation.

Activity 10

The Bicycle Wheel Turbine's Power Output

Again operating the turbine under constant wind speed conditions, students study the relationship between the voltage drawn from the wind turbine and its power output. The peak power of the turbine is found for one wind speed.

HOW TO USE THE ACTIVITIES

The format of the solar activities has been specially planned to make the activities easy for both you and the student to use.

The Teacher Information Sheet

Choosing an Activity

Looking over the Teacher Information Sheet will help you to make a selection. Listed there are

courses and skill areas for the activity and
skill and content objectives of the activity.

Getting Background

The background information is meant to save you time that might otherwise have to be spent looking for resources. For more information go to the list of references at the end of the Teacher Information Section.

Preparing for the Activity

The Teacher Information Sheet also provides

an advance planning section
suggested strategies for using the activity
the activity's time frame
points for student discussion
possible modifications
typical results
methods of student evaluation

The Student Activity Sheets

Orienting the Student

Before work begins, point out the parts of the activity:

- the introduction, providing an overview
- the objectives, setting expectations
- prerequisite skills and knowledge
- procedures for construction and use of apparatus
- charts, tables, and graphs keyed to the procedure
- questions to test student understanding
- the "Looking Back" section, summarizing the activity
- the "Going Further" section, suggesting more possible activities

Reproducing the Worksheets

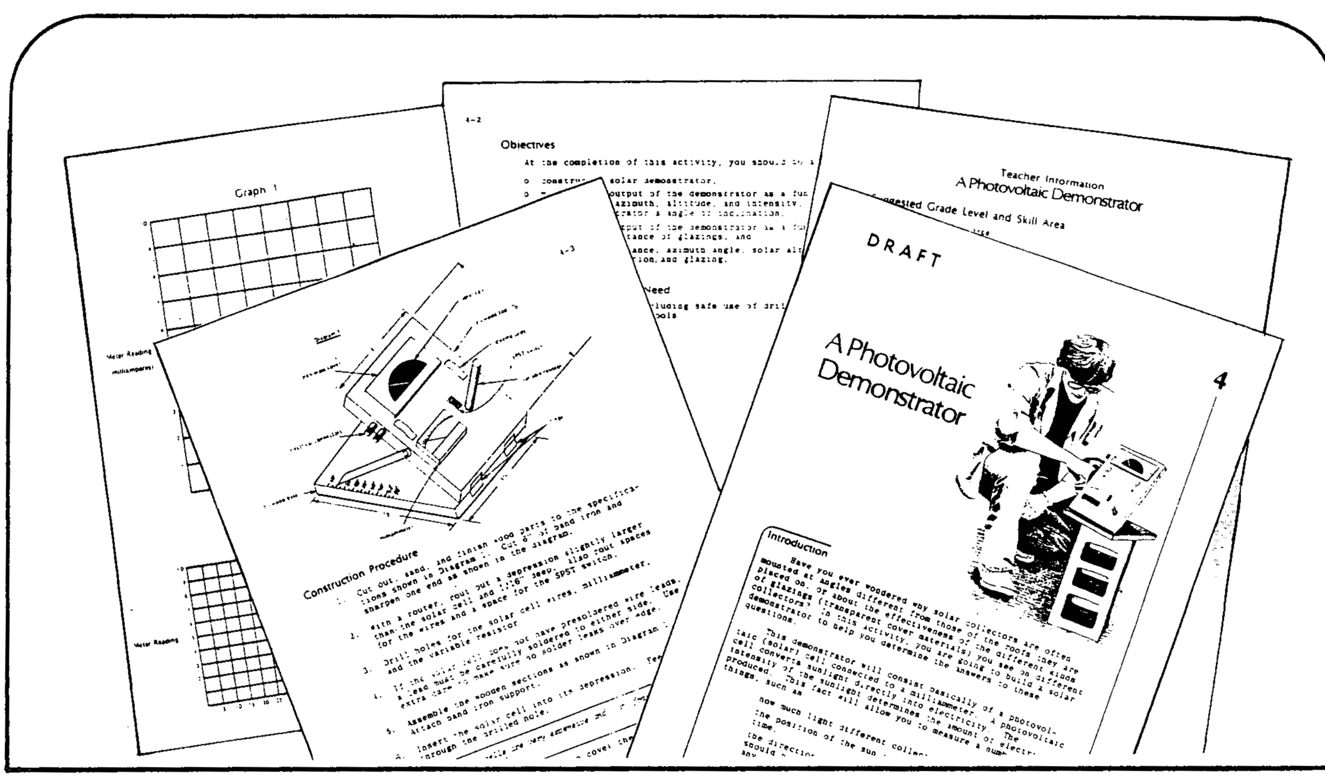
Student worksheets are marked with a gray square and are placed separately at the end of each activity.

These may be duplicated

- for use in class quantities, or
- to assemble as a separate student record book.

The following page numbers indicate student worksheets:

2-5	4-8	7-7
2-6	6-8	9-6
3-6		10-6

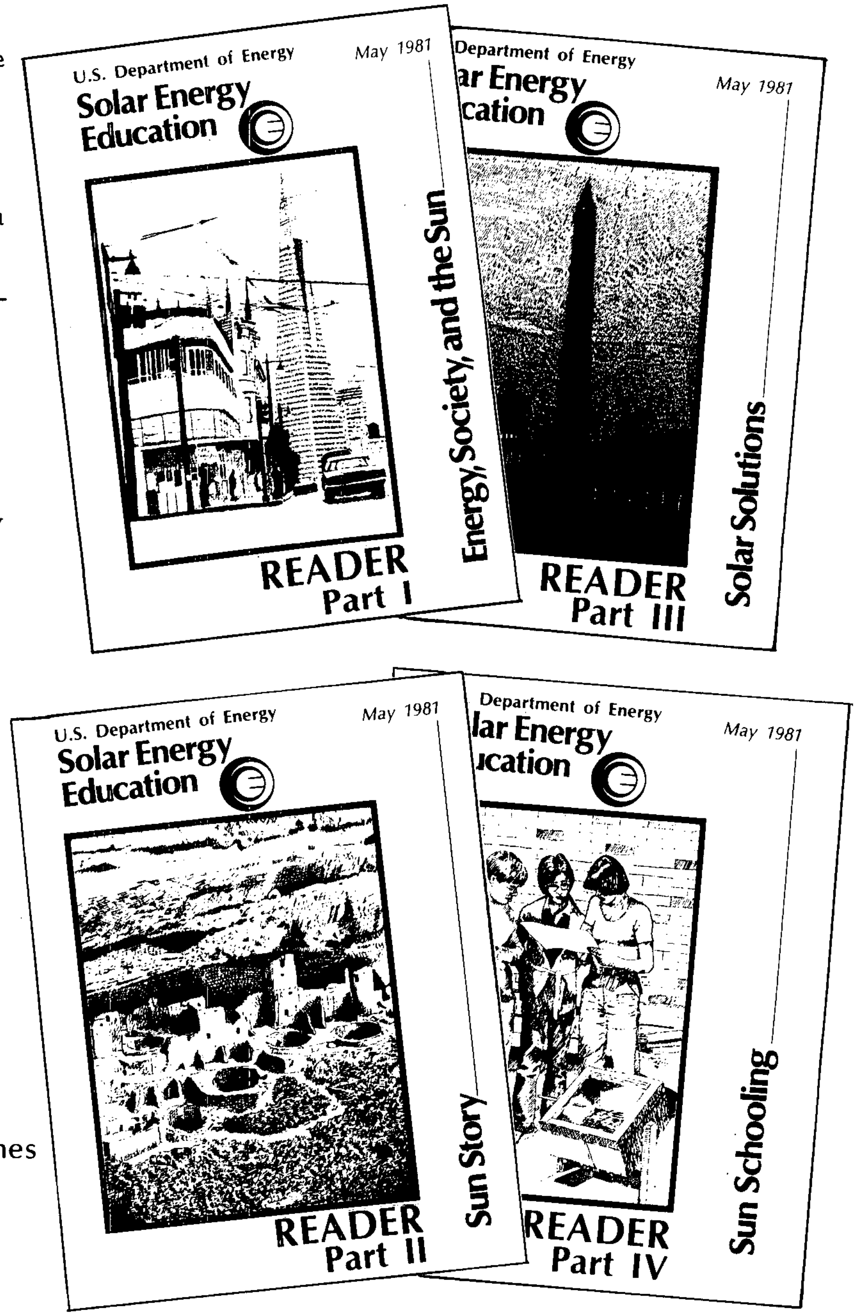


OTHER SOLAR ENERGY PROJECT MATERIALS

The Solar Energy Project produces other materials to go with the industrial arts activities. While some of these materials are still in preparation, others are already available.

The Solar Text

- a comprehensive treatment of the solar field
- appropriate for adults or advanced secondary students
- may serve as the framework for a short course
- has chapters that match individual activities



The Solar Reader

- a compilation of articles from popular periodicals
- covers all forms of solar energy
- discusses the role of energy in society, history, and art
- includes special selections for junior high students

The Science Activities

- offer many ideas appropriate to industrial arts
- involve simple and inexpensive equipment
- are divided into booklets for junior high science, earth science, biology, chemistry and physics, and general solar topics

The Solar Activities for Other Disciplines

- are grouped into booklets for home economics, social studies, and humanities
- offer excellent opportunities for teaming and interdisciplinary work

The emphasis of the Solar Energy Project materials is adaptability. Experiment with the activities and supplementary materials and fit them to your teaching style. Refer to the next section for ideas on how the project materials can be used.

TEACHING SOLAR ENERGY . . .

. . . in the Classroom

The solar activities for industrial arts are varied and adaptable. Try one of these approaches:

The Infusion Approach

use activities in an existing course
select activities that reinforce
course skills and concepts

The Individualized Approach

allow activity selection to match
student skill
permit pacing by ability
provide a variety of projects and
sharing of ideas

The Independent Study Approach

motivate the talented student
encourage supplementary reading
perhaps spell out responsibilities
in a contract

The Group Approach

use with low, high, or mixed ability groups
use to teach job sharing and division of labor
use to provide practice in production techniques

The Energy Mini-Course

group several activities around a common theme
use to attract new students to the industrial arts program

The Separate Energy Course

use the activities as a basis,
review other energy education materials (see bibliography),
evaluate and select materials, and then
plan and develop the course

TEACHING SOLAR ENERGY . . .

. . . beyond the Classroom

Competitions

can offer motivation
could involve a single class or several classes
might start with construction projects or a design contest and evolve into an energy fair

Field Trips

are especially interesting for vocational students
can include visits to building sites, manufacturers, laboratories, utilities, and related trades
may yield speakers or materials for future courses

The Alternative Energy Club

draws a broad spectrum of students
encourages outreach to the school and community
focuses effort of highly motivated students

The Energy Workshop

can be open to students, teachers, parents, or the public
encourages deepening of your own expertise
can involve guest speakers, hands-on work, media presentations
could be incorporated into a continuing education program

TEACHING SOLAR ENERGY . . .

. . . by Teaming with Other Teachers

Energy topics know no subject area bounds. In any school today, energy lessons are being taught in home economics, social studies, and science classrooms, as well as in the industrial arts shop. But students are not necessarily learning the interrelatedness of energy concepts, issues, and problems. How can you provide the needed connections?

The Unstructured Approach

Informally invite another teacher into your classroom, just to see what's going on, or to discuss a topic or help teach a skill. A social studies teacher can discuss energy politics. A math teacher can help with energy calculations. No matter what the lesson, students begin to see that the importance of energy goes beyond the industrial arts classroom.

Structured Team Teaching

When a team has scheduled planning time and classroom space, integrated semester programs can be offered. A typical team combination may include a science, an industrial arts, and a social studies teacher. Although a more demanding way to teach energy, the rewards are also greater.

An Energy Fair

By setting aside a special school day where all disciplines present programs and coordinate activities, you illustrate the interconnectedness of energy issues.

The Resource Center

The industrial arts shop can become an energy resource center. The energy books, pamphlets, catalogs, and other teaching aids collected by the industrial arts teacher can serve as valuable sources, for students presenting reports in other classes or for teachers interested in expanding energy education to their own classrooms.

. . . . . A Final Note

Just a word of caution about those cloudy, rainy, or windless days. It's not always possible to test out apparatus on the day you've planned for, so alternative activities for marginal days should always be up your sleeve.

THE ART OF SCROUNGING

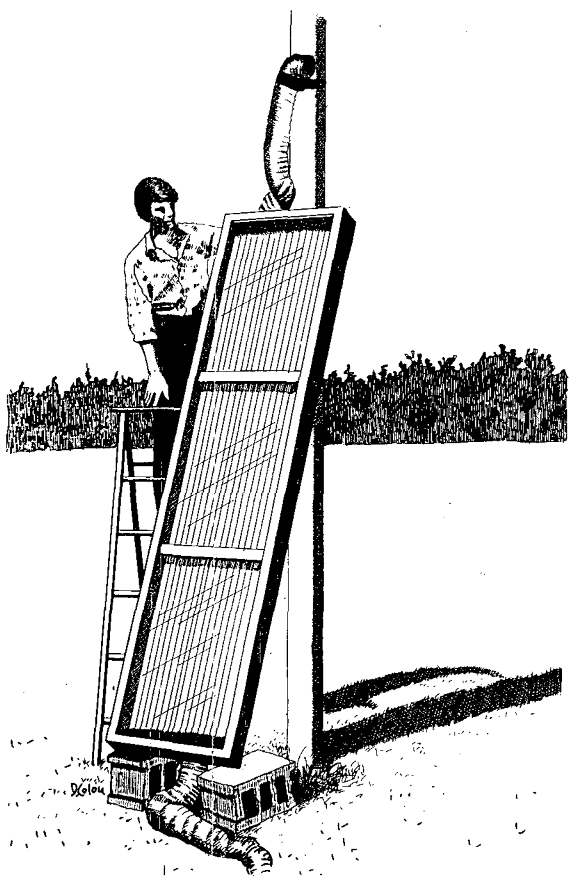
or Teaching the Concept of Recycling

If you're asking youself whether it's worth investing your time and effort in collecting scrap materials to use in teaching solar energy, then consider the following.

What better way is there to reinforce the concept of energy conservation than to recycle materials in the school program? There are no losers in this "game of scrounging", only more creative students and teachers, who have also learned the value of recycling materials for yet another use.

Scrounging should not be thought of as a replacement for the normal industrial arts supply budget. It can, however, supplement a budget allocation dwindling due to rising inflation.

For a teacher introducing energy concepts into the classroom for the first time, one sure problem is finding adequate supplies and materials. There is no one comprehensive and inexpensive source. But rather than giving up because you didn't budget last year for that energy activity you'd really like to teach this year, start making contacts with and seek help from local industry, manufacturers, and related energy trades.



Suggestions for Scrounging . . . . .

. . . . . General . . . . .

1. Determine which regional industries make surplus materials available to schools. Give them a list of your needs and check back with them often.

2. Don't overlook local tradesmen and shops as a source of scrap. Leave a container in each shop and check it periodically.

3. If possible or necessary, send a school truck or other vehicle to pick up scrap materials.

4. Use your students as a "scrounging force". If practical, use a problem-solving technique to incorporate the use of scrap materials into energy activities.

. . . . . and Specific . . . . .

. . . for Solar Glazing

1. Use scraps of polyethylene plastic film.

2. Check with local glass companies for scrap or surplus glass. (Exercise caution when handling glass.)

3. Check with local plastic companies for surplus sheet stock.

4. Old storm windows may be usable.

. . . for Solar Concentrating Surfaces

1. Leave containers for scrap mirror stock with local glass companies. Check them periodically.

2. Look for aluminized mylar gift wrapping at better gift shops.

3. Use aluminum foil (or aluminum pastry containers) as an inexpensive surface.

4. Use discarded snow dishes or snow saucers as parabolic reflectors.

5. Borrow overhead projector lenses from your audio-visual department.

. . . for Solar Absorber Materials

1. Check with local sheet metal contractors for scrap.

2. Remove coils and plates from junked refrigerators.

3. Look for scrapped corrugated metal.

4. Check with solar suppliers and dealers for scraps and damaged materials.

. . . for Insulation Materials

1. Have students look at home for left-over insulation materials.

2. Check with local carpet dealers for scraps of foam carpet padding.

3. Use foam packing materials or even sawdust or newspaper.

. . . for Heat Storage Containers

1. Collect ditto fluid containers from school offices.

2. Obtain tin cans, plastic milk containers, and plastic pails from the school cafeteria.

3. Check with local plumbers and scrap dealers for water storage tanks.

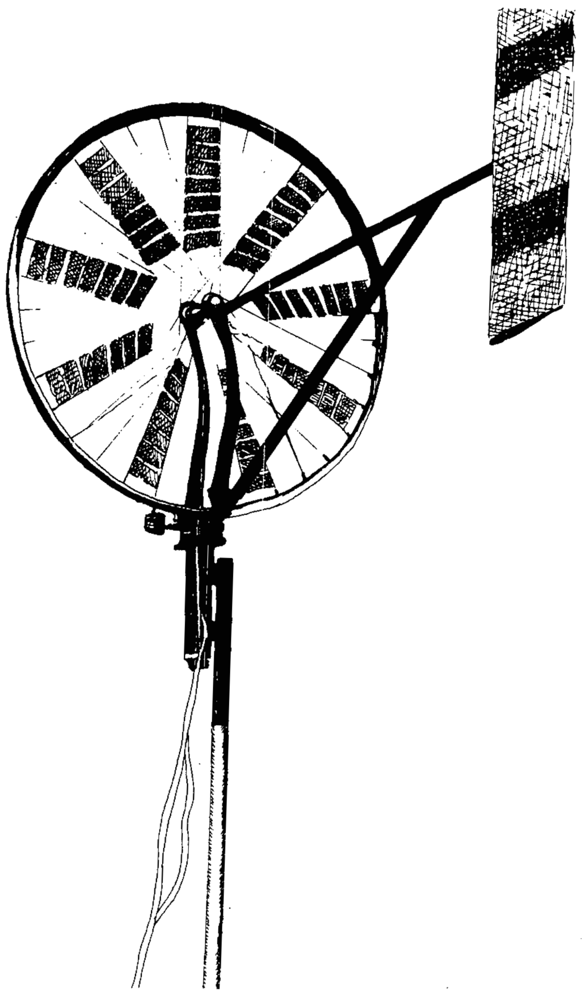
. . . for Photovoltaic Supplies

1. Look into low-cost surplus solar cells from industrial sources. You may have to solder leads onto the cells, however.

2. Obtain discarded meters and other electrical components from regional industries and laboratories or from surplus stores.

3. Find out what can be borrowed from your school science department.

4. Check with local electronics stores for damaged, defective, or returned equipment and supplies.



. . . for Wind Energy Supplies

1. Construct wind turbines from "L'Eggs" pantyhose containers, bicycle wheels, and oil drums.

2. Locate an unused farm windmill or wind generator. With a tax write-off as an incentive, the owner might donate the windmill for a class reconstruction project.

3. Collect speedometers, belts, pulleys, gears, chains, and sprockets from automobiles, lawn mowers, and bicycles.

4. Be on the alert for small D.C. motors, bicycle generators, auto generators, and alternators.

5. Use old batteries to store wind energy. Sources of used batteries include auto junk yards, telephone companies, surplus dealers, government surplus depots, and golf courses where electric carts are used.

SOLAR SAFETY

General Considerations . . .

As with all industrial arts projects, it is of utmost importance to take the necessary safety precautions when working on solar energy activities.

General lab safety requirements include the provision of

- properly laid-out machines and furniture,
- adequate illumination, ventilation, and temperature control,
- fire protection and extinguishers,
- a means of emergency exit,
- proper housekeeping and storage practices,
- well-maintained equipment, with proper safety guards,
- safe wiring and electrical installations,
- safe gas connections and controls,
- eye safety glasses and shields,
- instruction in lab safety, and
- an accident record system.

Proper body protection also needs consideration. In general, the body should be protected in the following ways for solar safety.

The head: Wear hard hats when working on wind energy systems and wind towers.

The eyes: Wear safety glasses or goggles at all times.

Use a #10 arc welding shade when setting up, focusing, and operating concentrating collectors.

When photographing collectors, caution students about the dangers of magnifying view finders.

Wear plastic face shields when working on solar collectors using hot water transport.

Do not wear sunglasses. They provide only minimal protection.

Don't look at the sun.

The ears: Wear ear protectors during noisy operations such as planing wood or cutting and forming metals.

Wear ear protection when operating chain saws.

The nose and mouth: Use respirators for protection against dust, and when spray painting, installing insulation, or wicking asbestos on stoves.

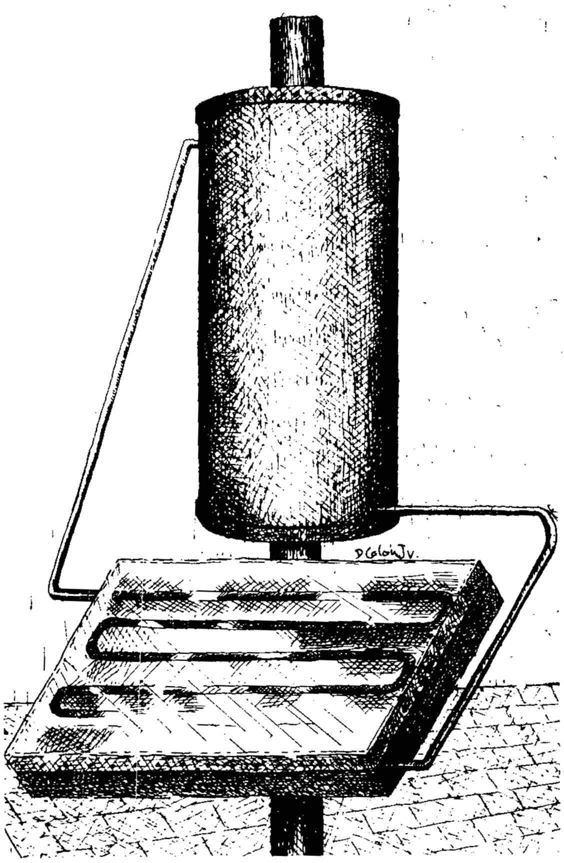
The body: Wear shop aprons or coats, leather aprons, or asbestos aprons and leggings when handling hot materials.

The hands: Wear leather gloves when handling hot hoses, fittings, or parts.

Wear appropriate gloves for welding and foundry operations.

Remove rings and bracelets when operating mechanical equipment. (Long necklaces should also be removed.)

The feet: Wear hard-toed shoes or shoe protectors when handling heavy metal pieces such as water tanks, collectors, or wind turbines.



. . . and Specific Considerations . . .

. . . for Solar Collectors

1. Use arc welding eye protection when making operating adjustments.

2. Handle absorber/collector units with caution.

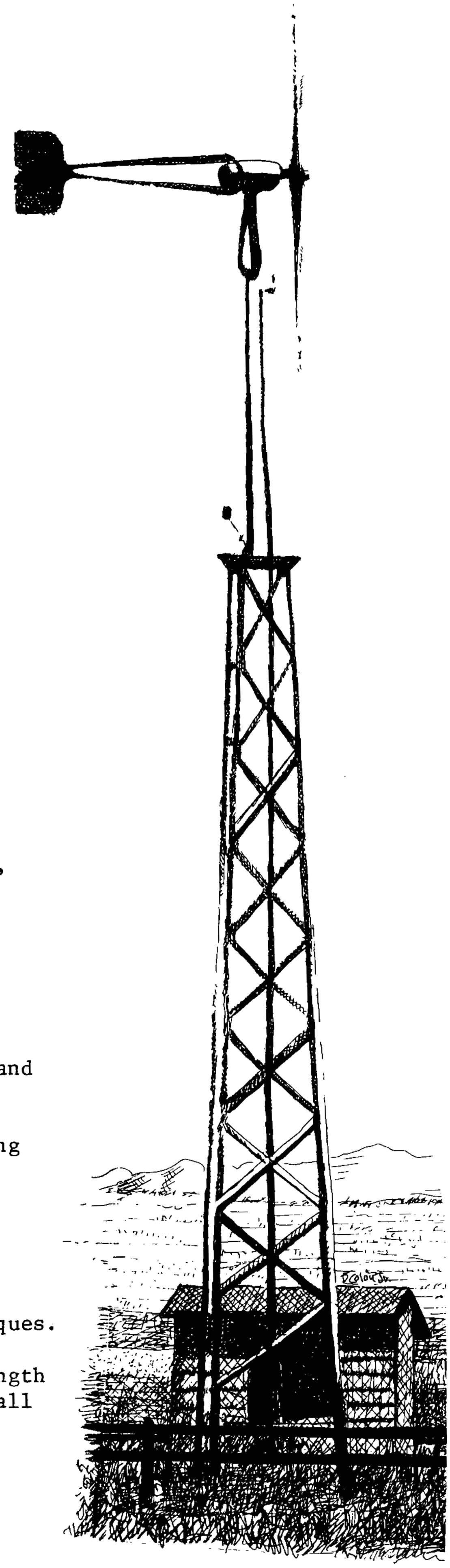
3. Do not allow lead or cadmium to contaminate drinking water.

4. Properly place pressure/temperature safety valves in active or thermosiphoning hot water systems.

5. Do not use wood as an absorber, spacer, or inner frame member in collector construction.

6. Have boilers inspected and approved before use.

... for Wind Systems



1. Balance blade units.

2. Install governing systems for high wind conditions.

3. Provide ground-activated brake systems.

4. Use welded steel towers or poles.

5. Provide work platforms and "tool pockets".

6. Wear hard hats and safety glasses. Use climbing belts above ground.

7. Install proper fuses in circuits. Provide an adequate metering and control panel.

8. Wear safety glasses and exercise caution when handling batteries and battery acids.

9. Protect against arcing when batteries are charging.

... for Hydropower Systems

1. Balance turbine units.

2. Install guards on mechanical shafts, belts, and drives.

3. Provide adequate pressure housings.

4. Install adequate shut-down and run-off valves.

5. Include acceptable power control, wiring, and charging systems.

6. Dams should be constructed to survive spring run-off conditions.

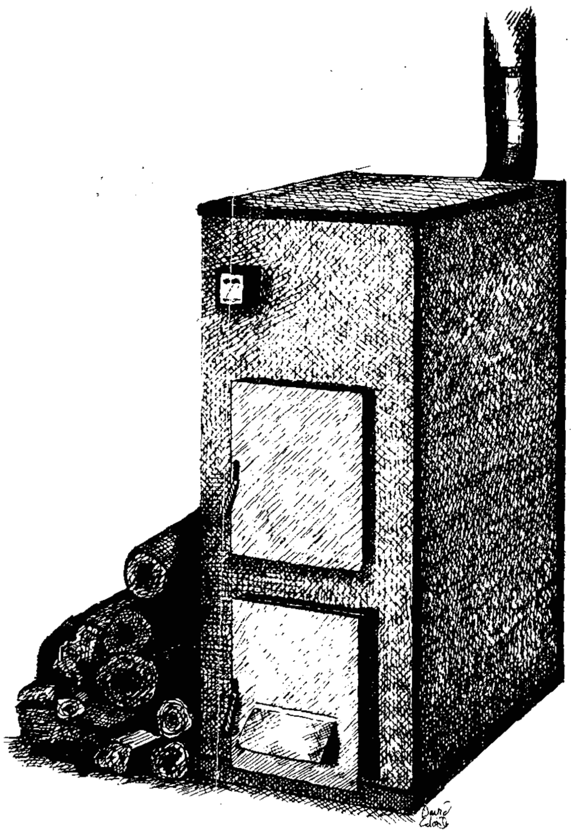
... for Biofuels Systems

Woodstoves:

1. Use proper welding and construction techniques.

2. Make sure woodstove legs are the proper length to protect floors from extreme heat. Install heat shields on walls and floors.

3. Install dampers and flue vents to provide controls against overheating.



4. Use sand or refractory bricks to protect the stove metal from overheating.

5. Allow for expansion and contraction of stove parts.

6. Always use properly located temperature/pressure safety valves in wood-heated hot water systems.

7. In hot water plumbing systems, avoid overhead elbows which might trap steam.

8. Unless proper procedures are followed, avoid welding propane or galvanized steel tanks.

Alcohol and Methane Systems:

1. Provide adequate ventilation.

2. Use temperature/pressure devices as required.

3. Once alcohol or methane generation begins, provide for adequate storage of the product.

4. Use protective procedures, including "No Smoking" and "No Open Flame" warning signs.

5. Avoid leaks in the system.

6. Monitor operating procedures.

7. Properly contain and control volatile liquids and gases.

. . . for Energy Conservation

1. Use respirators, safety glasses, long sleeves, and gloves when handling insulation.

2. Do not insulate around recessed lights.

3. Provide adequate ventilation when using insulating foams. Be aware of the possible safety problems with urea-formaldehyde foam.

4. Insulate hot water heaters according to safe, accepted procedures.

5. Caution students about possible adverse health effects from an overly tight house. Explain the use of air-to-air heat exchangers and ventilation systems for kitchen and bath.

METRIC CONVERSIONS

Base Units		Common Prefixes
gram (g)	= weight or mass	milli = 1/1000 or 0.001
meter (m)	= length	centi = 1/100 or 0.01
square meter (m^2)	= area	kilo = 1,000
liter (1)	= volume	
calorie (c)	= heat	
degree Celsius (°C)	= temperature	
kilometer per hour (km/hr)	= speed (velocity)	

Converting English Units to Metric Units

English units of measure have been used throughout the student activities. While we would have preferred to use metric units, there are two reasons why we did not:

It is difficult to obtain metric-sized lumber, accessories, and tools from today's construction industry.

It seemed cumbersome and confusing to report so many measurements in dual units.

The table below is intended to aid those who wish to use metric measurements with students.

Unit of Measure	English Unit	→ Multiply By ← Divide By	Metric Unit	Symbol
Length	inches feet feet yards miles	2.54 30.0 0.3 0.91 1.61	centimeters centimeters meters meters kilometers	cm cm m m km
Area	square inches square feet square yards	6.5 0.09 0.8	square centimeters square meters square meters	cm^2 m^2 m^2
Mass (Weight)	ounces pounds	28 0.45	grams kilograms	g kg
Volume	gallons cubic feet	3.8 0.03	liters cubic meters	1 m^3
Temperature	degrees Fahrenheit	→ 5/9 (after subtracting 32) ← 9/5 plus 32	degrees Celsius	°C
Heat	Btu	252	calories	c
Speed	miles per hour	1.61	kilometers per hour	km/hr

A SHORT SOLAR GLOSSARY

absorber: a surface, usually blackened metal, which absorbs solar radiation and converts it to heat energy in a solar collector.

active solar energy system: a system which requires external mechanical power (motors, pumps, valves, etc.) to operate the system and to transfer the collected solar energy from the collector to storage or to distribute it throughout the living unit. Active systems can provide space heating and cooling, domestic hot water, and/or steam for industrial use.

altitude: the angular distance from the horizon to the sun.

azimuth: the angular distance from true south to the point on the horizon directly below the sun.

Btu: British thermal unit, a unit for measuring heat; a Btu is the quantity of heat necessary to raise the temperature of one pound of water one degree Fahrenheit. It equals 252 calories.

calorie: a metric unit of heat energy; the amount of heat needed to raise the temperature of one gram of water one degree Celsius. It equals 0.0039 Btu.

collector: any of a wide variety of devices (flat-plate, concentrating, vacuum tube, greenhouse, etc.) which collect solar radiation and convert it to heat.

collector efficiency: the fraction of incoming radiation captured by the collector. If a system captures half of the incoming radiation, the system is 50% efficient.

conduction: the transfer of heat energy through a material by the motion of adjacent atoms and molecules.

convection: the transfer of heat energy from one location to another by the motion of fluids which carry the heat.

direct solar gain: a type of passive solar heating system in which solar radiation passes through the south-facing living space before being stored in the thermal mass.

earth berm: a bank of dirt that abuts a building to stabilize interior temperature or to deflect the wind.

energy: the ability to do work or make things move; the application of a force through a distance. Energy exists in a variety of forms (electrical, kinetic or motion, gravitational, light, atomic, chemical, heat) and can be converted from one to another. Common units are calories, joules, Btu, and kilowatt-hours.

eutectic salts: a group of materials that melt at a low temperature, and absorb large quantities of heat in the process.

flat-plate collector: an enclosed, glazed panel containing a metal absorbing surface that converts sunlight to heat without the aid of a reflecting surface to concentrate the rays. The collector transfers its heat to a circulating fluid.

generator: a device that converts heat or mechanical energy into electrical energy.

Glauber's salts: sodium sulfate decahydrate, a eutectic salt that melts at 90 degrees Fahrenheit and absorbs about 104 Btu per pound as it does so; inexpensive, used for storing solar heat.

glazing: the transparent or translucent cover of a solar collector (also: cover plate), or that material which forms a window or skylight. In solar applications, glass or acrylic is usually used as a glazing.

greenhouse effect: a phenomenon which converts solar radiation to heat. Sunlight penetrates glazing quite easily but, when absorbed by objects behind the glazing, is reradiated as heat which does not penetrate the glazing as easily. Heat is thereby trapped and can be used.

heat capacity (specific heat): the quantity of heat required to raise the temperature of a given volume of material by one degree in a given system of measurement.

heat sink: a medium (gas, liquid, or solid) capable of accepting and storing heat.

horizontal shaft wind turbine: a wind machine on which the shaft to which the rotors are attached is parallel to the earth.

hybrid solar energy system: a system that uses both active and passive methods to operate.

indirect solar gain: a type of passive solar heating system in which the storage is placed between the collecting and the distributing surfaces (example: Trombe wall, water wall, or roof pond).

infiltration: the uncontrolled movement of outdoor air into a building through cracks around windows and doors and in walls, roofs, and floors.

infrared radiation: the invisible rays just beyond the red of the visible spectrum; their wavelengths are longer than those of the spectrum colors and they have a penetrating heating effect.

insolation: the amount of solar radiation (direct, diffuse, or reflected) striking a surface exposed to the sky; measured in watts per square meter or Btu per square foot.

insulation: material with high resistance (R-value); used to retard heat flow.

isolated solar gain: a type of passive solar heating system in which heat is collected in one area (sunspace, attic collector) and used in another (living spaces).

<u>langley</u>: a measure of solar radiation; it equals one calorie per minute per square centimeter, or 3.69 Btu per square foot.

<u>passive solar energy system</u>: an assembly of natural and architectural components which converts solar energy into usable or storable thermal energy (heat) without mechanical power. Current passive solar energy systems often include fans.

<u>photovoltaic cell</u>: a device which converts solar energy directly into electricity. Sunlight striking certain materials (silicon, most common) causes the release of electrons. The migration of these released electrons produces an electrical current. The conversion process is called the photovoltaic effect.

<u>power</u>: energy used per unit time. The power rating of a particular light bulb, say a 100-watt bulb, is that rate at which the bulb consumes energy.

<u>radiation</u>: the method by which heat is transferred through open space. About 60% of the heat transferred to a room from a wood stove is by radiation. Sunlight travels to us by radiation through the void of space at "the speed of light", 299,728 kilometers per second.

<u>renewable energy source</u>: an energy source which replenishes itself; solar energy and certain forms derived from it, such as wind, biomass, and hydro.

<u>retrofit</u>: to modify an existing building by adding a solar heating or cooling system, or insulation to improve its energy efficiency.

<u>rotor</u>: a rotating blade or other surface moved by the wind.

<u>R-value</u>: the measure of resistance to heat flow; thermal resistance.

<u>solar energy</u>: the electromagnetic radiation emitted by the sun. The earth receives about 4200 trillion kilowatt-hours of solar radiation per day.

<u>solar greenhouse</u>: a sun space containing thermal mass and used to grow plants.

<u>stagnation</u>: a high temperature condition occurring in a solar collector when the sun is shining and no fluid is flowing through the collector; temperatures range from 250 degrees Fahrenheit to 400 degrees Fahrenheit, depending on collector design. Any condition under which a collector is losing as much heat as it gains.

<u>storage</u>: the device or medium that absorbs collected heat and stores it for later use.

<u>sun space</u>: an attached, glazed room from which heat is withdrawn to the living space during the day.

<u>sun tempering</u>: when solar energy contributes to the energy efficiency of a structure, but is not the main energy source.

temperature: a measure of the energy of motion of the atoms and molecules of a substance. Thermometers and thermistors are used to measure an object's temperature. The tip of a burning match has a high temperature, but the object as a whole might contain very little heat due to its size.

thermal mass: mass used to store heat energy, usually collected solar energy. Rock bins, sand beds, and containers filled with water or eutectic salts have been used successfully as thermal masses.

thermosiphoning: heat transfer in a fluid (air, liquid) by means of currents resulting from the natural fall of heavier, cooler fluid and rise of lighter, warmer fluid.

transfer medium: the substance that carries heat from the solar collector to storage or from storage to the living areas.

Trombe wall: masonry, typically 8 to 16 inches thick, blackened and exposed to the sun behind glazing; a passive solar heating system in which a masonry wall collects, stores, and distributes heat.

turbine: a motor, the shaft of which is rotated by a stream of water, steam, air, or fluid from a nozzle and forced against the blades of a wheel.

vertical shaft wind turbine: a wind machine on which the shaft to which the rotors are attached is perpendicular to the earth.

watt: a unit of measure for electrical power equal to the transfer of one joule of energy per second. The watt is the unit of power most often associated with electricity, determined by multiplying required volts by required amperes. One horsepower = 746 watts.

weatherstripping: reduces the rate of air infiltration by making sure that all doors and windows fit their frames snugly; for example, puttying around windows.

WECS (wind energy conversion system): a system which converts mechanical energy from the wind to electricity, heat, or fuel which is used directly or stored.

wind turbine generator: a wind machine, powered by a rotating blade or propeller, that drives an electric generator.

work: a force acting against resistance to produce motion in a body; measured by the product of the force acting and the distance moved against the resistance.

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