

## Present Status of Solar Energy Education

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### Abstract

This paper briefly describes the history and status of solar energy education. The energy awareness in the early 1970s led to a concerted research and development effort in solar energy applications. Solar energy education followed these efforts at the advanced college level. However, R&D slowed down in the mid 1980s and solar energy education at the college level followed that trend. Over the last three decades developments in solar energy applications have made it possible to use solar energy for most of our energy needs and even some environmental needs. However, despite the worldwide awareness of environmental degradation, the present public policy does not favor the use of solar energy over conventional fuels. Many solar energy applications do not appear cost effective using conventional financial tools. Therefore, there is a need to educate public policy makers, financial professionals and the general public. This presents an opportunity to develop educational materials, short courses and seminars, to educate public policy makers and financial professionals who are extremely important to increase the use of solar energy, yet who are least familiar with it. There is a great deal of K-12 solar energy educational materials that has been developed in different parts of the world. Advanced information technologies can be used to compile and make this material available throughout the world.

### 1. Introduction

The oil crisis of the mid 1970s was mainly responsible for creating the awareness to develop solar energy applications. Large-scale solar energy research programs were started at universities in the U.S.A. and other parts of the world. Research programs at these universities created a need and an opportunity for solar energy education for science and engineering students at the graduate level. Solar energy courses at these universities were eventually expanded to include advanced undergraduate students. Some architecture schools included passive solar design in their curricula. The oil crisis of the mid 1970s turned into an oil glut and the consequent drop in oil prices in the mid 1980s. It is debatable as to what factors combined to bring this about; however, energy conservation efforts played some part in it.

The temporary disappearance of an energy crisis coupled with the fact that there were very few job opportunities in solar energy caused a decline in student interest in solar energy

education in universities. At present, student interest in solar energy education is still low in the industrialized countries, although it is up in some developing economies. Recent concerns about electricity shortages in California have caused a renewed interest in energy, especially renewable energy in the U.S.A. An increased interest in renewable energy education is expected to follow.

Over the last three decades developments in solar energy applications have made it possible to use solar energy for most of our energy needs, such as heating, cooling and electricity and even some environmental needs such as detoxification of contaminated water, air and soil. Prices of solar energy systems have come down as much as 5 to 10 times. In many applications life cycle costing shows solar energy systems to be more cost effective than the conventional systems. However, despite the worldwide awareness and concerns about environmental degradation, the present public policies in most of the world do not favor the use of solar energy over conventional fuels. Also, using conventional financial tools (which do not use life cycle costing), many solar energy applications do not appear cost effective. In order to develop public policies that recognize the environmental value of solar energy and the financial tools that recognize the life cycle advantage of solar energy systems, it is important to educate public policy makers, financial professionals and the general public.

In the past 3-5 years, a number of government and private organizations in the world have made available solar energy educational information on the Internet. A survey of these information sites conducted by us in May 2000 and an earlier survey by Bhattacharya in 1999, show that enough material is publicly available that can be used to develop short courses, seminars and self-study guides for public policy makers (elected officials and their staff), and financial professionals (bankers, economists, insurance professionals). This again represents an opportunity for the IASEE to help. Table 1 summarizes the internet resources of educational materials which is excerpted from our survey and from Bhattacharya (2000).

## **2. Levels of Solar Energy Education**

As explained before, initially solar energy education was limited to scientists and engineers who could develop the technology and conduct research and development. However, as time passed a need was recognized to educate those who design and build buildings because solar energy applications were well developed for these applications. At the present time solar energy applications are well developed for heating, and cooling of buildings, electricity production for stationary and mobile applications, and for environmental cleanup. However, because of unfavorable policies, use of unfavorable financial tools and a general lack of solar energy information among the public policy makers, financial professionals and the general public, there is a mismatch between the solar energy technology availability and its demand. Therefore, there is a need to educate such non-traditional (non-scientists, engineers, etc.) students about solar energy. The following list gives the various levels of solar energy education available, or needed.

- College (Undergraduate and Graduate)  
Sciences and Engineering

Architectural and Building Construction  
Environmental Studies  
Business, Law, Economics etc.

- Schools (K-12)
- Technicians
- Business and Financial Professionals
- Public Policy Makers
- General Public

## **2a. College Level**

Solar energy education for the scientists and engineers at the college level is perhaps the most developed. Well-written textbooks are available throughout the world. Education at this level goes up and down with the need. For example, around 1980 solar energy was taught in about 150 universities in the U.S.A. Today, because of the low demand, only about 10 universities are regularly offering solar energy courses in the U.S.A. One area where improvement could be made in college level education is to develop courses and texts for students in the fields of environmental studies, business, law, economics, etc.

## **2b. Schools**

It is very important to teach K-12 students about the intimate relationship between solar energy use and clean environment, because these children will eventually set the policies that will affect solar energy use. In order to educate school children, it is necessary to educate and train the teachers and to develop appropriate educational materials. A large amount of educational materials have been developed for school children in different parts of the world. These include lecture notes, experiments, project ideas, design competitions, etc. These materials are available in print form, computer CD-ROMs, videos, slides, project kits, etc. Table 1 gives an example of some of the materials available. IASEE has an opportunity to compile all the material and make it available through the Internet.

## **2c. Technicians**

Technician training and certification is important for proper installation and working of solar energy systems. In the late 1970s and early 1980s a number of solar heating systems were improperly installed in the U.S.A. by technicians not trained for solar energy systems. Some systems, however, were improperly designed. This resulted in a negative image of solar energy that has not been completely overcome even today. Technician training, though important, depends on market demand.

## **2d. Business and Financial Professionals**

Bankers and other financial professionals are very important in achieving increased use of solar energy; however, they are perhaps the least familiar with solar energy systems. They can develop financial tools that recognize the advantages of solar energy systems over

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conventional energy systems. For example, when you compare a domestic solar water heater costing \$3,000 in the U.S.A. with a conventional electric resistance water heater, costing about \$300, the solar water heater does not look financially attractive. However, in an innovative financial analysis Beckman (1997) showed that the same solar water heater would save money every month right from the start over the conventional electric water heater, by using life cycle analysis, long-term financing and tax advantages. In another example, a passive solar designed house would have lower monthly energy costs than a conventionally designed house. If the bankers were educated to recognize this fact, the passive solar house would be eligible for a higher mortgage value than the conventional house. At the present time there are no programs to train and educate business and financial professionals on how to value solar energy systems. Again, this presents an opportunity to develop materials for seminars, short courses and self-study for such professionals.

## **2e. Public Policy Makers**

Public policy makers can have the most profound impact on how solar energy is used in the future. This group of people includes elected officials, and their staff, government civil servants, regulatory officials, etc. Elected officials and their staff need to understand general overview, examples of working systems, economics and the impact of policy on the economics. For example, based on conventional economics, electricity from a solar thermal plant costing about 10-11 cents/kWh could not compete with electricity from coal power plants at about 6 cents/kWh. However, if you include the costs of environmental externalities, as was done by the Nevada Public Service Commission (Kreith, 1993), the cost of electricity from coal increases to about 13 cents/kWh which makes solar electricity the cheaper alternative. Public policy makers must be educated in how to account for the environmental and social costs of energy. At the present time, no organized material exists for the education of public policy makers. Therefore, this is another opportunity for IASEE to help.

## **2f. General Public**

General public needs to understand that solar energy systems work, provide comfort, have favorable economics and provide environmental benefits that are important for their family members. Once convinced of the above, they will create a favorable climate for the use of solar energy systems and further R&D investments by governmental funding agencies. There are very practical examples suitable for education of the general public. One successful example is the National Solar Home Tour organized by the American Solar Energy Society (ASES). During this tour, which is held in October each year, owners and builders of solar homes put their homes on display for the general public to see. This tour attracts national and local publicity in the print and television media. At the solar home, the general public not only sees actual solar systems working, but are also able to discuss with knowledgeable volunteers and take additional solar energy educational material home.

### 3. Conclusions

Our survey (2000) and a survey conducted by Bhattacharya (2000), have uncovered a wealth of information available worldwide for solar energy education. Most of that information is available on the Internet. There are also many websites available about Biomass, Geothermal, Wind, and Hydropower, each with varied educational levels. These resources may be used to prepare specialized educational modules, workshops, and seminars for business and financial professionals, public policy makers and the general public. There is enough solar energy educational materials (such as textbooks) available for traditional undergraduate and graduate courses in science and engineering. However, there is an opportunity to develop solar energy courses and texts for students in the fields of environmental studies, business, law, economics, and architecture.

### Bibliography

1. Beckman, William [1997) Financial Analysis of Solar Water Heaters, *ISES 1997 Solar World Congress*, Taejon, Korea, August 1997.
2. Bhattacharya, S.C. (April 2000). Solar and Renewable Energy Links Updating ISES Education Module of WIRE. WIRE is the electronic magazine of the International Solar Energy Society. Refer to Website: <http://wire0.ises.org/wire/wire.nsf>
3. Kreith, F., and Burmeister, G. (1993). "Energy Management and Conservation," National Conference of State Legislatures, Denver, CO.
4. Solar Energy and Energy Conversion Laboratory, University of Florida (May 2000). Solar and Renewable Energy Links survey.

### D. YOGI GOSWAMI

Dr. D. Yogi Goswami is a professor of Mechanical Engineering and Director of the Solar Energy and Energy Conversion Laboratory at the University of Florida. He is internationally known for his research in fundamental and applied areas of renewable energy. He has published as an author or editor 5 books, 8 book chapters, 4 conference proceedings and more than 100 technical papers. He also holds 5 US patents and 1 world-wide patent.

**Table 1: Solar Educational Materials Available**

(excerpted from S.C. Bhattacharya, April 2000; and UF Solar Lab survey May 2000)

Name	Link and Contact	Synopsis	Educational Level
Solar Now Project	<a href="http://www.eren.doe.gov/solarnow/">http://www.eren.doe.gov/solarnow/</a> Email: <a href="mailto:solar19@idt.net">solar19@idt.net</a>	The “Kids Corner” includes glossary of renewable energy terms, simple experiments and information on the Beverly, Massachusetts photovoltaic array.	All levels
Sun Lab	<a href="http://www.eren.doe.gov/sunlab/">http://www.eren.doe.gov/sunlab/</a> Email: <a href="mailto:skshowa@sandia.gov">skshowa@sandia.gov</a>	Site provides technology overview, photos, documents, upcoming meetings, and related links. The Concentrating Solar power program validates solar power technologies.	College: Undergraduate and Graduate
Photovoltaics Pgm.	<a href="http://www.eren.doe.gov/pv/">http://www.eren.doe.gov/pv/</a>	Detailed description of photovoltaics, its mechanisms, examples, and quizzes. A 72-second animated video “Solar Cell Animation” shows the function of a solar cell.	Secondary/Middle
What Stores Solar Energy Best	<a href="http://www.eren.doe.gov/solarnow/activ_2.htm">http://www.eren.doe.gov/solarnow/activ_2.htm</a> Email: <a href="mailto:solar19@idt.net">solar19@idt.net</a>	Describes an experiment introducing concepts of materials that may help to cool or warm a home.	Elementary
Roofus	<a href="http://www.eren.doe.gov/roofus">http://www.eren.doe.gov/roofus</a> Email: <a href="mailto:roofus@nrel.gov">roofus@nrel.gov</a>	A virtual tour inside an energy-smart house (solar home) exploring the roof, garage and backyard. Activity suggestions are included.	Elementary
The Sun’s Joules	<a href="http://solstice.crest.org/renewables/SJ/info.html">http://solstice.crest.org/renewables/SJ/info.html</a> Email: <a href="mailto:joules@crest.org">joules@crest.org</a> or <a href="mailto:www-content@solstice.crest.org">www-content@solstice.crest.org</a>	A CD-ROM multimedia encyclopedia on renewable energy and the environment (demonstration version available at: <a href="http://solstice.crest.org/renewables/SJ/index.html">http://solstice.crest.org/renewables/SJ/index.html</a> )	High School Young People Adults
Community PV	<a href="http://www.solstice.crest.org/softwarecentral/html/cpv.shtml">http://www.solstice.crest.org/softwarecentral/html/cpv.shtml</a> Email: <a href="mailto:mkcampbell@repp.org">mkcampbell@repp.org</a>	Educational community PV software teaches about utility PV programs worldwide, benefiting businesses, homes, schools and communities. Dozens of successful projects and a multimedia introduction to PV technology are included.	Secondary/Middle
Photovoltaics	<a href="http://aurora.crest.org/pv/index.htm">http://aurora.crest.org/pv/index.htm</a> Email: <a href="mailto:aurora@crest.org">aurora@crest.org</a>	Provides introduction to Photovoltaics (cells, arrays and systems).	College
Solar, Heat Transfer, Electricity and Energy Consumption	<a href="http://aurora.crest.org/basics/index.htm">http://aurora.crest.org/basics/index.htm</a> Email: <a href="mailto:aurora@crest.org">aurora@crest.org</a>	Basic information on topics of solar, heat transfer, electricity and energy consumption.	College
Solar Project	<a href="http://www.picoturbine.com/projectlist.htm">http://www.picoturbine.com/projectlist.htm</a> Email: <a href="mailto:comments@picoturbine.com">comments@picoturbine.com</a>	Describes and lists solar project plans and kits including Solar Stovetop Cooker Pattern, Basic Solar Electricity Education Kit and Deluxe Solar Electricity Education Kit.	Grade 5 through Secondary/Middle
Guide to Renewable Energy	<a href="http://www.picoturbine.com/booklist.htm#CAT">http://www.picoturbine.com/booklist.htm#CAT</a> Email: <a href="mailto:comments@picoturbine.com">comments@picoturbine.com</a>	Lists books on solar energy including <i>Solar Water Heating</i> , <i>Tapping the Sun: A Solar Water Heating Guide</i> , <i>Solar Heating: Teachers Guide to Renewable Energy Projects</i> and <i>Solar Power Pupil’s Guide</i> .	Grade 8 through High School Vocational Trng. Teachers
Solar Energy	<a href="http://www.picoturbine.com/videos.htm">http://www.picoturbine.com/videos.htm</a> Email: <a href="mailto:comments@picoturbine.com">comments@picoturbine.com</a>	Renewable energy videos <i>Solar Powered Home with Rob Roy</i> , <i>Residential Microhydro Power with Don Harris</i> and <i>Solar</i>	Vocational Trng. College:

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Name	Link and Contact	Synopsis	Educational Level
		<i>Water Pumping with Windy Dankoff</i>	Undergraduate and Graduate
Fundamentals of Remote Area Power Supply	<a href="http://www.energyvic.vic.gov.au/efficient/renew.htm">http://www.energyvic.vic.gov.au/efficient/renew.htm</a> Email: <a href="mailto:infocentre@energyvic.vic.gov.au">infocentre@energyvic.vic.gov.au</a>	Text and figures about renewable energy systems, remote area power supply systems and solar hot water, in Australia.	Secondary/Middle Vocational Trng. College: Undergraduate and Graduate
Brochures and Project Sheets	<a href="http://energyvic.vic.gov.au/products/products.htm#ed">http://energyvic.vic.gov.au/products/products.htm#ed</a> Email: <a href="mailto:infocentre@energyvic.vic.gov.au">infocentre@energyvic.vic.gov.au</a>	Includes extensive range of practical brochures and student projects sheets on energy efficiency and renewables, including solar pool heating, solar and wind power systems, and energy resources.	Secondary/Middle Vocational Trng. College: Undergraduate and Graduate
A Solar Energy Science Unit	<a href="http://alpha.fsec.ucf.edu/ed/solar-unit/menu.htm">http://alpha.fsec.ucf.edu/ed/solar-unit/menu.htm</a> Email: <a href="mailto:info@fsec.ucf.edu">info@fsec.ucf.edu</a>	"Solar Matters" provides curriculum on <i>Solar Home, Sun and Energy, Sun Tracking and Shadows, Solar thermal, Photovoltaics, Solar Energy and Me</i> , and a Resource Section.	Secondary/Middle
Solar Radiation Resource	<a href="http://rredc.nrel.gov/solar/">http://rredc.nrel.gov/solar/</a> Email: <a href="mailto:rredc@nrel.gov">rredc@nrel.gov</a>	Provides links to archived data, NREL data collection activities, solar codes, algorithms, models and calculators, and publications.	College: Undergraduate and Graduate
Pizza Box Oven	<a href="http://www.nrel.gov/education/solar_oven.html">http://www.nrel.gov/education/solar_oven.html</a> Email: <a href="mailto:linda_lung@nrel.gov">linda_lung@nrel.gov</a>	Provides easy-to-follow instructions for building a simple cooker <i>pizza box solar oven</i> .	Secondary/Middle
Solar Science Projects	<a href="http://www.nrel.gov/education/pdfs/sciproj.pdf">http://www.nrel.gov/education/pdfs/sciproj.pdf</a> Email: <a href="mailto:linda_lung@nrel.gov">linda_lung@nrel.gov</a>	Four solar energy science projects/experiments and a glossary: <i>Solar Air Heater, Solar Water Heater, Solar Hotdog Cooker and Effects of Amount and wavelength of Light on a Solar Cell</i> .	High School
Solar Energy Technologies	<a href="http://www.nrel.gov/lab/pao/solar_energy.html">http://www.nrel.gov/lab/pao/solar_energy.html</a> Email: <a href="mailto:linda_lung@nrel.gov">linda_lung@nrel.gov</a>	Introduction to solar thermal and photovoltaic technologies for power generation and heating applications.	Secondary/Middle
Energy from the Sun	<a href="http://www.energy.ca.gov/education/projects/projects-html/sunenergy.html">http://www.energy.ca.gov/education/projects/projects-html/sunenergy.html</a> Email: <a href="mailto:energia@energy.ca.gov">energia@energy.ca.gov</a>	"Energy Quest's" simple energy and science projects show importance of the sun and gives instructions on how to make a sun mask and puppet.	Elementary
Jobs the Sun Does	<a href="http://www.energy.ca.gov/education/projects/projects-html/sunjobs.html">http://www.energy.ca.gov/education/projects/projects-html/sunjobs.html</a> Email: <a href="mailto:energia@energy.ca.gov">energia@energy.ca.gov</a>	<i>Jobs the Sun Does</i> is an illustrative activity of listing the jobs that the sun does.	Elementary
Energy Projects for Young Scientists	<a href="http://www.xmission.com/~nef/3.7.html">http://www.xmission.com/~nef/3.7.html</a>	"Energy Projects for Young Scientists" by Robert Gardner contains invaluable information on how to conduct experiments and investigations.	Secondary/Middle through High School
Sunrayce Education Kit on Sun and Energy	<a href="http://www.sunrayce.com/education/se_sec1.html">http://www.sunrayce.com/education/se_sec1.html</a> Email: <a href="mailto:sunraycehq@mindspring.com">sunraycehq@mindspring.com</a>	Sunrayce provides lessons plans on Sun and Energy involving heat, light, and solar energy. Each lesson has a classroom activity, list of supplies, teacher guide and background information.	Secondary/Middle High School

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<b>Name</b>	<b>Link and Contact</b>	<b>Synopsis</b>	<b>Educational Level</b>
Sunrayce Education Kit on Sunrayce and Technology	<a href="http://www.sunrayce.com/education/se_sec2.html">http://www.sunrayce.com/education/se_sec2.html</a> Email: <a href="mailto:sunraycehq@mindspring.com">sunraycehq@mindspring.com</a>	Lesson plans on Sunrayce and Technology using technologies which develop Sunrayce cars. Each lesson includes student lesson and Teacher/Mentor Guide.	Secondary/Middle High School
Solar Electric Applications	<a href="http://solarDome.com/SolarDome4.html">http://solarDome.com/SolarDome4.html</a> Email: <a href="mailto:SolarDome@aol.com">SolarDome@aol.com</a>	The site provides a list of solar electric applications from agriculture to water harvesting.	Vocational Trng. College
Schools Going Solar	<a href="http://www.ttcorp.com/upvg/schools/">http://www.ttcorp.com/upvg/schools/</a> Email: <a href="mailto:upvg@ttcorp.com">upvg@ttcorp.com</a>	Extensive information in a guide for schools. Includes solar facts (PV, passive solar and solar thermal), an introduction of solar energy in U.S. schools, and links to U.S. schools going solar.	All School Levels
Information Books on Solar Energy	<a href="http://www.aep.com/environment/solar/power/index.html">http://www.aep.com/environment/solar/power/index.html</a> Email: <a href="http://www.aep.com/search/cindex.dfm?RecipientName=corpcomm">http://www.aep.com/search/cindex.dfm?RecipientName=corpcomm</a>	American Electric Power provides information books containing fact sheets about energy sources, links to "Power Pie" (articles about energy) and energy-environment news.	Elementary Secondary/Middle
Solar Energy: The Basics	<a href="http://zebu.uoregon.edu/ph162/14.html">http://zebu.uoregon.edu/ph162/14.html</a> Email: <a href="mailto:nuts@moo.uoregon.edu">nuts@moo.uoregon.edu</a>	Features college notes from Physics 162 lecture on Solar Energy: The Basics. It discusses the sun, solar power, photon scattering (with animation) and energy calculation.	College
Solar Energy: Conduction and Heat Transfer	<a href="http://zebu.uoregon.edu/ph162/15.html">http://zebu.uoregon.edu/ph162/15.html</a> Email: <a href="mailto:nuts@moo.uoregon.edu">nuts@moo.uoregon.edu</a>	Features notes from Physics 162 lecture on Solar Energy: Conduction and Heat Transfer, discussion use of solar energy, modes of heat transfer and thermal conduction.	College
Solar Energy: Convective and Radiative Heat Trans.	<a href="http://zebu.uoregon.edu/ph162/15a.html">http://zebu.uoregon.edu/ph162/15a.html</a> Email: <a href="mailto:nuts@moo.uoregon.edu">nuts@moo.uoregon.edu</a>	Features college notes from Physics 162 lecture on Solar Energy: Convective and Radiative Heat Transfer, with discussion on convection and thermal radiation.	College
Solar Energy: Conversion into Electricity	<a href="http://zebu.uoregon.edu/ph162/16.html">http://zebu.uoregon.edu/ph162/16.html</a> Email: <a href="mailto:nuts@moo.uoregon.edu">nuts@moo.uoregon.edu</a>	Features college notes from Physics 162 lecture on Solar Energy: Conversion into Electricity, with discussion on solar energy, conversion into electricity, photovoltaic devices, silicon and advances in silicon technology, and energy calculations.	College
Solar Energy: Large Scale Production	<a href="http://zebu.uoregon.edu/ph162/19.html">http://zebu.uoregon.edu/ph162/19.html</a> Email: <a href="mailto:nuts@moo.uoregon.edu">nuts@moo.uoregon.edu</a>	Features college notes from Physics 162 lecture on Solar Energy: Large Scale Production, with discussion on the facilities, production and PV.	College
Photovoltaics	<a href="http://www.seda.nsw.gov.au/ren_photovoltaics.asp">http://www.seda.nsw.gov.au/ren_photovoltaics.asp</a> Email: <a href="mailto:seda@seda.nsw.gov.au">seda@seda.nsw.gov.au</a>	Information on photovoltaics and New South Wales, Australia power needs.	Secondary/Middle through High School
Solar Thermal Energy	<a href="http://www.seda.nsw.gov.au/ren_solarthermal.asp">http://www.seda.nsw.gov.au/ren_solarthermal.asp</a> Email: <a href="mailto:seda@seda.nsw.gov.au">seda@seda.nsw.gov.au</a>	Information on solar thermal energy, how it is used, benefits from using it, and its potential in Australia.	Secondary/Middle through High School
Photovoltaics: Technology Synopsis	<a href="http://seref.org/slides/pv/pv.html">http://seref.org/slides/pv/pv.html</a> Email: <a href="mailto:info@seref.org">info@seref.org</a>	Site provides "Energy Notes on Photovoltaics: Technology Synopsis" that includes an introduction, history and overview of photovoltaics.	

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<b>Name</b>	<b>Link and Contact</b>	<b>Synopsis</b>	<b>Educational Level</b>
Photovoltaic Slides	<a href="http://seref.org/cgi-bin/slidesho.pl?section=Photovoltaics">http://seref.org/cgi-bin/slidesho.pl?section=Photovoltaics</a> Email: <a href="mailto:info@seref.org">info@seref.org</a>	Slides of 150 photovoltaic pictures are shown of different kinds of PV systems, PV applications in agriculture, industry and households, and solar vehicles and houses.	
Solar Science Activities	<a href="http://seref.org/index2.html">http://seref.org/index2.html</a> Email: <a href="mailto:info@seref.org">info@seref.org</a>	Features 4 simple hands-on experiments about various aspects of solar energy, including: "In collecting solar energy, is bigger better?" "How much solar heat comes from the sun to you?" "Which material best stores solar energy?" "What color absorbs the sun's heat best?"	Secondary/Middle
Educational Solar Energy Kit	<a href="http://www.nspri.org/asn_94sunmate.html">http://www.nspri.org/asn_94sunmate.html</a>	Reviews the "Educational Solar Energy Kit" by Sun Mate corp. It is rated as having the greatest educational value of any PV kit readily available as a low-cost and educational kit.	Secondary/Middle through High School
Solar Energy International	<a href="http://solarenergy.org/online">http://solarenergy.org/online</a> Email: <a href="mailto:sei@solarenergy.org">sei@solarenergy.org</a>	Renewable Energy Education Program (REEP) teaches practical use of solar, wind and water power; includes five on-line PV design courses	College International Professionals
Global Solar Partners	<a href="http://www.asehq.org.uk/solar/solar_eng.pdf">http://www.asehq.org.uk/solar/solar_eng.pdf</a> there are separate links for various languages <a href="mailto:kl@3ECONSULT.de">kl@3ECONSULT.de</a>	A project from the Association for Science Education. Solar education units for studying energy resources and technologies, helping to understand issues involving sustainable development.	Secondary/Middle
Fundamentals of Photovoltaic Materials	<a href="http://www.nspri.org/pv.pdf">http://www.nspri.org/pv.pdf</a>	Features "Fundamentals of Photovoltaic Materials" by Olivia Mah in PDF format. The content includes photovoltaics, photovoltaic cells and types of PV cell materials.	High School through College
Centre for Alternative Technology	<a href="http://www.cat.org.uk/services/eduinfo.tmpl">http://www.cat.org.uk/services/eduinfo.tmpl</a> <a href="mailto:info@cat.org.uk">info@cat.org.uk</a>	Holistic approach integrating ideas and practice relating to land use, shelter, energy conservation and use, diet and health, waste management and recycling; committed to the implementation of co-operative principles and best achievable environmental practices.	
Energy Efficiency and Renewable Energy Network	<a href="http://www.eren.doe.gov/education">http://www.eren.doe.gov/education</a>	Extensive links list available for renewable energy education sources.	
Renewable Resource Information	<a href="http://rredc.nrel.gov/otherlinks.html">http://rredc.nrel.gov/otherlinks.html</a>	Extensive links to other sources of renewable resource information.	
Midwest Renewable Energy Association	<a href="http://www.the-mrea.org">http://www.the-mrea.org</a> Email: <a href="mailto:mreainfo@wi-net.com">mreainfo@wi-net.com</a>	Offers two to five-day workshops on a variety of renewable energy and energy-efficient house construction.	People of All Ages
North Carolina Solar Center	<a href="http://www.ncsc.ncsu.edu/edu/eduprog.htm">http://www.ncsc.ncsu.edu/edu/eduprog.htm</a> Email: <a href="mailto:ncsun@ncsu.edu">ncsun@ncsu.edu</a>	Offers teachers an energy curriculum package "Energy, Technology and Society," wide range of concepts and are interdisciplinary easily used in science, ecology/environment or social studies curricula.	High School
University of	<a href="http://www.ecs.umass.edu/mie">http://www.ecs.umass.edu/mie</a>	Courses in solar energy and wind energy conversion. Students	College

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Massachusetts	E-mail: <a href="mailto:mie@ecs.umass.edu">mie@ecs.umass.edu</a>	may develop program of study at graduate level.	Graduate
National Energy Information Center	<a href="http://www.eia.doe.gov/kids">http://www.eia.doe.gov/kids</a> Email: <a href="mailto:infoctr@eia.doe.gov">infoctr@eia.doe.gov</a>	Collects statistical information on energy supply and consumption, and offers free materials for students and educators.	
National Energy Education Development	<a href="http://www.need.org">http://www.need.org</a> email: <a href="mailto:need@erols.com">need@erols.com</a>	Project promotes an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.	
Northeast Sustainable Energy Association	<a href="http://www.nesea.org/education">http://www.nesea.org/education</a> Email: <a href="mailto:nesea@nesea.org">nesea@nesea.org</a>	Educational resources that engages students with competitions, activities or lessons on the theme of transportation. Can be used to teach Technology, Science, Math, Social Studies, and Health.	Kindergarten through High School
Sunstone Press	<a href="http://www.sunstonepress.com">www.sunstonepress.com</a>	<i>Done in the Sun: Solar Projects for Children</i> Available from.	Grades 3-5
<b>Educational Development Corp.</b>	<a href="http://www.edcpub.com/">http://www.edcpub.com/</a> Email: <a href="http://www.edcpub.com/feedback.asp">http://www.edcpub.com/feedback.asp</a>	<i>Energy and Power</i> EDC develops curriculum materials for schools; making reading and learning fun and not a boring or intimidating experience.	
Union of Concerned Scientists	<a href="http://www.ucsusa.org">http://www.ucsusa.org</a> Email: <a href="mailto:ucs@ucsusa.org">ucs@ucsusa.org</a>	<i>Renewables are Ready: A Guide to Teaching Renewable Energy in Junior and Senior High School Classrooms</i>	Grades 9-12
American Solar Energy Society / Solar Energy Research Institute	<a href="http://www.ases.org">http://www.ases.org</a> Email: <a href="mailto:ases@ases.org">ases@ases.org</a>	Science Projects in Renewable Energy and Energy Efficiency <i>Educational Tools for All Ages</i> includes slides, videos and books.	K-12
University of New South Wales, Centre for Photovoltaic Engineering	<a href="http://maestro.ee.unsw.edu.au/~appv/">http://maestro.ee.unsw.edu.au/~appv/</a> email: <a href="mailto:apvsc@unsw.edu.au">apvsc@unsw.edu.au</a>	Applied Photovoltaics Short Course available on-line. Intended for those having some background in the subject.	Experienced
Beakman and Jax Science Stuff	<a href="http://www.beakman.com/">http://www.beakman.com/</a>	Science for students, grades 3-6	Elementary
Bill Nye the Science Guy	<a href="http://nyelabs.kcets.org/">http://nyelabs.kcets.org/</a>	Science according to "Bill Nye the Science Guy"	Elementary Secondary/Middle
Ecokids	<a href="http://www.ecomall.com/biz/ecokids.htm">http://www.ecomall.com/biz/ecokids.htm</a>	Many links to environmental websites for students	Elementary Secondary/Middle
Energy Quest	<a href="http://www.energy.ea.gov/education/index.html">http://www.energy.ea.gov/education/index.html</a>	Energy education for kids that touches on solar, nuclear, geothermal, biomass, fossil fuel and wind energy.	Elementary Secondary/Middle
Environmental Protection Agency	<a href="http://www.epa.gov/">http://www.epa.gov/</a>	The children's section of this site houses the Explorer's Club, containing stories, games and vocabulary words about recycling, air quality and animals.	Elementary Secondary/Middle

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Hotlist of Science Sites from the Franklin Institute	<a href="http://sln.fi.edu/tfi/hotlists/kid-sci.html">http://sln.fi.edu/tfi/hotlists/kid-sci.html</a>	Web resource list for kids.	Elementary Secondary/Middle
Optics for Kids	<a href="http://www.opticalres.com/kidoptx.html">http://www.opticalres.com/kidoptx.html</a>	The science of light in kid terms.	Elementary Secondary/Middle
Yahooligans	<a href="http://yahooligans.com">http://yahooligans.com</a>	A children's internet search engine with categories ranging from the Earth to museums and exhibits to physical science and more.	Elementary Secondary/Middle
AIMS Education Foundation	<a href="http://www.aimsedu.org/">http://www.aimsedu.org/</a>	Provides hands-on activities that integrate, math, science and other disciplines.	Elementary Secondary/Middle
Association for Science Education	<a href="http://www.ase.org.uk/">http://www.ase.org.uk/</a>	"Teachers helping teachers to teach science." UK's largest educational association for science teachers, technicians, and advisors and is dedicated to the teaching of science.	Teachers
B.C. Hydro	<a href="http://137.82.194.74/environment/education/class0.html">http://137.82.194.74/environment/education/class0.html</a>	Safety, energy and the environment, and energy efficiency resources.	Elementary through High School.
Brevard County Science Resource Guide	<a href="http://pss/fit/edu/teachers/education.html">http://pss/fit/edu/teachers/education.html</a>	Very well organized science links of all kinds.	Teacher Resource
California Energy Commission / Geothermal Resources Council Publications Online	<a href="http://www.grc.org/pubs3.html">http://www.grc.org/pubs3.html</a>	Information about city planning, sustainability, recycling, etc.	Teacher Resource
Capital Area Math / Science Alliance	<a href="http://www.caiu.k12.pa.uis.msahome.msamain.htm">http://www.caiu.k12.pa.uis.msahome.msamain.htm</a>	Numerous links to mathematics and science education resources for teachers and students.	Teacher Resource
CEA Science Education Pages	<a href="http://www.cea.berkeley.edu/Education/">http://www.cea.berkeley.edu/Education/</a>	Lesson plans and activities designed by science teachers	K-12 Teacher Resource
Cody's Science Education Zone	<a href="http://dcom.ousd.k12.ca.vx/~codypren/CSEZ_Home.htm">http://dcom.ousd.k12.ca.vx/~codypren/CSEZ_Home.htm</a>	Science lessons, ideas, issues and more	Teacher Resource
Cyberscience	<a href="http://www.publish.csiro.au/cyberscience">http://www.publish.csiro.au/cyberscience</a>	Magazine articles, puzzles, experiments, downloadable multimedia demos and more	Teacher Resource
Discovery Channel	<a href="http://www.discovery.com">http://www.discovery.com</a>	Science articles and activities for students and teachers	Teacher Resource
Earthwatch	<a href="http://earthwatch.org">http://earthwatch.org</a>	Descriptions of over 150 on-going field research projects worldwide, interactive links to scientists, virtual field trips, and access to the Earthwatch Global Classroom	Teacher Resource

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Earthweek Classroom Companion	<a href="http://www.bconnex.net/~lepages/earthweek/">http://www.bconnex.net/~lepages/earthweek/</a>	Environmental issues in the news, puzzles, resources, lessons and more. Updated weekly	Teacher Resource
Ecomall	<a href="http://www.ecomall.com">http://www.ecomall.com</a>	Environmental focus including solar and renewable energy products	Teacher Resource
Education and Science	<a href="http://www.globe.gov/">http://www.globe.gov/</a>	Find out how students and teachers from over 3000 schools in 39 countries are working with research scientists to learn more about our planet	Teacher Resource
Eisenhower National Clearinghouse	<a href="http://www.enc.org/">http://www.enc.org/</a>	Information source for K-12 math and science teachers	Teacher Resource
Elementary Science Program	<a href="http://www.monroe2boces.org/shared/esp/">http://www.monroe2boces.org/shared/esp/</a>	student and teacher resources for elementary science	Teacher Resource
Energy Education	<a href="http://www.eren.doe.gov.education/">http://www.eren.doe.gov.education/</a>	Information on renewable energy sources, energy conservation, and energy education resources (compiled by the U.S. Department of Education)	Teacher Resource
Energy Matters	<a href="http://library.advanced.org/20331">http://library.advanced.org/20331</a>		Teacher Resource
Environmental Education Link	<a href="http://eelink.net">http://eelink.net</a>	For teachers and students grades K-12	Teacher Resource
ESTEEM:	<a href="http://www.sandia.gov/ESTEEM/home.html">http://www.sandia.gov/ESTEEM/home.html</a>	Department of Energy Educational Resources	Teacher Resource
FAQs About the Sun	<a href="http://solar-center.stanford.edu/FAQ">http://solar-center.stanford.edu/FAQ</a>		Teacher Resource
Fundamental Interactions	<a href="http://www.intothecosmos.com/">http://www.intothecosmos.com/</a>	Space library and resources	Teacher Resource
Global Network of Environment and Technology	<a href="http://www.gnet.org/">http://www.gnet.org/</a>		Teacher Resource
Global Change Home Page	<a href="http://www.globalchange.org/">http://www.globalchange.org/</a>		Teacher Resource
Global Change Research Information Office	<a href="http://www.gcrio.org">http://www.gcrio.org</a>	Access to data and information on global change research, adaptation/mitigation strategies and technologies, and global change related educational resources. Links to other environmental sites, equipment	Teacher Resource
Gorby Files: Renewable Energy	<a href="http://www.halcyon.com/alancrab/re.page.html">http://www.halcyon.com/alancrab/re.page.html</a>	Small directory of significant alternative energy and environmental on-line sites	Teacher Resource

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Jr. Solar Sprint Web Page	<a href="http://www.nrel.gov/business/education/sprintweb">http://www.nrel.gov/business/education/sprintweb</a>		Teacher Resource
KNC Software	<a href="http://www.kidsnetconnect.com/teachers/newframe/education/eframe.htm">http://www.kidsnetconnect.com/teachers/newframe/education/eframe.htm</a>	K12 education and technology	Teacher Resource
NASA Learning Technology Project	<a href="http://www.lmsal.com/YPOP">http://www.lmsal.com/YPOP</a>	Watch the solar theater and learn all about the sun	Teacher Resource
Newton's Apple	<a href="http://ericir.syr.edu/Projects/Newton/">http://ericir.syr.edu/Projects/Newton/</a>	Website of the PBS science show includes lesson plans – energy projects include solar cars, acid rain and ethanol	Teacher Resource
Public Citizen	<a href="http://www.citizen.org/cmep/renewables.html">http://www.citizen.org/cmep/renewables.html</a>	Renewable energy information	Teacher Resource
Refdesk.com	<a href="http://www.refdesk.com">http://www.refdesk.com</a>		Teacher Resource
Renewable Energy Education Module	<a href="http://solstice.crest.org/renewables/re-kiosk/index.html">http://solstice.crest.org/renewables/re-kiosk/index.html</a>	Words and pictures are used to teach the theoretical and practical basics of renewable energy	Teacher Resource
Renew America	<a href="http://solstice.crest.org/environment/renew_america/index.html">http://solstice.crest.org/environment/renew_america/index.html</a>	Network of community and environmental groups, businesses, government leaders and civic activists exchange ideas and expertise for improving the environment	Teacher Resource
Residential Energy Efficiency Database	<a href="http://www.its-canada.com/reed/">http://www.its-canada.com/reed/</a>	Database designed as an educational tool to promote the benefits of energy efficiency and is maintained as a free, on-line information service	Teacher Resource
The School Page: The Educator's Resource	<a href="http://www.eyesoftime.com/teacher/index.htm">http://www.eyesoftime.com/teacher/index.htm</a>		Teacher Resource
Science Daily Magazine	<a href="http://www.sciencedaily.com">http://www.sciencedaily.com</a>	On-line version of Science Daily Magazine, including headlines and articles covering several branches of science	Teacher Resource
Shedding a New Light on the Universe	<a href="http://astroe.gfsc.nasa.gov/docs/xte/learning_center/universe.html">http://astroe.gfsc.nasa.gov/docs/xte/learning_center/universe.html</a>		Teacher Resource
Softseek.com	<a href="http://www.softseek.com">http://www.softseek.com</a>	Free and shareware	Teacher Resource
Solardome	<a href="http://www.solardome.com">http://www.solardome.com</a>	Energy education resources	Teacher Resource
Solarex	<a href="http://www.solarex.com/">http://www.solarex.com/</a>	Informative web page that explains in detail how photovoltaics (PV) work, some history of PV use and more.	Teacher Resource
Southeast Michigan Math-Science Coalition	<a href="http://www.eecs.umich.edu/~coalitn/sciedoutreach/mainpage.html">http://www.eecs.umich.edu/~coalitn/sciedoutreach/mainpage.html</a>		Teacher Resource
Starfish	<a href="http://www.2nature.org/programs/starfish/sfhome.nsf">http://www.2nature.org/programs/starfish/sfhome.nsf</a>	A branch of the Second Nature program that is trying to incorporate environmental themes into educational curriculums	Teacher Resource
Today's Space Weather	<a href="http://www.selinoaa.gov/today2.html">http://www.selinoaa.gov/today2.html</a>		Teacher Resource

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What is Ultraviolet Light?	<a href="http://snoopy.gfsc.nasa.gov/orfeus2/ultraviolet.html">http://snoopy.gfsc.nasa.gov/orfeus2/ultraviolet.html</a>		Teacher Resource
Whatzit	<a href="http://www.oms.edu/online/whatzit/home.htm">http://www.oms.edu/online/whatzit/home.htm</a>	Answers scientific questions from “what makes electric eels electric?” to “why do leaves change color in the fall?” Ask your own questions	Teacher Resource
The Why Files	<a href="http://whyfiles.news.wisc.edu">http://whyfiles.news.wisc.edu</a>	A product of the National Institute for Science Education. This is an effort to illuminate the science, math, and technology that lurks behind the headline news. The page is updated bi-weekly and touches on a variety of topics including air pollution and solar energy.	Teacher Resource
World Resources Institute	<a href="http://www.wri.org/wri">http://www.wri.org/wri</a>	An independent center for policy research and technical assistance on global environmental and development issues	Teacher Resource
Worldwatch Institute	<a href="http://www.worldwatch.org">http://www.worldwatch.org</a>	A public research organization with an online publication about emerging global problems and trends	Teacher Resource
WWW Virtual Library: History of Science, Technology, and Medicine	<a href="http://www.asap.unimelb.edu.au/hstm/hstm_ove.htm">http://www.asap.unimelb.edu.au/hstm/hstm_ove.htm</a>		Teacher Resource
Zero Population Growth (ZPG)	<a href="http://www.zpg.org">http://www.zpg.org</a>	Population information, teacher workshops schedules, posters, curriculum and more	Teacher Resource
Platforma Solar de Almeria	<a href="http://www.psa.es/mainengl.html">http://www.psa.es/mainengl.html</a>	European Test Centre for solar energy applications	
Sandia National Laboratories	<a href="http://www.sandia.gov/py">http://www.sandia.gov/py</a>	Slide show presentation with sound.	
Potomac Region Solar Energy Association	<a href="http://solstice.crest.org/renewables/prsea/contest99/index.htm">http://solstice.crest.org/renewables/prsea/contest99/index.htm</a>	High School student solar design contest	High School
Australian Institute of Energy	<a href="http://www.aie.org.au/">http://www.aie.org.au/</a>	Offers technical meetings, symposia and conferences about energy to accountants, economists, engineers, fuel technologists, policy makers, geologists, lawyers, managers and scientists.	
Solar Energy Lab., Univ. Wisconsin-Madison	<a href="http://sel.me.wisc.edu/">http://sel.me.wisc.edu/</a>	Internationally recognized lab for accomplishments in practical applications for solar energy .	College – Graduate
Solar Energy Applications Lab, Colorado State Univ.	<a href="http://www.colostate.edu/Orgs/SEAL/sites.html">http://www.colostate.edu/Orgs/SEAL/sites.html</a>	Research in solar thermal, building analysis, and HVAC systems.	College – Graduate
Solstice – Center for	<a href="http://solstice.crest.org/index.shtml">http://solstice.crest.org/index.shtml</a>	Solstice is the Internet information service of the Renewable	

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Renewable Energy and Sustainable Technology		Energy Policy Project and the Center for Renewable Energy and Sustainable Technology (REPP-CREST), and is your site for sustainable energy and development information.	
Institute of Energy Conversion, Univ. Delaware	<a href="http://www.udel.edu/">http://www.udel.edu/</a>	A multi-disciplinary laboratory devoted to research and development of thin-film photovoltaic cells. IEC's research program is complemented by an educational mission that enables students to obtain degrees while working with professionals engaged in solar cell research.	College – Undergraduate and Graduate
The Millennium Debate	<a href="http://millennium-debate.org/">http://millennium-debate.org/</a> Email: <a href="mailto:rfoulk@millennium-debate.org">rfoulk@millennium-debate.org</a>	This website is designed to be used as a resource for information on any environmental issue. It is a framework for public inclusion in addressing one of the great environmental issues confronting humanity: energy, and how we will generate it and use it in the next century.	
<b>Elementary = Grades Kindergarten through 5; Secondary/Middle = Grades 6 through 8; High School = Grades 9 through 12; College = Beyond High School</b>			

Active solar stills operate with an extra-thermal energy that is fed into the passive basin in order to achieve higher evaporation rate ( Tiwari et al. 2003). In other words, passive solar stills are direct solar technology while active solar stills are indirect solar technology. Modeling the Feasibility of Employing Solar Energy for Water Distillation. Chapter. Jan 2018. The emergence of direct solar steam generators (DSSG) based on plas- monic photothermic conversion of noble metals materials [3] has attracted much attention in the last few years as an impactful quest of mankind for renewable energy applications. The DSSG technol- ogy could be developed in the fields of water purification [3,4], desalination [5,6], distillation [8], sterilization [9] and photo- catalysis [10], etc. At present, numerous solar energy applications have been developed. Solar energy is currently used for heating and cooling of buildings, production of electricity for stationary and mobile applications, solar lighting systems, crop drying, water treatment, and environmental cleanup. Given the expanding use of solar energy, there is a need to educate society about solar energy. This manuscript provides an overview of the status of solar energy education and training in the United States. Though the focus of this chapter is on the solar energy education and training programs provided by the academic institutions in the USA, a short description of non-academic programs is also provided. Chapter Preview. Top.