Project Number: 42-KM-0401

Renewable Energy Education

An Interactive Qualifying Project Report

Submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

by

____
Michael Conrad

____
Larry Nelson Jr.

____
Gregory Panagiotou

____
Jason Sargent

Date: May 3, 2005

____
Professor Kankana Mukherjee, Major Advisor

____
Professor Scott Jiusto, Co Advisor

Abstract

The purpose of this project was to educate on the subject of renewable energy. We conducted a detailed analysis to evaluate the effectiveness of the different education tools. The core achievements implemented by our group to achieve our goal was to design an interactive website to educate children. The MCAS standards were addressed throughout the website.

Authorship

Chapter	Author
Abstract	Conrad
Authorship	Conrad
Acknowledgments	Conrad
Executive Summary	Conrad, Nelson, Sargent
1. Introduction	Conrad
2. Background	All
2.1	All
2.2	All
2.3	All
2.4	All
2.5	All
2.6	All
2.7	All
3. Methodology	Conrad
3.1	Panagiotou, Sargent
3.2	Panagiotou
3.3	Conrad, Sargent
3.4.1	Conrad
3.4.2	All
3.4.3	Conrad
3.5	Panagiotou, Sargent
4. Results and Analysis	Conrad
4.1	Nelson, Panagiotou
4.2	Panagiotou, Sargent
4.3	Sargent
4.4	Panagiotou
4.5	Conrad, Panagiotou
4.6	Nelson, Sargent
4.7	Conrad
5. Recommendations	Conrad, Nelson
6. Resources	All
Appendices	All

Acknowledgments

We would like to take the opportunity to thank the individuals and departments that aided in the success of our project and gave selflessly to providing information and experience. Our hope is that all help was acknowledged, but if for whatever reason there is a lapse, please excuse our mistake and understand that your contributions were also well appreciated. Thanks for making this project a success!

First, we would like to thank our project advisors, Kankana Mukherjee and Scott Jiusto. Their ideas, contributions, evaluations, and reviews really kept our team focused, professional and our project on task. They were both as important to this project as any one of our group members, and gave a tremendous amount of time and effort.

We would like to thank Martha Cyr for her contributions and ideas for our project. The input provided by Dr. Cyr, along with her website, www.teachengineering.com, was the reason we decided to create a website for younger children. Thanks for taking the time to meet with our group members and contribute with your time, ideas, and the possible use of the website.

We would like to thank Sean O'Connor and the Network Operations Department for taking the time to meet with our group members and discussing with us the issues regarding installation of a kiosk at the Atwater Kent building.

We would like to thank Chris Salter for allowing access to the roof of Morgan Hall at WPI to view and analyze the solar panel.

We would like to thank Betsy Lauring and the Ecotarium for maintaining communication and meeting with our group members for the possible installation of a kiosk exhibit.

We would like to thank Dean Daigneault and the Electrical and Computer Engineering department for trying to allocate equipment and allowing the use of the space in the lounge for displaying the SunViewer software. He most likely will be supervising and maintaining the display in the future and we graciously thank him and the department in advanced for doing so.

We would like to thank Columbus Park School for all of the help that they have given us in order to complete this project. The Columbus Park School allowed our team to talk to the students and receive a feel for what they already know about solar energy. We were able to assess the need and a way to convey the knowledge of solar and renewable energy as well as its benefits

We would like to thank Joseph Buckley for taking time to meet with our group at WPI. The input provided by Mr. Buckley helped to structure and develop the content for the website.

We would like to thank the previous solar project teams for their efforts and suggestions. Their work greatly supported our progress and created a foundation to start from.

We would like to thank the Worcester Polytechnic Institute and their Writing Center for helping us with the flow and wording of our report. The Writing Center's advice and professional knowledge of proper grammar allowed us to create an appropriate report of our hard work.

Lastly, we would like to thank Matthew Arner from Heliotronics for meeting with our group and supporting our efforts on the project. In addition, thank you for providing the software to run on the kiosk as well as all the aid you provided to the previous project groups.

Executive Summary

Introduction

There is a huge demand for energy to produce electricity, heating, and transportation in the world today. Unfortunately, the majority of the means to produce these are neither renewable nor clean. An effort must be made to educate on the problems this creates and more importantly on renewable energy, a sustainable and clean solution. Renewable energy resources include solar power, wind power, and many other resources that are sustainable and minimally polluting.

By educating on the benefits and need for renewable energy resources the knowledge can be used to make smart future decisions and create an understanding that other options are available. There are many ways to educate and many audiences susceptible to attaining this information. Our group worked to increase education on this topic. These efforts furthered the work accomplished by earlier project teams that both attained funding and installed the solar panel on the top of Morgan Hall at WPI.

Project Scope

In the world, the need for sustainable energy is an unmistakable reality. The WPI community has put together three solar energy awareness and outreach project teams to spread knowledge throughout the community. The basis behind the team's work can be associated with the solar panel above Morgan Hall.

The first project team recognized the need for promoting solar energy awareness and established a base for future project goals by doing a large feasibility study. This team set the continuous project in motion as they executed interviews, obtained funding granted before their project from the class of 1975, acquired approval from the WPI administration for a Solar Learning Lab©, and retrieved price quotes for the equipment needed. They also made a key contact with the Heliotronics Company who provided the Learning Lab© and has agreed to sponsor the future teams towards solar energy promotion.

The second project team continued the work of the first by installing the Solar Learning Lab© on the WPI campus. The Solar Learning Lab© was purchased through Heliotronics and RWE Schott Solar Inc. They also created many educational programs to help spread the knowledge of solar energy. The educational program created was a weeklong lesson plan for high school educators to teach to their students about the importance and benefits of using solar energy.

This project is the third of the Solar Interactive Qualifying Project projects. We have read and analyzed the previous project teams' accomplishments and recommendations. Our group conducted a thorough evaluation on the effectiveness of the various educational tools and arrived at the conclusion that creating an interactive website to educate grades 3rd through 5th on the benefits of renewable energy would be the most effective.

Project Goals

The goal of our project was to outreach and educate the community about the benefits of renewable energy resources. To achieve these goals we contributed the following to the project:

- We created an interactive website for young students to educate
  The website has the following characteristics:
  - A curriculum for teachers meeting new Massachusetts Comprehensive Assessment System standards
  - Educational videos
  - Educational activities

An interactive website could not only provide awareness, but also educate on the benefits to a much larger audience. Within the website a curriculum, videos, and activities can be linked and promoted to further educate on the topic of solar panels and the benefits of renewable energies.

- We also purchased an 18" LCD touch-screen computer kiosk.

The computer was fully funded by our team members. This unit will be installed at the Atwater Kent building at WPI in the near future to host the Sunviewer Software, which receives data from the solar panels atop Morgan Hall.

Methodology

The previous project teams have accomplished a vast amount of important tasks that needed to be further completed. Furthering these efforts is to set a secure base and get the community into moving toward renewable energy, particularly solar energy. The first group established the ways in which to convey the message of solar energy. They researched the best location for the solar photovoltaic installation and obtained price quotes from different companies for the equipment necessary to complete the Solar Learning Lab©.

The second project team continued the hard work and installed the solar photovoltaic array with the sponsorship of Heliotronics and the funding from the class of 1975. They researched different options for the equipment of the lab, and found another company, RWE Schott Solar Inc for the power generating components of the Learning Lab©. The second team also obtained funding from the Massachusetts Technology Collaborative, who realized the effort that the WPI community is willing to make to promote renewable energy. This team also created a lesson plan for 8^{th} and 9^{th} graders to promote solar energy awareness.

With the help of Dr. Martha Cyr, the K-12 outreach director of the WPI community and Mr. Joseph Buckley, the science liaison of Worcester Public Schools, the team was able to establish a good educational module for the students. Our team had many different options in front of us to continue this project. We decided to continue contact with previous team's key experts. In doing so, we decided to achieve the goal of outreaching solar energy awareness to the community by creating an interactive website that would allow many users to learn about the benefits of solar energy. We also realized that the Solar Learning Lab© was missing a kiosk that would display the interactive SunViewer software.

Results

We have created an interactive website to aid in the teaching of renewable energy, particularly in the area of solar power. The target audience of the website is elementary students in grades three through five along with educators of those grades. Our site is broken up into two main parts, a teacher resource section and an interactive section for students.

To fulfill our goals of having educational videos and activities, we developed three short videos and two complete activities. The three videos created are titled “Solar Circuits”, “The WPI Solar Tour”, and “Air Pollution from Fossil Fuels.” The two activities created were “Weather and the Sun” and “Pollution from Fossil Fuels.” The video about fossil fuels and the activity about fossil fuels coincide to create a large lesson for the students. The activities each have content that complies with current MCAS standards. Along with detailed procedures to complete the activity, the “Weather and the Sun” activity includes worksheets, which can be used as an aid in learning. All of the videos and activities are available on the website in the teacher resources section.

In addition to creating a website, we explored and completed a feasibility study of other methods of educating students about solar energy. The study compared the feasibility of placing a kiosk in the Ecotarium, placing a kiosk at WPI, setting up laptops that could connect to the live data from the WPI solar panels, and creating our interactive website. Our team has put together our own funding to accomplish this goal. We purchased a kiosk to be displayed in the Atwater Kent building in the near future, where many students pass by and campus tours are shown. Our team reviewed other areas for the kiosk but within our time constraints, we felt that the designated area was sufficient for our purpose of outreaching solar awareness to the WPI community.

Recommendations

Recommendations to Our Project Advisors and Future Project Teams

We recommend that an effort be made to enhance the website through further project effort.

We recommend that an effort be made to possibly install a kiosk at the Ecotarium or other museum.

We recommend creating an awareness of the website through future work.

We recommend continuing communication with Martha Cyr.

Recommendations to WPI Network Operations

We recommend an effort to aid the publishers of the www.teachengineering.com site in launching our website.

Recommendations to Martha Cyr

We recommend an installation of our website on the www.solarengineering.com site.

We recommend an effort to boost awareness of the site.

We recommend that the MCAS standards be compared to national standards and that these standards be shown on our website.

Table of Contents

Abstract ..... **i**

Authorship ..... **ii**

Acknowledgments ..... **iii**

Executive Summary ..... **v**

Introduction ..... *v*
Project Scope ..... *v*
Project Goals ..... *vi*
Methodology ..... *vi*
Results ..... *vii*

Recommendations ..... **viii**

Table of Contents ..... **ix**
Table of Figures ..... **xi**
List of Tables ..... **xi**

1. INTRODUCTION **1**

2. BACKGROUND **3**

2.1 Current Energy Resources – The Problem *3*
2.2 Technology Behind Solar – The Benefit *8*
2.3 Solar Energy and Other Renewable Energies – A Solution *12*
2.4 Barriers to Growth of Renewable Energy *16*
2.5 Current Renewable Energy Education Efforts – What Has Been Done *20*
2.6 Local Efforts – At WPI *22*
2.7 Current Options – How and Who to Educate *23*

3 METHODOLOGY **26**

3.1 Assessing the Need for Educational Outreach towards Renewable Energy *26*
3.2 Identifying and Interviewing Knowledgeable Individuals in the Field *27*
3.3 Exploring the Possible Tools to Achieve Outreach *27*
3.4 Evaluating the Alternative Outreach Tools *30*
3.5 Conceptualizing the Layout of the Interactive Website *30*
3.6 Integration and Approval *35*

4 RESULTS AND ANALYSIS **37**
4.1 Results from Evaluating the Alternative Outreach Tools *37*
4.2 Description of the "as-is" Website *42*
4.3 Website Developed by this Project Team *43*
4.4 Design of Website *46*
4.5 Site Design and Applications Utilized *46*
4.6 Efforts towards SunViewer Setup in Atwater Kent Building *47*
4.7 Efforts on a Kiosk at the Ecotarium *48*

5 RECOMMENDATIONS **50**

6 REFERENCES **52**

7. APPENDICES **56**
APPENDIX A – List of Important Contacts *56*
APPENDIX B – Interview 1 with Martha Cyr *58*
APPENDIX C – Interview 2 with Martha Cyr *59*
APPENDIX D – Interview with Joe Buckley *60*
APPENDIX E – Interview with Sean O'Connor *61*
APPENDIX F – Interview with Ecotarium *62*
APPENDIX G – Interview with Columbus Park *63*
APPENDIX H – Meeting with ECE Lab Manager *64*
APPENDIX I – Affordable Kiosk Quote *65*
APPENDIX J – Affordable Kiosk Brochure *66*
APPENDIX K – MCAS Standards and Links *68*
APPENDIX L – MCAS Standards and Curriculum to be Used *72*
APPENDIX M – Solar Learning Lab *81*
APPENDIX N – Comments on Website, Columbus Park School *83*
APPENDIX O – Kiosk Item Won Email Invoice *84*
APPENDIX P – Kiosk Seller Confirmation Email *85*
APPENDIX Q – Kiosk Seller Payment Received Email *86*
APPENDIX R – Kiosk Seller Shipping Confirmation Email *87*
APPENDIX S – Pictures of Purchased Kiosk *88*
APPENDIX T – Website *90*

Table of Figures

Figure 1: **Energy Consumption** **4**

Figure 2: **World Energy Usage** **7**

Figure 3: **Jobs Through Solar** **11**

Figure 4: **Renewable Energy Consumption** **15**

List of Tables

Table 1: **Fossil Fuel Emissions** **6**

Table 2: **Economic Impact of Blackout** **10**

Table 3: **GreenUp Providers** **22**

1. INTRODUCTION

Our world depends on the use of energy to facilitate the many life-enhancing devices we have become so accustomed to. There are problems associated with energy and how to consume, distribute, and conserve it. The current means of production are neither sustainable, reusable, nor clean. Eventually fossil fuels will become depleted and another primary method for energy production will be needed to continue with society's need for energy. In the mean time, their byproducts are deteriorating the atmosphere, polluting the air, and giving off harmful chemicals.

Other methods of producing energy are available that are both renewable and clean. Once these methods are further enhanced, more economically feasible, and awareness is established then progress towards a cleaner and a more sustainable future will exist. Educating the public on the benefits of renewable energy resources over those currently in place, which are neither renewable nor clean, is a major step towards this future. Various approaches and levels to teach on this subject exist for different age ranges, economic classes, cultures, and geographical areas, but there are many gaps that need to be addressed. With further education, awareness should grow and eventually contributions as well as purchases will be made towards enhancing and installing renewable energy systems.

Previous IQP teams have made advancements toward attaining the goal of promoting solar energy education. These Worcester Polytechnic Institute students have installed a solar panel atop Morgan Hall with a data acquisition system to acquire useful information on power produced, wind speeds, physical problems, and other photovoltaic data. This information can be used to establish educational benefits for a variety of audiences. Developing further informative material such as lesson plans and a curriculum for teachers, displays, and other tools should enhance the information provided by the solar panel and increase awareness of renewable energy resources. The most promising audience to address with this data would be children. By learning at an early age, their future choices can be influenced by their previous knowledge and a mind-set can be established towards creating cleaner, and more renewable energy production systems for future generations.

The efforts of the previous teams went beyond just installing a solar panel. They covered lesson plans, installed a Solar Learning Lab©, and gave further recommendations on educational programs. While their goal was to educate, no further ways to educate were actually implemented, but rather a means by which to educate, that being the data acquisition system. There are many ways to use this data and other available information, but the real task is how to distribute the information and knowledge. The recommendation for a Solar Learning Lab© incorporates purchasing and installing a computer based kiosk for local individuals and visitors of WPI to use. While a kiosk would only engage a small target audience, there are still further benefits that could be achieved though the Solar Learning Lab©, but the development of exactly who to educate must be addressed.

Our group has reviewed all of the work from the previous teams and evaluated the internal as well as external community need for renewable energy resource education. Using the information gathered from the solar panel atop Morgan Hall among other resources, a final product has been developed to achieve this goal. Our group incorporated many ways of educating a community into an interactive website. The website is both an updateable and interchangeable learning and teaching tool that focuses on educating the students, who are the future hope for renewable energy progress. Research towards understanding the current educational tools, current usage of renewable energies, as well as who is in need and will benefit from our efforts, helped us in designing the components as well as contents of our website. Our work on the website has been reviewed and the Columbus Park School in Worcester has also revealed an appreciation for our efforts. Aside from creating the educational website, our group made tangible progress on several other directions. Not only will our efforts support education on the topic of renewable energy resources, but the future effects from a better understanding of the topic could improve the quality of life with a cleaner atmosphere and a more sustainable energy future.

2. BACKGROUND

While the current state of the Earth focuses on using fossil fuels to produce electricity, heat, as well as many other lifestyle-enhancing products and energy, the main source of energy providing the necessities of life cycles to plants and animals is the sun. Not only does the sun directly connect to life's many needs, but it also is the indirect reason for many of the non-renewable and renewable resources that we as humans currently use. Sun affects the atmosphere that in turn changes the effectiveness of wind power and other earthly functions. Fossil fuels are in fact solar energy stored through many years of evolution from the sun, and there are further effects attributed to the sun as well. The chain started by the energy of the sun is rather endless.

This chapter contains seven main sections. The first section discusses fossil fuels and their problems as the world's source of energy. Second, we look at solar energy as part of the solution to fossil fuels. In the third section, details and a description of the technology and ideas behind solar power brings the concept to light. The next section brings forward concerns and problems encountered developing solar energy. The fifth section addresses the efforts of various local and national groups to tackle the issues presented in terms of solar power. Previous efforts on the same topic drawn by two preceding teams, Solar IQP Team 1 and Solar IQP Team 2, comprise section six. Last is a look at current options towards furthering education and bringing the topic of solar energy to the public. These topics are to aid in the realization and basis that our group uses to formulate our topic.

2.1 Current Energy Resources – The Problem

In the world today, the majority of energy production comes from a source attained from a fossil fuel. Many problems can be attributed by this wide use of fossil fuels such as global warming and air pollution due to emissions, health issues, and rising prices. Because of the high demand for energy and the demand for fossil fuels for other products, this valuable resource is diminishing at a rapid rate.

Fossil Fuel Usage

Fossil fuels produced eighty six percent of the energy consumed within the US in 2001. (Inventory of U.S. Greenhouse Gas, April 15, 2003) The figure below shows the breakdown of the various fossil fuels used in producing energy.

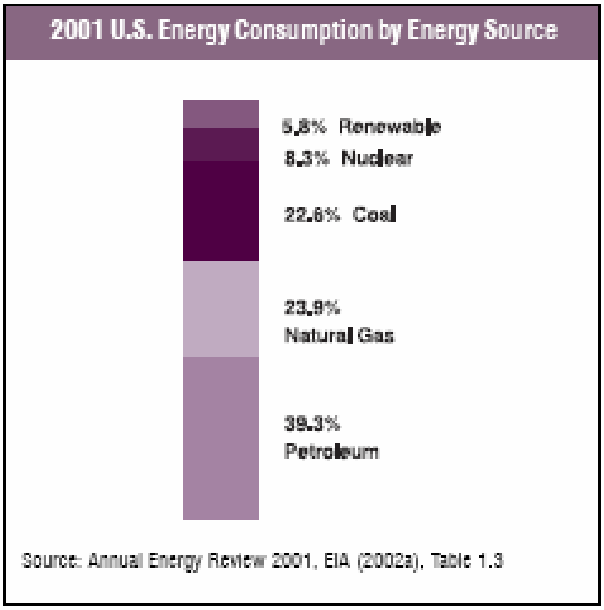


FIGURE 1: ENERGY CONSUMPTION

Capturing and using energy from these fuel sources, however, are having adverse affects on our world in multiple ways. Probably the gravest effects of fossil fuels used for energy production, particularly in our nation, are those stemming from the emissions.

According to the IEA (International Energy Agency), in the year 2000, total renewable energies accounted for two percent of the worlds' energy, while coal, oil, and gas accounted for a combined 87%. The IEA also projects in the year 2030, total renewable energy will jump to 4% of total energy production, as fossil fuels remain to increase to 89%. From the emissions of the fossil fuels, 25,000 tons of CO_2 releases into the atmosphere starting in the year 2000 and increases annually. Fortunately, as Renewable Energy will play a bigger role in the future there are ways to create cleaner burning of Fossil fuels. Investments need focus in new plants and additional investment to existing ones may drastically reduce the CO_2 emission. The International Energy Agency predicted by the year 2030, 3.4 Gt of reduced CO_2 emissions obtainable by introduced new methods of carbon separation. These new technologies estimate to cost between 353 billion and 403 billion U.S. dollars. According to Energy Information Administration the total energy consumption from the U.S., 98 quadrillion Btu was consumed in the year 2003. With the new cleaning technology, the world would reduce the emissions of harmful CO_2 and other molecules, giving renewable energy more time to spread and become a more dependable source of energy.

Fossil Fuel Emissions

Coal, oil, and natural gas are the most abundant forms of fossil fuels that the U.S. uses today. In fact, 85 percent of all current fuel use is from these three fossil fuels. Although the United States depends primarily on fossil fuels for energy, it incurs many costs and consequences that are unnecessary when clean renewable energy sources are readily available. The numerous costs include the actual labor of mining for coal and drilling for oil, the refinishing processes of both of these fossil fuels, and to pay for the massive factories to do such a process at a certain pace is more than comparable to that of renewable sources. The consequences are numerous, some of them being the health of animals and humans, the environment, and to neighboring communities.

Global Warming

Since reliable records began in the late 1800's, the global average surface temperature has risen .5-1.1 degrees Fahrenheit. That may not seem to be much but the consequences of such a small rise has affected many aspects of life. The burning of fossil fuels gives off carbon-dioxide molecules that trap heat within the earth's atmosphere. Within the last 150 or so years, the uses of fossil fuels around the world have caused an estimated 25 percent increase in carbon dioxide. The result from this increase has caused a higher average temperature, and has caused glacial melting, which causes higher shorelines and many erratic occurrences.

"Energy-related activities were the primary sources of U.S. anthropogenic greenhouse gas emissions, accounting for 85 percent of total emissions on a carbon equivalent basis in 2001." The table below compares the amount of CO_2 emissions that different forms of fossil fuels produce as well as the sector of the economy they are benefiting.

Air Pollution

Carbon dioxide, trapping heat, is not the only negative molecule in the air from the burning of fossil fuels. Many other material including, carbon monoxide, nitrogen oxides, sulfur oxides, and hydrocarbons suspend in the atmosphere. All of these molecules contribute to the world's air pollution. When nitrogen oxides and hydrocarbons combine, they form false troposphere ozone, called smog. Smog is the white haze seen over many cities with large fossil fuel consumption. In addition to smog, the particles irritate people's lungs, cause bronchitis, pneumonia, asthma, and decrease resistance to respiratory infections.

Fossil fuels also have a large affect on the environment. Nitrogen oxides and sulfur oxides are the leading contributors to acid rain. Acid rain effects vegetation, drinking water, animal life, buildings, automobiles, and human life. The waterways risk pollution from the refinishing processes of fossil fuels as well. The washing of coal uses water as a coolant and the warm water eventually causes a deterioration of vegetation and animal life. The processes also dump many chemicals into the water that harms the neighboring ecosystem causing death to much wildlife and plants. (The Hidden Cost of Fossil Fuels, 10/29/2002)

Table 2-3: CO_2 Emissions from Fossil Fuel Combustion by Fuel Type and Sector (Tg CO_2 Eq.)

Fuel/Sector	1990	1995	1996	1997	1998	1999	2000	2001
Coal	**1,697.3**	**1,805.8**	**1,893.4**	**1,939.1**	**1,957.3**	**1,961.1**	**2,051.5**	**1,993.8**
Residential	2.5	1.6	1.6	1.5	1.2	1.3	1.1	1.1
Commercial	12.3	11.1	11.5	12.1	8.7	9.7	8.6	8.6
Industrial	151.6	148.8	145.3	146.4	137.8	131.7	134.0	126.3
Transportation	NE	NE	NE	NE	NE	NE	NE	N
Electricity Generation	1,530.3	1,643.4	1,734.0	1,778.1	1,808.7	1,817.5	1,906.9	1,856.8
U.S. Territories	0.6	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Natural Gas	**1,012.5**	**1,172.6**	**1,193.9**	**1,200.3**	**1,177.2**	**1,183.8**	**1,240.3**	**1,202.1**
Residential	238.8	263.0	284.2	270.2	246.5	256.5	270.3	260.8
Commercial	142.6	164.3	171.3	174.3	163.5	165.2	174.3	175.8
Industrial	419.9	478.8	494.6	495.8	484.1	466.4	478.9	445.5
Transportation	35.9	38.2	38.9	41.1	35.1	35.6	35.5	33.9
Electricity Generation	175.3	228.3	205.0	218.9	248.0	260.1	280.6	284.9
U.S. Territories	NO	NO	NO	NO	NO	NO	0.6	1.2
Petroleum	**2,104.5**	**2,162.7**	**2,238.2**	**2,260.3**	**2,285.6**	**2,343.6**	**2,400.0**	**2,418.6**
Residential	87.6	94.0	102.8	100.0	91.1	99.5	102.4	101.4
Commercial	66.6	51.4	53.6	50.6	47.2	46.7	51.4	51.4
Industrial	383.7	374.9	399.6	408.6	378.2	375.0	378.2	365.8
Transportation	1,434.6	1,539.6	1,578.5	1,585.8	1,618.8	1,677.5	1,727.3	1,747.0
Electricity Generation	99.0	59.7	64.5	73.5	103.2	95.6	89.9	100.7
U.S. Territories	33.1	43.1	39.1	41.8	47.0	49.3	50.8	52.3
Geothermal*	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**
Total	**4,814.8**	**5,141.5**	**5,325.8**	**5,400.0**	**5,420.5**	**5,488.8**	**5,692.2**	**5,614.9**

NE (Not estimated)
NO (Not occurring)
* Although not technically a fossil fuel, geothermal energy-related CO_2 emissions are included for reporting purposes.
Note: Totals may not sum due to independent rounding.

TABLE 1: FOSSIL FUEL EMISSIONS

As one can see, coal is the largest source of CO_2 for power generation. Coal used for power generation is also the single highest contributor of the greenhouse gas.

Health Issues Concerning Fossil Fuels

The miners, who risk their own lives collecting coal, can develop numerous diseases such as black lung disease and whooping cough. Oil drillers and refining workers lives are also at risk from things such as fires and oil spills. Oil spills also affect everything around it including animals and vegetation. The process of refining and obtaining the fossil fuels is dangerous, but the consequences of burning them are becoming a major concern to everyone.

Asthma, a major health concern especially in children within major cities, is continuing to increase into epidemic levels. According to the Harvard Medical School, asthma has, "grown 160 percent between 1980 and 1994, more than twice the rate (75 percent) for the overall U.S. population." The cause of a rapid increase in asthma found in children in urban areas directly correlates to the increase in pollen allergens and smog from the burning of fossil fuels.

The Harvard report: "Inside the Greenhouse: The Impacts of CO_2 and Climate Change on Public Health in the Inner City," goes on to show rising levels of CO_2 trap heat within the ozone, "promoting pollen production in plant communities by favoring opportunistic weeds (like ragweed and poison ivy)." The emissions from burning fossil fuels in automobiles forms smog, which intensify asthma, while the burning of diesel fuels from vehicles helps carry allergens to the lungs of children. The greatest risk is to those children in inner city dwellings because of the high volume of exhaust from automobiles, increase level of pollen count, and low amounts of health care. (Greenhouse Gas Emissions Endanger the Public's Health, 11/7/1997)

Fossil Fuels, Other Uses besides Energy

When thinking of fossil fuels, we tend to look upon the burning of them to create electricity, heat, and for transportation. Fossil fuels also serve to make many different products that people use everyday, and they may not even know their creation draws from the source of these non-renewable resources. Some of the products fossil fuels make are things such as clothing, bottles, containers, automotive parts, and hospital instruments. Fossil fuels like coal create heat for cooking, while refined oil has uses for machine lubrication and in hospital medicines. Many machines and motors with rapid moving parts would seize and break down without the use of oil as a lubricant and coolant. Hospitals also use fossil fuels for machines and plastic devices. Petroleum jelly (vapor rub) is probably the most known medicinal remedy that is widely used to clear nasal passages and soothe the chest. Fossil fuels are non-renewable resources massively consumed by the world, being non-renewable once they run out it will be very difficult to form many everyday products that we use without fossil fuels. (Solar Opportunity Assessment Report, 2003)

Demand for Energy

As time goes on our demands for energy continue to increase. Figure 2 below shows the break down of energy consumption based on fuel sources and their increase in demand over the decades.

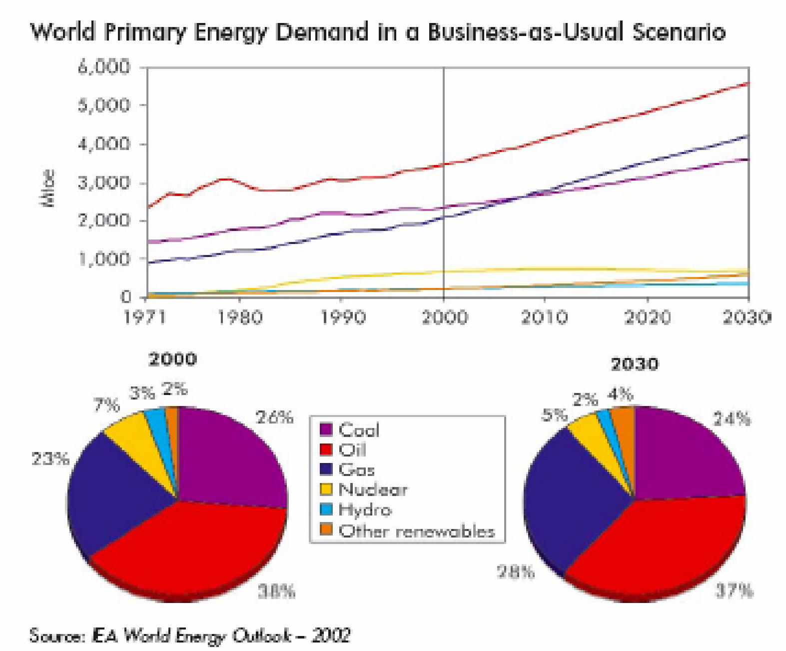


FIGURE 2: WORLD ENERGY USAGE

Looking to the left of the graph it is seen that from the 1970's to 2003 the amount of energy produced by fossil fuels has risen from around 70 to 80 quadrillion BTUs. Just the change in the amount fossil fuels is more than the mere eight quadrillion BTUs of all renewable energies produced at their peak.

The consumption of fossil fuels in the United States is an outstanding amount. Around 17 million barrels of oil per day, which about two-thirds of the oil is burned by inefficient automobiles. With the United States' vast consumption of oil, the fossil fuels are being consumed 100,000 times more than they are produced. A decrease of 1% of industrial energy would save an estimate of 55 million barrels of oil. The cash amount of the oil barrels saved would be worth around one billion dollars.

If the concentration of renewable energy increased, the result would generate enough electricity to power almost 40 million single-family homes. The rapid increase in oil, gives way to the rapid increase of alternate fossil fuels, which means natural gas has increased in 35 million barrels per day, which is growing more rapidly then that of any other major fossil fuel. The gigantic consumption of fossil fuels gives way to not only the knowledge, but also the requirement of alternate energy to keep the world in proper running order.

If even a one kilowatt PV system was used per household, that would prevent 150 lbs of coal from being mined, 300 lbs of CO_2 from entering the atmosphere, and keeps deadly molecules such as NO and SO_2 from being released into the atmosphere. The monthly average of residential consumption of electricity per survey in 1999 was 866 kilowatts per hours (US D.O.E). In terms of electricity, in 1999 the average Untied States single household family used $70.68 per month (US D.O.E).

Rising Fossil Fuel Prices

Among the obvious problems surrounding fossil fuels, including emissions and non-renewable status, prices are increasing over time and are assumed to only increase in the long-run. In general, any non-renewable product will increase in value as availability decreases due to demand and shortage. Supplies of fossil fuels are being depleted at an increasing rate. These resources are edging very close to there complete depletion. Recent fuel prices have reflected this and can only be expected to increase further over the coming years. (Rising Fossil-Fuel Costs, 2004)

2.2 Technology Behind Solar – The Benefit

The increase in solar power use would not only create a wider usage of clean renewable energy, but could benefit many other areas of interest not even thought of by potential consumers. Some of these fields include job creation and reliability. "According to the Renewable Energy Policy Project (REPP), for every megawatt of Solar PV, 35.5 jobs are created." Solar installations require various skills and have the potential to create many different types of jobs. Solar energy is also a very reliable source of energy. As long as there is sunlight, solar energy can be produced.

No Cost Associated With Sunlight

One major and notable advantage to the use of solar power is that there is no cost associated with the generation of electricity. Solar arrays, and other forms of solar energy systems, harness the sun's abundant natural energy potential and convert it into different energy forms that society can use. Because of their robust design, solar panels and their power conversion components require little to no maintenance. Many components of solar arrays come with at least a ten-year warranty. This further contributes to their low cost. Energy production with fossil fuels requires the availability of those resources, which carry a considerable cost. This makes solar energy a much more economical source of energy.

Strengthening the Economy

On a whole, the world as it stands depends on electrical energy to continue economically. Electrical energy provides power to enhance industrial processes, heat, machinery, computers, lighting and so much more that contributes to our economy on both a national and global level. Without being able to produce electrical energy, one can only imagine where the economy will end up.

With an increasing population and increasing industry the electricity demand will only grow, growths predicted to climb by thirty-two percent by 2020. A major concern about fossil fuels and other non-renewable energy sources should obviously be their limited supply, and by 2020, no one can truly predict what their availability will be. Therefore, the true answer to this problem of limits has to be renewable, hence renewable energy resources. In addition, as prices rise, industries and business will find it hard to keep up with these increased utility bills and this can both decrease production and employment through the effects of lost profit.

The Economic Impact of ONE Blackout

A study measuring the economic impact of the August 2003 blackout found that the event will have far-reaching, long-term implications for businesses and organizations in the affected region. The study is a joint undertaking of Mirifex, a business and technology consulting firm headquartered in the region; The Center for Regional Economic Issues at Case Western Reserve University's Weatherhead School of Management; and CrainTech, an on-line publication based in Cleveland that serves the technology community of Northeast Ohio. Preliminary study findings include:

- Eleven percent of firms surveyed say the blackout will affect their decision making about growth or relocation.
- Because of the blackout, more than one-third (38%) of businesses surveyed said they'd be somewhat or very likely to invest in alternative energy systems.
- More than one-third (34%) of firms surveyed have no risk management or disaster recovery plans in place, and nearly half (46%) of the businesses surveyed will invest more in risk management, business continuance, and/or disaster recovery in the future.
- More than one-third (35%) of the businesses surveyed felt it was somewhat or very likely that the region's image would suffer as a result of the blackout.
- More than half the businesses surveyed say the top threat of future interruption is either cyber crime (26%) or a utility outage (26%), outdistancing other concerns more than 2:1.
- Two-thirds (66%) of the businesses surveyed lost at least a full business day because of the blackout.
- A quarter (24%) of the businesses surveyed lost more than $50,000 per hour of downtime, translating to at least $400,000 for an 8-hour day. And 4% of businesses lost more than $1 million for each hour of downtime.
- Nearly half (46%) of the businesses surveyed said lost employee productivity was the largest contributor to losses caused by the blackout.
- Production/manufacturing and customer sales/service were the areas of business hardest hit by the blackout.

Sources: Mirifex, and Craintech.

TABLE 2: ECONOMIC IMPACT OF BLACKOUT

Another economic concern focuses on the reliability of the current National Grid and its future with problem of increased energy usage. Renewable energy currently plays a part in providing electricity to the grid, and furthering these efforts could only improve the reliability of the system. In the outage on August 14, 2003, over fifty million people were unable to continue their normal routines, and many left unable to work. If stoplights are inoperable traffic situations limit the ability of an individual getting to work, jobs based around computers limit completion without a backup power source, industrial factories don't produce, and the daily economy is put on a sudden halt.

The current national market for solar energy stands to be worth two billion dollars by 2020, this estimate also includes photovoltaic installations and their actual production. Around twenty thousand jobs exist from these efforts, many of which are professional based and well paying. These numbers expect to grow as the need for renewable energy increases and awareness evolves. By 2020, the solar industry should grow to around one hundred and fifty thousand employees with an industry growth existing of around twenty seven billion dollars.

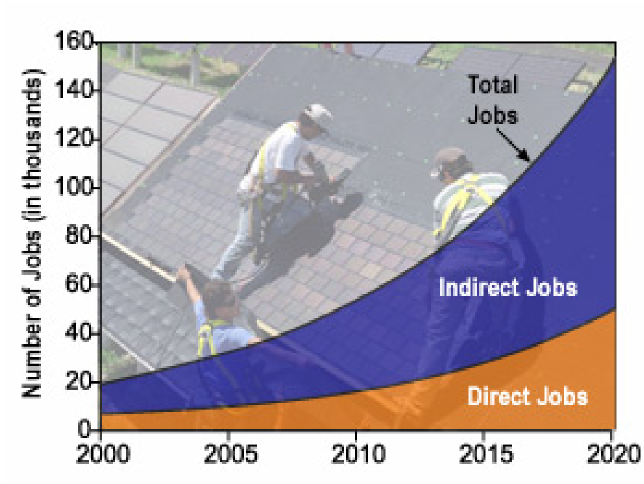


FIGURE 3: JOBS THROUGH SOLAR

The solar industry has grown in the past twenty-five years at an astronomical rate of about fifteen to twenty percent a year thus far. In 2000 about eight-hundred and twenty five gigawatts of electricity contributed through solar power. For the future, a twenty-five percent growth currently predicted per year, and according to speculators that is possible, which will bring the contribution of solar power to be ten percent of the market for electricity. By increasing solar power systems more jobs should exist, a more reliable grid system is obtainable, and with hope, prices will remain rather consistent. (Solar Opportunity Assessment Report, 2003)

Reliability

Reliability and low maintenance also are positive attributes to solar power systems. A PV system lasts an average of 25 years with little to no maintenance required. The solar panel itself does not have any moving parts, which cuts down on the wear and tear of the products used. The panel depending if it is monocrystalline or polycrystalline can have a difference in the required maintenance. In polycrystalline applications, a couple of the crystals in the panel could not work, but the panel as a whole would still function. As years pass, the reliability of the solar panels will only increase.

There are numerous U.S. funded projects as well as Japanese projects that will elongate the life of solar panels and increase their efficiency. Some of the funded projects include thinning the film of silicon used while increasing the efficiency would create a more reliable and useful panel. This would also drop the price in the solar panel.

Another project funded by the Japanese deals with inventing systems to monitor the drops in performance of the PV array to know how reliable every part really is.

Yet another task is the development of a recycling plant for solar mechanisms. If the scientist could make a recyclable PV module, this would drive down the prices by re-using old parts instead of making new ones. Solar PV arrays are just starting to be field tested for years of reliability and solutions to any minor problems are still to be determined.

Tax Relief

Currently in Massachusetts, the state government offers some tax relief and offers a $5 per watt buy-down with 70% paid upon installation. The remaining 30% of cost paid for the system based on system performance over the three years of installation. The state offers many tax credits along with net metering, which means the consumer installs a particular meter that can rollback when the solar power system produces more energy than the consumer is using. (Introduction to Photovoltaic (Solar Cell) Systems)

2.3 Solar Energy and Other Renewable Energies – A Solution

The goal of this project is to address the need for renewable energy, and the major providers we look into are photovoltaics, also known as solar power. We take a brief look into the technology behind photovoltaics and how they work. Further research was done on the subject of renewable energy and clean power including wind power, fuel cells, water turbine, biomass and geothermal. Each process has its benefits, complications, as well as current utilization and although each betters the community, previous research from earlier projects focused their attention on solar power.

Technology Behind Solar

With hydrogen in its center layer and helium in the outer, the sun burns off the hydrogen in the center, which in effect creates the outer layer. A huge amount of solar energy, created through this process, actually has very little energy reaching the Earth through a process called solar radiation.

The solar energy travels in particles called photons in the form of a wave. A shorter wavelength means greater photon energy. Visible light is the main source of energy, and the only source used for the use of photovoltaic and other manufactured solar energy products. The energy is not exactly what we desire for passive solar techniques and heating, we need heat for these processes. Heat is created when these solar waves are absorbed by materials found on the Earth and the released as heat.

The amount of energy that comes from the sun depends on how photons are in the wave. A light wave with short wave length, the distance in between two wave peaks, has a higher concentration of photons while a light wave with a long wavelength has fewer photons. The most useful forms of solar radiation are within a small band of wavelengths measuring from about 400 to 780 nanometers.

The amount of waves, which reach the earth, is also important in determining how much energy is available for solar technologies. Not all the waves produced by the sun reach the surface. Some are deflected into space off the ozone layer while others bounce off the clouds. The amount of the light waves, which do reach the surface, is measured in terms of solar intensity. Different areas on the earth have higher and lower averages of solar intensity because of the different weather patterns and distance from the sun.

How Photovoltaic Works

A solar panel is one or more photovoltaic cells that convert light from the sun into electricity. The photovoltaic cell usually consists of a semiconductor. The purpose of the semiconductor is to absorb energy from the light and release electrons knocked loose. When there are multiple layers of the semiconductor with special treatments, the electrons withstand a force to move in a certain direction. The electrons, gathered with metal strips up next to the semiconductor, then are used to power things. (How Solar Cells Work)

The most common used semiconductor used in the solar industry is silicon. Silicon use bases in a crystalline form. Because silicon alone holds on to its electrons so well when pure, the impurities of boron and phosphorus are added. One layer of the photovoltaic has a phosphorus mix, and another layer has boron mixed with silicon. When the two layers place on top of each other a one-way flow of electrons occurs from the phosphorus that has more electrons to the boron, which has less. Because of the makeup of the boron/silicon layer, electrons, which move to that side, stay in that layer. The electrons of the phosphorus then move to the boron side and “holes” remain on the phosphorus. This inequality creates the voltage and the movement of the electrons make the current combined together a power source is born. (How Solar Cells Work)

Today there are many types of solar panels made. The panel previously described above is a basic panel called a monocrystalline. These panels manufacture from silicon grown in boules and sliced as small as 200 microns thick. The next type of cell, also made from silicon, named a multicrystalline solar cell. These cells are made of silicon cast in blocks and sliced. These cells do not collect energy from the sun as well as the monocrystalline, but are cheaper to make. Solar cells made from copper indium diselenide have the name of CIS. CIS is a polycrystalline material that has a lot of power and uses for items most people buy, like a solar watch. The last type of cell is Cadmium Telluride, which is another polycrystalline material and is one of the lowest efficiencies of solar panels made. (Sunwise Technologies)

Active Solar Usage

An active solar system is any solar system where hardware collects, converts, and delivers solar energy. Energy from the sun harnesses in a few different active solar processes. Photovoltaic arrays, solar concentration systems, and various types of solar water heating systems are a few types of active solar systems. When it comes to electricity generation, active solar systems are different from passive solar systems in that they primarily generate electricity that has the ability to be stored for later use. Photovoltaic arrays convert the suns energy into electricity that can feed directly into the power grid or stored in batteries. Solar concentration systems use mirrors arranged in a fashion to concentrate the suns energy to heat a fluid. The fluid then will boil water, creating steam to turn a turbine generator. Hot water heating systems requiring water to pump to the heating location to heat, thus also considered active solar systems as well. (So You Want to Put PV on Your Roof)

Passive Solar Usage

Unlike active solar systems, passive solar systems collect and deliver solar energy with little or no hardware. Passive solar systems are available for home heating, day lighting, solar hot water, and industrial uses. Solar energy's use as home heating is beneficial during the colder months of the year. With the use of special building materials and rooms such as sunspaces or sunrooms, the sun's heat energy from the day can be stored and released during the night when heating becomes necessary. Water can heat by passing through a series of small tubes concealed in a transparent protective casing. The sun heats the water passing through the small tubes, which then flows to a storage tank similar to that of a conventional hot water system. Solar heat has use in many industrial applications such as preheating ventilation air, large-scale hot water and space heating and even solar cooling through various chemical processes. (Introduction to Passive Solar Heating and Daylighting)

Wind Power

Wind power, which is becoming one of the most up and coming forms of renewable energy, is created using giant turbines that are placed normally over 100 ft in the air. Although the turbines are normally very large and require a lot of clearance around the mast, wind turbines have the ability for placement over water and ground, thus utilizing space better. Some of the problems associated with wind turbines are that that the power output fluctuates continuously with the wind and that they can ruin scenic views for individuals. (Renewable Energy > Wind)

Fuel Cells

Fuel cells are definitely a form of clean energy but a controversy arises when including fuel cells with forms of renewable energies. They require a chemical input, whether straight hydrogen, methane, or some other chemical combination containing hydrogen. The most common fuel cell takes only two parts hydrogen and one part oxygen to make water, and though this process releases electricity and heat.

A fuel cell is much like a battery with the exception that if inputs are constant, the outputted energy is consistent. There are no pollutants in a direct hydrogen fuel cell, and they have proven to be more efficient than many other powering methods as well. The major problem surrounding fuel cells can be attributed to obtaining hydrogen, a process both expensive and energy consuming.

Water Turbine Power

Energy produced by water is also renewable. The energy, most often called hydroelectric power, creates production either by water falling or by the current. To collect the energy, a turbine, placed in the current or in a position where the water falls, can rotate the turbine. The turbine connects to a generator that turns the mechanical energy into electricity. The energy produced then will feed into the power grid for dispersion. A good example of this process is the Hover dam. One of the great advantages to hydro electricity is that the water is always moving so energy consistently produces. (Renewable Energy > Water)

Biomass

Although not as well known as the other forms of renewable energy, biomass is the largest percentage of the renewable energy in the United States, taking 47 percent of the renewable market. Biomass is the production of electricity using organic matter. The most useful form of biomass is methane, which often collects in landfills or bogs and sometimes made using biogas generators. The generators take bacteria to break down organic material to release the gas. The gas then collects and burns to produce electricity. (Renewable Energy > Biomass)

Geothermal Power

Geothermal power is a renewable energy that truly comes from the earth. Geothermal energy is stored in water normally deep within the crust of the earth. The energy gains capture using turbines in two different manners, depending on the state of the geothermal reservoir. When the reservoir is mostly vapor, a well drilled to release the steam pipes steam through a turbine that spins a generator. When the water is in liquid form, the water pumps to holding locations where the pressure drops to cause steam to be made. The steam produced then pipes through turbines to spin generators. (What Is Geothermal Energy)

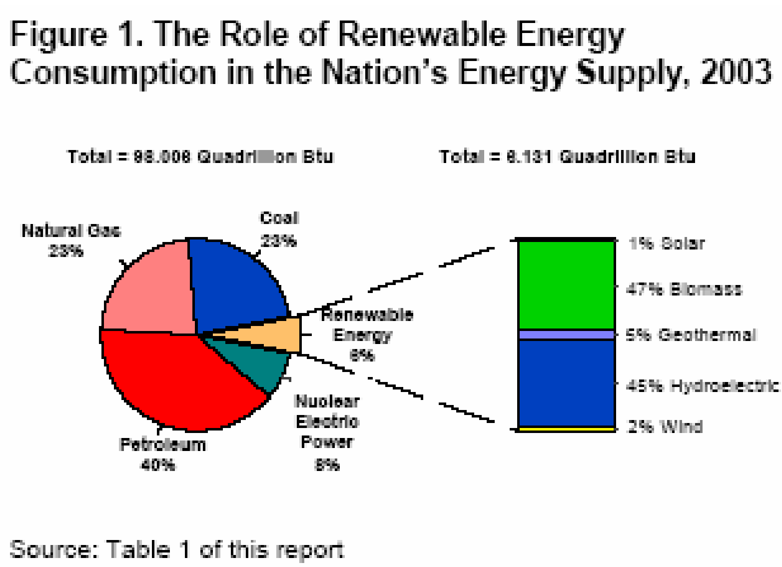


FIGURE 4: RENEWABLE ENERGY CONSUMPTION

2.4 Barriers to Growth of Renewable Energy

Many complications can be attributed to the use of photovoltaics as well as other renewable energies. There are purchasing complications with production, price, comparative cost, regulations, and national regulations. Physical complications include size and appearance, inoperability, and other technology. Lastly is a societal problem not often thought of except when considered during marketing, this is the information gap behind solar and renewable technology.

Production

The main challenge that keeps solar power a struggling industry is the small production scale, which keeps quantities of solar panels low and prices high. High prices keep many consumers sticking to fossil fuels for energy sources. One of the other problems of less importance is that the production and manufacturing of solar panels use toxic chemicals. Some of the more common chemicals used include toxic hydrogen selenide, phosphine and diborane. When these chemicals are used, small amounts of toxic waste is released, which must be disposed of properly. The reason this problem is not a reason to claim solar power is unclean is that" according to a report from Utrecht University, "Estimated air emission is maximally 0.16 [kilograms of fluorine] and 430 [kilograms of chlorine] per [1000 megawatt-hours] of electricity supplied by PV modules, which is orders of magnitude smaller than the corresponding emissions of a coal plant." (Implications of PV Manufacturing and Production)

On a National Level

The US Federal Government unfortunately does not control the solar regulations, therefore leaving the manufacturers and the purchasers of solar equipment to meet separate state mandated requirements. This diminishes the exportation process of solar panels to different states if that particular company does not meet the other states' requirements. The state regulations weaken the allowance of standard "plug and play" systems that would make the cost of the systems reduce greatly.

Although regulations on equipment is not addressed on a national level, There are programs, training programs, lesson plans and curriculum offered by the government through the Energy Efficiency And Renewable Energy section of the Department of Energy. The lesson plans offered cover all grade levels, including higher education.

Information Gap

Consumer education is an important part of increasing solar and renewable energy use. "The sun generates enough clean energy in one day to provide a year's supply of energy for your home or office." In the past few years, PV ownership costs reduced due to federal and state programs and incentives. These cost reductions have the ability to price solar energy competitively with traditional energy sources. Products, such as solar shingles, are also available that hide the unsightly appearance of installing solar panels on houses or businesses. (Solar Roofing Systems)

A major concern in the challenge of making solar generate breakthrough improvements is a lack of education about solar benefits to many different audiences. The most crucial steps are to fill in critical information gaps to manufacturers, installers, policy makers, and all potential clients.

Some believe solar energy does not have a high demand simply because there is not effective media coverage and awareness on the topic. On top of that, there is the simple concept of the high initial setup cost of solar panels being a barrier and driving many interested consumers away. Consumers support the decision on renewable energy but the main decision directly falls in the hands of major corporations and the electric companies. Most energy companies have an interest to create the largest profit possible in the shortest amount of time. Solar energy tends to be a long-term investment with no exact defined costs and does not have a set social cost to the consumer. (Annual Energy Outlook, 2004)

Education at a younger age is very important to broadening the use of solar energy by consumers. Introducing the benefits of solar energy to young students will allow them to make decisions that are more educated when confronted with energy sources. An educated student will be more likely to use renewable energy sources once they become the consumers, as they are aware of the many benefits that go along with these sources.

Price

Unlike non-renewable means of energy production, solar energy production carries an upfront cost and no continuing energy source costs. By using the sun as its energy source, solar power is able to eliminate almost all cost after installation. Installation costs of PV arrays, however, can be pricey. The cost for a typical home PV system producing 1.35 kilowatts is a whopping $11,500 installed. This price does however include all of the necessary components to complete the installation and tie the PV array to the power grid. Smaller scale systems are available for use in applications such as an RV (recreational vehicle). The cost for a typical RV array producing 120 watts is only $1490.95. This figure does include all the necessary items to connect this array to the RV's power system. (Typical RV System)

Regulations

If someone is looking to purchase and set up their own solar photovoltaic system, that individual must comply with many different regulations. First, there are state regulations on tapping into the grid and net metering. Some states have very strict rules about net metering. Net metering is the electricity a building or house uses, minus the electricity the owner's solar photovoltaic array produces, hence producing a net metering billing. Massachusetts supports net metering and allows tapping into the electrical grid, but some states may not. Other states may allow a consumer to hook up to the grid but may not credit their electric bill.

A consumer of a solar photovoltaic system not only will have to deal with state regulations on net metering and grid connections but will also have to comply with strict building codes, zoning ordinances, historic district regulations, flood-plain provisions, and any special regulations a person may have to follow. Any consumer in any state, the majority of the time will have to obtain a building permit to install a solar energy system onto an existing building.

Once a consumer decides to purchase a solar photovoltaic system, they have the options to either install the system on their roof or in their yard. This may depend on many different factors including the owner's thoughts and the states' regulations. If a solar panel installs on the ground of the owner's property, they must first be sure they will have adequate sun exposure. The state has some restrictions including obstructing side yards, citing the system too close to streets and lot boundaries, and flood-plain restrictions. The flood-plain provisions prohibit a consumer to put a land-based solar system on their property if the property is within the flood-plain boundaries, which one confirms through the city. An area in the city is termed flood plain if there is a lot of rain accumulation and poor drainage. If the consumer decides to place the solar panel atop their roof, they must also follow many restrictions. Some states do not allow solar panels atop homes because of unlawful protrusions atop the roof, exceeding roof loads, unacceptable heat exchangers, improper wiring, and unlawful tampering with water supplies. A consumer must check individually with their city and state officials on any specific requirement and rules for a solar panel instillation.

To attach solar panels to today's city buildings and homes is not only a difficult process to follow, but solar access is also a major problem. Simple examples are in any major cities that have tall skyscrapers. For example, if a business obtains a solar panel atop its roof and a skyscraper blocks the sun most of the time, then the panel is not of much use to the business. To avoid this from happening many cities in the U.S. have "developed solar access planning guidelines and/or ordinances," to allow everyone an opportunity for sun access. (For Consumers)

Daily and Seasonal Inoperability

An obvious problem surrounding all uses of solar energy is the inconsistent availability of direct sunlight. This occurs on a daily basis through the normal rotation of the Earth. Seasonally there is considerably less light available during certain parts of the year depending on the chosen location as well. Both the circulation of the Earth around the sun as well as the Earth's orbital tilt causes the seasonal change.

Understanding the problematic seasonal changes in certain areas, many developers choose to locate major solar projects around the equator to minimize the affect of the Earth's tilt. Light patterns around the equator are more consistent and the part of the Earth that is closest to the Sun at all times is the also the equator. Nothing can be done to avoid the Earth's daily cycle, but the areas of the Earth near the equator also have the longest amount of daylight, which is also fairly consistent throughout the year.

There is no way a photovoltaic cell could provide constant power throughout a twenty-four hour period. The only way to accomplish a full power system would be to store part of the energy produced by the photovoltaic cell during a peak time or have an alternative energy source while sunlight is not readily available. Therefore the solution to the above problems confide in either another power generation source or some form of energy storage, both which cost additional money, may pollute, require further space, require additional maintenance, and make the system less reliable.

Size and Appearance

At the community level, many private home developers and apartment complexes simply shun the idea of ugly black panel adhered to the aesthetically pleasing rooftops. Many contractors believe the houses would not sell or the price may not be as high because of the “ugly panel” on the roof.

In the past, solar panels were flat arrays mounted on the roof of a building and were angled to collect sunlight efficiently. Alternatives are now available to replace the unsightly panels. Companies, such as United Solar Systems Corporation, have developed solar shingles, which can replace asphalt shingles on a building. These shingles are capable of producing 17 watts each under full sun. When tied together on an average sized roof, a system of photovoltaic shingles can produce around 1.2 kilowatts of power. In addition, these PV shingles provide the same protection of a standard asphalt roof shingle as well. (Solar Roofing Systems)

Other Technology for Solar Conversion and Connectivity

Because the power produced from photovoltaics is DC, and our nation’s power grid is AC, inverters become necessary to convert the electricity produced. An AC inverter enables the solar panels to feed power directly into the grid, assuming the State allows net metering. There is a major disadvantage in having to use a power inverter to convert the DC power to AC power. The inverters are not 100 percent efficient and a large amount of the power produced by the solar array can be lost in the conversion. The efficiency losses can vary among different components and can be as high as 25 percent. Even the most efficient inverters lose energy to internal components normally in the form of heat dissipation.

In addition to the inverter, building regulations require other electrical components to complete the link between the solar panels and the power grid. Circuit breakers are needed to protect the wiring and components from high voltages such as surges and short circuits. Electric meters are also necessary to accurately measure the output of the solar array.

Comparative Cost

Compared with the cost of traditional energy production, solar energy has a completely different cost structure. All costs attributed to solar energy incurs during its installation. Because only sunlight centers as the source for solar power, there are no ongoing costs associated with running a PV array except for maintenance. Many traditional sources of energy, such as energy produced using fossil fuels, carries an ongoing cost through inputs. With oil prices hovering around $55 a barrel and prices expected to reach $100 a barrel by 2010, the continuing cost of energy produced by fossil fuels is not only high, but also expected to rise to double that in the next few years. (For Consumers)

The solar technology contains no expectation to make major future contributions to the United States grid supply through the year 2025. In the year of 2002, the photovoltaic systems only generated 0.6 kilowatt-hours of electricity, which makes only a

0.02 percent contribution to the total electricity grid. In the year 2025, the projected PV systems are only to supply about 5 billion kilowatt-hours. Although that may seem like a lot when incorporating our growing national need for electricity this only comes out to about .08 percent total contribution. Renewable energy projections account for only 9.1 percent of the nation's generation. (Annual Energy Outlook, 2004)

2.5 Current Renewable Energy Education Efforts – What Has Been Done

Several programs are in existence that aid in integrating solar energy into school curriculum. One such program that is local to our efforts is Solar Now, currently based out of the Beverly High School. Solar now is a non-profit international energy education organization that works to promote renewable energy and environmental education. Through use of teacher workshops, summer college internships, conferences, and additional K-12 related programs, Solar Now is able to promote solar energy use. In addition to Solar Now, many other programs strive to promote solar energy.

Solar Sprint Program

On a national level, one program that has taken off to introduce students to solar energy is the Solar Sprint program. Managed for the U.S. Department of Energy by National Renewable Energy Laboratory, the Junior Solar Sprint (JSS) Program is a classroom-based, hands-on program for sixth, seventh, and eighth grade students. The students use math, science, and creativity to construct model solar-powered cars and race them. Depending on the involvement and support of the school system, races can scale from within the classroom, up to state and regional competitions. As of now, the program involves 26 states across the US.

New York's Initiative

Some states have taken the task of educating the students about renewable energy to heart more than others. One such example is New York. Heliotronics in partnership with the New York department of education has taken initiative to incorporate solar and renewable energy education into their curriculum by placing solar installations in New York State schools. The curriculum that New York applies teaches the value and uses of renewable energy sources in the classroom. Some of the specific materials covered include the nature of solar energy, photovoltaics, economic and environmental impacts of solar energy, and other renewable energies. (Technology Education)

Expanding education of renewable energy sources in Massachusetts and elsewhere is important in expanding the use of these sources. To further the use of renewable energy, education concerning renewable energy sources in Massachusetts and elsewhere is necessary. Renewable energy has many benefits, which through education can include further exploitation. Lesson plans, created for the New York school system as well as by one of the previous IQP project groups, would be a good starting point for developing lessons for the Massachusetts school system.

Within Worcester County, several schools participate in the program including Shrewsbury and Webster. The reason the number of schools involved is so low is partially due to financial reasons. The cost of one of the solar panels and motors needed is between 25-40 dollars depending on the distributor. Most of the schools that have the program though have found outside funding, such as the IEEE Worcester County section who has donated the funds for solar panels and motors for teachers to reuse every year.

GreenUp

Many programs exist in the various states throughout the US to bring together the different forms of renewable and clean energy on a mass scale through the national electrical grid. In Central Massachusetts, the main electrical power company, Massachusetts Electric, put together a program that allows customers to choose whether they would like to have a portion to all of their electricity come from renewable sources. The electricity does not flow directly from the renewable source to the buyer's home but rather to the grid to all customers connected. Therefore, what the customer is actually doing is paying an extra portion on their bill to fund renewable energy for all, and a portion of these funds actually goes to research and development. It can be considered both a charity and an initiative towards a cleaner, better future.

The name of the Massachusetts Electric supported program is GreenUp renewable energy options. Consumers have a variety of programs to choose from delivered from four different renewable energy service providers. These providers use a combination of options to bring the energy forward including biomass, solar, wind power, and small hydro. Visibility of the different companies, their breakup of sources, as well as the cost to consumer is obtainable in the table below. (GreenUp Renewable Energy Companies, 2004)

GreenUpOptions

COMPANY & CONTACT	OFFERINGS	BIOMASS	SOLAR	WIND	SMALL HYDRO	SYSTEM MIX	ADDITIONAL PRICE PER KWH
Sterling Planet *Clear the air with our diverse renewable blend, all from New England. Develop solar, keep energy local and choose energy independence.*			New*				
1-800-473-1362	Sterling Premium™ 100%	30%	5%	15%	50%	–	1.35¢
www.SterlingPlanet.com	Sterling Premium™ 50%	15%	2.5%	7.5%	25%	50%	.675¢
Community Energy** *Sign up today for CEI's low-impact, pollution-free new wind and small hydro products and help us build new wind farms in New England.*				New*			
1-866-WIND-123	NewWind Energy® 100%	–	–	50%	50%	–	2.4¢
www.NewWindEnergy.com	NewWind Energy® 50%	–	–	25%	25%	50%	1.2¢
CET & Conservation Services Group, Inc.** *Passionate. Committed. Massachusetts non-profits delivering energy efficiency and renewable energy resources for over 25 years.* 1-800-689-7957		New*	New*	New*			
www.GreenerWattsNewEngland.com	GreenerWatts New England®	9%	1%	5%	85%	–	2.2¢
Mass Energy Consumers Alliance*† *We're a nonprofit group offering clean energy options and discount heating oil service, helping you save money and the environment.*		New*	New*	New*			
1-800-287-3950	New England GreenStart℠ 100%	19%	1%	5%	75%	–	2.4¢
www.massenergy.com	New England GreenStart℠ 50%	12%	.5%	2.5%	35%	50%	1.25¢

* *New* denotes new renewable energy sources activated on or after 1/1/98 and that meet the Massachusetts Renewable Portfolio Standard.

** The Massachusetts Technology Collaborative's Clean Energy Choice (CEC) matches that portion of your payments allocable to *new* renewables with grants for your community and for low-income residents (**www.cleanenergychoice.org**).

† The portion of your payments for *new* renewables qualifies for a tax deduction under the CEC program.

Product is Green-e certified. Information available at **www.green-e.org** or **1-888-63-GREEN**.

Product is ERT certified. Learn more at **www.ert.net, 1-202-785-8577**.

See supplier websites for more information on their products and emissions data.

TABLE 3: GREENUP PROVIDERS

Dino Park in Connecticut

Another existing program, which educates people of all ages about renewable resources, is based out of Dino Park in Connecticut. The park has installed a hydrogen fuel cell, which will eventually produce one-half to one-third the electrical power needed by the facility. As of now, the project, funded by the Connecticut clean energy fund, will be there for a trial period of 2 years. The public front of the project is a kiosk that displays information on fuel cells and other kinds of clean energy. The kiosk is currently located in the Exhibit center.

2.6 Local Efforts – At WPI

Two previous project teams initiated the work on solar power. Their efforts effectively attained funding and installed a solar array atop Morgan Hall at WPI. This section further addresses their goals, achievements, and recommendations.

Solar IQP One

The beginning of a multi-part solar project started with the feasibility of installation of a one-kilowatt photovoltaic power source on the top of Morgan Hall on WPI campus. Among the feasibility of installation, the pioneer group also found reasons for the installation including educational value through the Solar Learning Lab©

software**,** cost efficiency of the panel, and the maintenance of the panel and the power inverter. The group also took care of the funding for the PV system from a generous contribution from the class of 1975 and a contribution from the MTC (Massachusetts technology collaborate).

The first IQP team made an effort to acquire ownership of the Solar Learning Lab© in order to make sure there would be a supervisor for the software and the panel itself. WPI's Plant services, under Chris Salter's management, and Network operations, under the control of Sean O'Connor, both agreed to maintain and supervise the PV system and the SunViewer server through the first IQP group's efforts. The group also made an effort in providing a layout for future groups to develop an outreach to the local community on importance in solar energy.

Martha Cyr, the K-12 outreach coordinator for the WPI community, was interested in seeing future groups' development upon the current Worcester County curriculum. Joseph Buckley, the Science Curriculum Liaison to Worcester public schools, also was interested in the same kind of developments in this manner. The important point the group stressed was to outreach to the community using the Solar Learning Lab© and the SunViewer technology from Heliotronics.

Solar IQP Two

Within the span of their IQP, the second solar team completed three major goals that boosted solar education within and around the WPI campus. The most visible contribution is the solar array on the roof of the Morgan Residence Hall. The array Provides 1 kW, in full sunlight, to the grid supplied to the WPI campus. Heliotronic's Epiphany™ system collects data for display in multiple ways to benefit further understanding and education.

Another contribution of the second IQP group's project was their education program that focused on middle school and high school students. For the educators, a portion of a professional development workshop designates a program for high school and middle school educators focusing on the engineering design process and solar energy. Created for the students is a weeklong curriculum involving energy use and alternative energy resources to further their education.

The last major accomplishment was actually publicity in terms of solar use. Through media coverage on the local news channel 3 and publishing in multiple journals, the team was able to spread awareness about solar energy and its positive affects in their community.

2.7 Current Options – How and Who to Educate

The interest addressed in this section focuses on certain individual groups that include but are not limited to the Pre K-12 educational sector, general consumers, corporations, as well as the government. A solution to the underlying problem of education has a possible solution if clean energy advocates could portray clean energy to be worth the initial cost over fossil fuels. This wider educational awareness might also spawn private and government grants and assistance to overcome the hump created by large initial costs associated with solar power.

There is a high demand for education to all audiences of the solar energy world. The policy makers, manufacturers, government employees and consumers must learn to work together and receive information together as well. Whether the information is technical data for manufacturers and installers or an ad-campaign for business and residential consumers, it must be easily accessible and up to date.

With either a web-based or a newsletter type informative resource, which is simple to understand with present information for PV customers, the solar industry ideally would increase at a faster rate than it is currently. The general knowledge and cost decrease of the system would provide greater interest at the industrial and home based levels. The media has the ability to both locally and nationally advertise a web site.

Education into solar power and renewable energy is essential to expanding its use in society. Education at a young age will help promote the use of renewable energy by future generations. Presently, there is little effort put into educating students about the benefits of renewable energy use and the different types of renewable energy available. Expanding the education of younger students will aid in acceptance of renewable energy.

Massachusetts Renewable Energy Curriculum

Massachusetts Department of Education curriculum frameworks are very vague in describing the technology and engineering subjects that teachers shall cover in the classroom. The various topics covered in the frameworks include the use of natural resources as well as energy and power technologies including electrical power. There is no mention of renewable energy specifics, which teachers necessarily have to teach to students, included in the current curriculum. Unfortunately, this leaves the decision of teaching students about renewable energy up to the individual schools and school systems. In order to expand the knowledge of solar power and other forms of renewable energy in Massachusetts, the technology and engineering curriculum requires expansion to include renewable energy topics. (Massachusetts Science and Technology…, 2001)

Ecotarium

One location that is in need of an educational influence on the topic of renewable energy is the Ecotarium in Worcester Massachusetts. This museum and nature education center focuses on wildlife and protecting their habitat. They currently do not have any exhibits covering the topic of renewable energy, solar power, or the effects of fossil fuels.

Betsy Loring, the exhibit coordinator for the Ecotarium, agrees that they are in need of something educating their viewers to the importance of renewable energy and the destructive path burning fossil fuels carry. An oil-burning generator that obtains excellent efficiency and is completely isolated from the national grid powers their entire campus. They are looking forward to an alternate solution to their current generation system that would be a more environmentally friendly alternative. Betsy also agreed that an exhibit would help to promote awareness of renewable energy sources as a basis for a future installation at the Ecotarium as well as an educational source for the many visitors of the museum.

The Ecotarium hosts many visitors from all over the state. Many schools take field trips to this museum throughout the year. According to Betsy, the busiest times of the year are late winter to early spring and school vacation times.

In order to establish an exhibit at the museum consisting of a kiosk, a constant internet connection is necessary to the exhibit to allow it to display data from WPI. Internet connections are available randomly throughout the building and additional connections are available if necessary. Another necessity, electricity, is readily available throughout the building.

3 METHODOLOGY

The effort of the two previous solar projects led to the installation of a photovoltaic array on the top of Morgan Hall at WPI. The goal of this IQP is to further enhance WPI's green image and commitment toward green energy by educating the public (with particular focus on schoolchildren) about the benefits of solar and renewable energy. This section aims to address the assessment, the evaluation, and the feasibility of different ways to educate about the impact of fossil fuels as well as the need for renewable and solar energy. By educating on the need for renewable energy, we hope to create an awareness of its benefits and support the possibility for a cleaner, more efficient, and economically stable future.

3.1 Assessing the Need for Educational Outreach towards Renewable Energy

The first step we undertook in this project was to conduct thorough research (as documented in chapter 2) to evaluate and assess the need to educate on renewable and solar energy. This section assesses the need to educate on renewable energy, what specific topics to cover, and standards that would be beneficial if met. By covering the current usage and teaching on solar power, current standards to cover, and ways in which to gather information on how to obtain a better understanding of what to address and how to go about doing so can then be achieved.

Current Utilization of Solar Power

We have completed extensive research on the need and demand for alternative energies, including a strong push for more solar energy use. We realized that there is a need for further education on solar energy. Consumers, students, as well as future developers simply do not have the information or complete understanding on the use of clean solar energy and its benefits to the ecosystem.

In order to assess the demand and need, we had to first study about how much solar power is currently in use and more importantly how much is available. We have researched many government and professional educational websites and have read many books and pamphlets that have been provided to us by solar companies promoting solar energy. As discussed in section 2.1, results show that more knowledge about solar energy and its benefits is needed to increase solar usage, which in turn will increase production and reduce costs. Our research shows that a more complete knowledge and a greater exposure to the topic of solar energy beginning as young children will provide the greatest impact in future years and increase the use of solar energy in the future.

MCAS and Curriculum Standards and Gaps

Consumers currently have little to no education about renewable energy. In order to effectively promote its widespread use, we have found that education at an early age is essential. In order to educate students about the negative effects of fossil fuels and the many benefits renewable energy provides, the current curriculum frameworks must expand. We have found that integrating more general energy topics as well as some specific topics about renewable energy into the curriculum will help expand renewable energy education.

The current Massachusetts curriculum frameworks and MCAS exam standards are lacking when it comes to energy and renewable energy topics. Unfortunately, at this time, no specific renewable energy topics are covered in either the curriculum frameworks or the MCAS standards. Various energy topics, however, such as the basic forms of energy, simple electrical circuits, and electrical conductors contain current coverage in the curriculum. These provide a good foundation for our lessons in renewable energy.

Renewable energy education also has the potential to meet the requirements of some mathematics curriculum standards. We found that the mathematics curriculum incorporates a lot of graph, table, and chart analysis. Some of these requirements could be fulfilled by incorporating renewable energy graphs and tables into classroom lessons.

3.2 Identifying and Interviewing Knowledgeable Individuals in the Field

In order to get a sense of the instruction on energy issues in the classroom, and to explore various tools of outreach our group interviewed several individuals that were experts in the field. One of our interviews was with Dr. Martha Cyr, director of grades K-12 outreach at WPI and Liaison to the Worcester Public School System. Dr. Cyr is an expert in childhood education and offered a lot of information and many suggestions to aid our IQP.

We approached Dr. Cyr with our idea of constructing a kiosk to display the Sun Viewer information live on the WPI campus. She suggested that we take our idea a step further and create an educational resource that was easily accessible to teachers and a broader audience. Dr. Cyr told us about a website under construction that provides teachers with educational materials for science and technology.

As will be discussed in later sections within this chapter, the educational web site that Dr. Cyr introduced us to became the foundation for a new direction our project would take. We concluded that an interactive web site educating students about renewable energy would be the most beneficial way to convey the knowledge about renewable energy.

3.3 Exploring the Possible Tools to Achieve Outreach

Our group researched different ways in which to educate on the topic of renewable energy. Four ideas were constructed, each with different target audiences, locations, and concepts. In chronological order from the time they were construed, they are as follows:

-A kiosk setup in a location within WPI
-A kiosk setup in a museum such as the Ecotarium
-A portable computer system to display the Heliotronic SunViewer software
-An interactive website to educate

A kiosk, or any other type of computer for that matter, can potentially support the SunViewer software from Heliotronics. The benefits of having a kiosk are the simplicity of having only one program running, their durability, the touch screen, and the ability to be used by multiple users. With the SunViewer software, the individual using the computer can see the data collected from the photovoltaic above Morgan Hall in real-time. The software also is very user friendly and provides not only easy instructions on how to be used, but also more information on the topic of solar power.

Kiosk at WPI

The kiosk at WPI is a great opportunity for us to outreach our project goal to the WPI community as well as others who come to visit the school. The kiosk would be displayed in a key location where it would get the maximum visibility, namely in the Campus Center or the "wedge" in Morgan Hall next to the Network Operations building. The Campus Center appeared to be a logical piece of real estate for a kiosk because it is open to the public and is a central location that every student ventures to during some point in the semester. The reason why the kiosk would be beneficial to put in Morgan is that the actual solar panel is on top of Morgan, and the Network Operations center is in Morgan. With the television screen displaying the information on our network's activity combined with the kiosk, it would make an impressive display for not only the students but for campus tours.

The installation of the solar panels on top of Morgan Hall was only one step of a solar energy awareness project at WPI. The addition of a kiosk to display real time information from the solar array would complete the purpose of the solar installation. The SunViewer software displayed on the kiosk would have the ability to monitor power output of the solar panels in real time as well as display other information. It would have the ability to display weather information for a small weather station installed on the solar array. It also would have the ability to analyze information such as avoided fossil fuel emissions. All of this information displayed through a kiosk is a great tool to educate about solar energy.

Kiosk at the Ecotarium

Our next stronghold on this project centered on the idea of a kiosk at the Ecotarium in Worcester. The Ecotarium is a zoo with a focus on preserving and improving our environment. It receives less than adequate state funding, but mainly receives support through visitors. Many of the visitors include students there on school field trips.

Because of the amount of visitors and students circulating through the Ecotarium, we deemed the idea of putting a kiosk at this location as a great one. The kiosk would be enhanced though a museum quality display that we would design to incorporate different ideas and knowledge around the information provided by the SunViewer software. As a benefit to WPI, the display could act as an advertisement for the school.

Our idea included using a virtual private network to link the kiosk to the WPI computer system in order to retrieve information. The Ecotarium was both interested and willing to provide the necessary internet and power connections. An important contact for the Ecotarium is Betsy Lauring, the director of exhibits.

We met with Mrs. Lauring after communication by email at the Ecotarium to present our idea and asses the location. She agreed that this idea would be more than suitable to address the need for education on renewable energy and that the Ecotarium currently had no exhibit to display this type of material. The Ecotarium is powered however by their own natural gas powered generator, which completely separates them from the National Grid. In order to setup the kiosk, approval from the board for the Ecotarium would have to be granted, and Betsy Lauring alerted us to the excessive time this could take.

This idea could go beyond the Ecotarium. Either a portable unit or newly built units could enhance other venues. The idea requires mechanical skills, computer skills, and most importantly, funding.

Portable Computers with SunViewer Software

Another of our ideas to outreach to the community was to establish the SunViewer software onto portable laptops. We then would create a PowerPoint presentation to show the lessons taught using the SunViewer software. The laptop would have some other essential tools for the teachers and students to utilize. Lesson plans and worksheets would be loaded onto the laptops for the teachers to either use or get ideas on how to connect with his or her students' level of understanding renewable energies.

The laptops would stay at a location on WPI campus, possibly the library or the Network Operations office, where authorized personnel of the WPI community or Worcester Public Schools could retrieve them. The Worcester Public schools would receive notification of the interesting subject matter via the WPI website, WPI newsletters, or even a letter acknowledging the project and its usefulness to the children.

Interactive Website to Educate

Through the invention of the internet during the end of the last century, a new door to viewing information opened to almost anyone who has access to a computer. An idea to use this valuable resource occurred after a discussion with Dr. Martha Cyr. She would permit us to link our site on an educational website she was in the process of setting up pending our group's content is appropriate and valuable. Her intentions towards educating on the subject of renewable energy were to educate a specific age group, grades three through five.

With the internet, we can reach a huge audience with our message, even if geared to a specific age group. The idea is to have an interactive tour through the daily life of an elementary school student incorporating content focused on saving energy, the effects and use of fossil fuels, and of course the benefit of renewable energy and solar power. Grades three and five both are required to take MCAS testing in Massachusetts, and we believe that through our efforts on this website many of the curriculum standards can be touched upon. Ideally, the idea of the interactive tour should also appeal to the age group and keep their interests.

3.4 Evaluating the Alternative Outreach Tools

Our next step was to evaluate the overall feasibility and effectiveness of each of the previously described project ideas. The four ideas all have their positive qualities and benefits but with the time we have to complete this project only one will suffice. By sharing our analysis of the feasibility on each of the ideas at this point, we intend to establish the reasoning behind picking which one to pursue.

There were three pieces of criteria that we used to determine the feasibility of each tool used for teaching on renewable energy. The first and probably most pertinent to the team's decisions was the logistical aspects of the project ideas. Some of the most important parts of the practicality included the time, funding, and approval required to produce a finished product. The next piece of criteria used was the educational effectiveness of each product. Our team wanted to look at how each idea could complete the goals of effectively educating our targeted audience. The last piece of criteria we based the feasibility of each idea on was the technical aspects, such as the number of potential users. The details of our feasibility analysis and the results of this analysis are presented in the next chapter (section 4.1). Of the alternatives evaluated, the interactive website seemed to be the most effective and feasible for our project.

3.5 Conceptualizing the Layout of the Interactive Website

Through serious thought and analysis, the most feasible solution to the problem associated to educating about renewable energy was found to be educating through an interactive website. Next, a choice audience was determined and to address this audience an idea of their learning style, ability, and ways to attain their interest in the subject matter were looked into. Different components are associated with this website including educational videos, visual aids, worksheets, lesson plans, as well as extras for teachers. The main part of the website is an interactive tour through the life of a child teaching different attributes of energy, renewable and clean energy, as well as bettering society on the whole. In this section, the content is also addressed and different tools to unveil the content, fun animation and pictures are looked into for further understanding on how the whole project comes together.

3.5.1 Some Critical Issues for an Effective Outreach

In this section we describe what our team felt was important to outreach to the community. We first talk about our target learning age, which is 3rd through 5th grade. Then we move on to discuss how we plan to use MCAS standards to outline the goals that students achieve from using our material. We continue by explaining why it is important to match a student's learning ability along with ensuring the student stays interested in the material.

Structure for Grades 3-5

Dr. Martha Cyr informed us that it would be most beneficial to focus our efforts on grades 3 through 5. In grades three and five the students are required to take MCAS tests that include some of the material and concepts we educate through our website. It is also a good idea to instill the concepts covered in our website early on so an individual is both familiar with energy usage and renewable energy as well as hopefully having the desire to better our world and future generations.

The learning ability of a 3rd, 4th, or 5th grader varies because of their age and different skill levels. Our website takes an approach, which is hopefully familiar to each of these grades. Content may vary between the grades and it might intertwine in the website, therefore we are relying on the teacher to enhance certain topics and create a focus on what is truly important to what they are trying to get across to the student.

Mapping MCAS Standards

The mapping of MCAS standards to the content in the website is very important to the success of the project. Every activity we have created or linked in our website has at least one MCAS Standard associated with it. The reason we have decided to thoroughly integrate the MCAS standards into our work is that it allows teachers to bring our material into the classrooms and not diverge from the subject matter they are required to teach in Massachusetts. If we did not specifically point out what we were teaching in this form, most teachers would be hesitant to use the material in their classroom.

Because we have each standard thoroughly documented in one section of the site, the standards can be cross-referenced to other national standards. This will allow the spread of our project outside of the Massachusetts school systems. The activities we have created or have linked to so far are linked to the Math and Science curriculum standards at this point. However, the layout of the site will allow future material to be integrated in the areas of English and even History. Each can be hosted and thoroughly mapped to specific standards.

Matching Learning Ability

Analysis of the content, with the use of other material for this age group, makes sure that the reading level, vocabulary, structure, and graphics are appropriate and familiar to the student. Everyone learns in a different way, but aiding content with visual representation should aid our efforts. In actuality, no teaching tool is effective without the careful configuring and coordinating through the teacher responsible for their students. By creating many tools for the teacher we hope they can better add necessary material, configure our already available lesson plans, and most importantly teach the students what they and the school system feel is most important.

Stimulating Interest of Student

Through the interactive aspect, videos, pictures, animation, worksheets, demonstrations and experiments we hope that the venture through our site will be fun as well as educating. To learn one must pay attention, and to pay attention an individual must be interested. An interest in renewable energy probably does not occur under normal circumstances to a pre-teen. Our goal was to make the site as interesting and fun as possible to capture the student's interest, while at the same time covering the necessary content.

3.5.2 Components of the Website

We envision that the website will contain the following components, each enhancing the user's learning ability. Many studies have been completed on the topic of children's learning techniques. An attempt has been made to incorporate as many teaching techniques into our website as possible to achieve a greater outreach. We have integrated educational videos, experiments, worksheets, and lesson plans for teachers, and an interactive journey that a child can easily navigate. It is our understanding that because all students have their own learning style, it is necessary that our website offers an approach that can satisfy nearly everyone.

Educational Visual Aids

Every student has his or her own individual learning style. Some students are more apt to learn out of a book while others can take more out of a hands-on type activity. No matter which learning style the student benefits from, adding visual aids enhances the learning experiment.

Our goal for this project was to reach out to as many students as possible and educate them about renewable energy. We all agreed that visual aids would enrich the students' learning experience. Therefore, we created an interactive website that includes many graphics and animations. Combining these graphics with easy to understand educational content, we were able to effectively convey renewable energy lessons.

Interactive Tour

The main goal of the website is to educate grades 3rd through 5th, and to do this we needed to think of something interesting and relatable to these students. By creating an interactive lesson, the student must constantly give input back to the computer, so they remain interested and alert. This form of educating is an effective tool to meet many learning styles.

The idea is that from the initial home page of the site the student will begin an interactive tour of a day in the life of either Sally Sunshine or Solar Sam. By creating these two characters, we have created a more politically correct site and hopefully have captured the interest of both genders. A student should be able to relate to these characters because they go through a common daily routine that should be familiar with a student of this age.

Through the tour, many curriculum standards are covered and shown to the student in a simple yet effective way. The site is spread out to avoid clutter and builds upon previous ideas so the student is familiar with ideas and concepts before going forward with content that is more difficult. Also by creating familiarity with the student's individual life, they can take a different perspective on their own energy usage and their possible plans for future energy production.

Educational Videos

One of the advantages of an interactive website is the ability to integrate educational videos throughout the site. The videos will be short and focus on key information, which is best described visually. Some of the videos to be included in the site are of wood and oil burning to show how energy is dissipated. This video will also demonstrate the amount of pollution that fossil fuels produce when burned for energy. The other main video, which is currently planned for the website, is a tour of the WPI solar facility. The purpose behind this tour is to educate students of how renewable energy, in particular solar energy is effecting local communities. It will also allow the students to follow visually how the energy fro the sun is really made into electricity and used in homes.

Educational Worksheets and Lesson Plans

The worksheet and lesson plan section of the website is an important future in aiding teachers in presenting the material to be covered. The worksheets are designed to reinforce the concepts seen within the website. They also can be used to evaluate the knowledge students have gained from our lesson plans and our interactive website. The lesson plans will be set up to show the teachers a wide range of ways to teach the positive effects of solar and renewable energy. The worksheets will be based on general knowledge learned from the website and open-ended questions to meet many MCAS standards. The questions will be formed to test the knowledge as well as the critical thought process of many MCAS questions. Many of our lesson plans will be linked to other educational sites, from there teachers may either use or base further concepts for their class from the linked content.

Extras for Teachers

With an initiative to meet curriculum standards, the real goal of the website in its entirety is use as an educational tool for teachers. While making the site interactive and interesting to the student, an effort based on the teacher's needs and helping them meet important goals is necessary. Besides worksheets and lesson plans, we plan to aid in bringing forth the curriculum and MCAS standards and show an analysis on how to use the site to meet certain requirements.

To do this we included a page displaying the different standards we touch upon in the site. Further, we link the particular areas in the site that cover the material so that the teacher can see the content. Beyond that, we included a brief explanation on how to use this content and how to teach it to the students.

Another section we have included for the teacher's benefit is a page of links to various other resources that might be beneficial to teaching the topics covered in the site and then to expand on them. Also linked are other areas of interest that have relevance to meeting the goals of this site. So much information is available on the web. Our website does its best to take the most relevant and understandable information on the topic of energy and renewable energy to students from 3rd and 5th grade, but with other information available through links, the teacher has the option to curtail their student's lessons to their abilities and learning styles.

When contemplating on the definition of interactive and relating it to our goal of educating on renewable energy, nothing is more relevant than an experiment. We have included various demonstrations and experiments that the teacher might choose to use or allow the student to do on their own time. Some experiments are simple, such as just using a solar calculator, but many require parts and expertise. There was an effort by our team not to include anything dangerous, misleading, or not proper considering the age group this site is intended for.

Content

There are two portions to the content of the website. A useful portion to teachers is the activities, which are posted under the teacher resource section of the website. Each of the activities is designed to match up with specific MCAS standards. The format that the lesson plans are written in a format which lays out all the materials and procedures needed along with the goals and standards covered.

The second portion of the content is the information that is integrated in the interactive part of the website. This information is geared towards the students in 3rd and 5th grade. Content is designed to flow along one logical path. The flow of the content starts in a house where the student explores what different things in the home use energy and how to conserve energy. Then students are given information that relates the amount of pollution created by these appliances in a form that they will understand. After the students understand just how much pollution is created with fossil fuels, we introduce information about renewable energies, in particularly solar. At the end of the interactive journey, we have videos and information for the students to further enhance the educational benefit of the website.

3.5.3 Benefits of a Link-based Website over Software

The problem with software is that of size, ease of use, and of course availability of programs to run them. Using a website the individual has to download nothing and only needs an internet browser and flash utility, both extremely common and free to get. In addition, the website takes little to no space on the viewer's computer, and minimal space on our host server.

Using a link based approach through a website the viewer only has to wait for the next page to load, which should take only about thirty seconds with a slow connection. With software, there is the possibility of not needing an internet connection, but with the availability of the internet in today's world and multitude of potential users, we do not anticipate this being a major problem.

Almost anyone that knows how to use a computer is familiar with browsing the internet. A problem with software is that you need to know how to install it and then need to learn how to use it. Also with a website, we do not need to create a tutorial or detailed instructions.

3.6 Integration and Approval

We have focused our main goal of outreaching to the community with an interactive website that helps both educators and students. We sought out to get approval and to incorporate professional ideas for our website. First, we wanted to get the approval and discuss details with our own K-12 outreach coordinator, Dr. Martha Cyr. In order to gain her approval, we need to make sure all of our content for our website meets MCAS standards.

Our next step was to receive approval and further discuss content with Worcester Public Schools science director for K-12 grades, Joseph Buckley. Lastly we had to test our ideas and seek out approval from actual Worcester Schools. We talked to some teachers in the grades of 3rd- 5th grade and sought out their advice as well as their interest in using this website. We are still seeking out other approval and obtaining advice from professionals in the educational field to make our website more complete.

Dr. Martha Cyr

A major concern for our outreach to the community was to have our ideas and project focus approved by the WPI personnel as well as our local Community. Dr. Martha Cyr is the outreach coordinator for WPI for grades K-12. She has been involved in the previous IQP projects and has been extremely helpful to our team. She has been able to assist our efforts to outreach solar and renewable energy to the community.

We went into our first meeting with different angles to accomplish our project goal. The first meeting with Dr. Cyr spread a new light for the focus of our project. After discussing all the pros and cons of each of our project ideas, the interactive website was clearly the best choice, easily approved, and suggested by Dr. Cyr as being the wise choice.

In our second meeting with Dr Cyr, details of the layout and content of the website were discussed. We revealed to Dr Cyr the specific 3rd and 5th grade standards we intended to address. She became enthusiastic because in upcoming years there will be new MCAS standards, and 3rd grade students will be tested heavily in math. Currently there is little material on the subject of math for 3rd grade students that teachers can draw upon. She felt the layout of our site would benefit teachers because of the ability to lookup which curriculum standards each activity applied to. She also felt our site should allow future project groups to develop very detailed lesson plans and content that could be added to the site with little further work. At the end of the meeting, she requested to the current process of the website to ensure our content was at an appropriate level for the grade levels we are targeting.

Meeting MCAS Standards

In order for our teaching resource to be accepted and used by educators, it had to meet the requirements of the Massachusetts curriculum frameworks and the newer MCAS exam standards. The MCAS tests have become a large influence in teaching over the past few years. Many teachers have begun to use MCAS standards as the primary resource from which they plan their class work. Because, we wanted our web site to benefit students as much as possible, we decided that it was necessary to fulfill as many MCAS and curriculum standards as possible. We designed our lessons around these standards and provided evidence to teachers to validate our website as a professional classroom-teaching tool.

Meeting with Worcester Public Schools

In order for us to have a good grasp on the content for our project, we had to meet with the Worcester Public Schools and their students. We went to the schools and actually met with some of the children to get a general idea of how they learned and what they already knew about general science and renewable energy. It was apparent that there is a need for renewable energy knowledge from simply talking with the children. After meeting with 3rd and 5th grade teachers, a lab technician, and a principal, they all seemed very excited to try our interactive website. It gave us a greater realization that an interactive website could be used as a valuable tool.

4 RESULTS AND ANALYSIS

The previous project teams recommended to create a complete Solar Learning Lab© and to outreach to the community. Our team has set out to accomplish two major goals during the timeframe for this project. After thorough research, we have found that reaching those goals is possible. We feel that first, by creating an interactive website geared toward students in grades 3rd through 5th, conceptual knowledge on the topic of renewable energy can easily be achieved through this age range. Secondly, we made tangible progress with respect to a kiosk at WPI and a kiosk at the Ecotarium.

4.1 Results from Evaluating the Alternative Outreach Tools

As mentioned in Section 3.4 we conducted a detailed feasibility study to compare the relative effectiveness of the four possible educational tools:

- Kiosk at WPI
- Kiosk at the Ecotarium
- Portable Laptops with SunViewer software
- Interactive Website to Educate

The three broad categories of criteria used for comparison were:

- Technical Aspects
- Educational Effectiveness
- Logistical Aspects

Comparison of Alternative Outreach Tools					
	Methods of Conveying Information	WPI Kiosk	Ecotarium Kiosk	In-Class Laptops	Website
Technical Aspects					
Licenses		required	required		
Portability		no	no	yes	N/A
Effectiveness					
Coverage		limited	better	good	best
Number of simultaneous users		1	1	1	unlimited
Interactive		yes	yes		yes
Deterioration		yes	yes	yes	
Meet MCAS standards					yes
Additional teaching tools				included	included
Uses WPI PV		yes	yes	possible	yes
Educational Effectiveness					
Skills Learned					
Understanding of solar		yes	yes	yes	yes
Importance of renewable energy		yes	yes	yes	yes
Graph analysis		yes	yes	yes	yes
Tables		yes	yes	yes	yes
Sun and its importance					yes
Fossil Fuels		yes	yes	yes	yes
Age/Gender					
Boy Interests		yes	yes	yes	yes
Girl Interests		yes	yes	yes	yes
K-2				yes	yes
3-5			yes	yes	yes
6-8			yes	yes	yes
9-12		yes	yes	yes	yes
Beyond		yes	yes	yes	yes
Subjects Covered					
Science		yes	yes	yes	yes
Math		yes	yes	yes	yes
Vocabulary				yes	yes
Literature				yes	yes
Logistical Issues					
Cost					
WPI Funding		required	required	required	N/A
Maintenance needed		yes	yes	yes	small
Outside Funding		possibly	possibly	possibly	none
Approval					
Advisors		needed	needed	needed	needed
Administration		needed	needed	needed	needed
MCAS Standards					required
School Board					required
Financing		required	required	required	
Time					
Within project allotment		no	no	no	yes
To find Funding					N/A
Material Allocation		required	required	required	N/A

TABLE 4: FEASIBILITY MATRIX

The table above is a summary and comparison of the results from our feasibility study of each idea. Each of the four headings is one of our proposed ideas. The row titles are the criteria we examined. The headings in red are the three basic groups we broke the criteria into. We discuss below the details of our evaluation of each of the four ideas.

Kiosk at WPI

The first project idea that we examined was placing a kiosk on the WPI campus. The kiosk was designed to provide an understanding of renewable energies, particularly solar, and illustrate the problems with fossil fuels using graphs and tables. This project idea seemed to meet the educational effectiveness that we strived to meet. The ability of the kiosk to display live data from WPI's solar panels even further increased the educational value. This would allow the users to learn how solar effected their community in real time.

We found many benefits to setting up a kiosk on the WPI campus. One advantage we noted was that no outside approval was necessary to complete this idea. We would only require approval of the WPI administration as well as our advisors. Another benefit was the kiosk would be able to access data from the network without any problems or security risks. Since the kiosk would be on campus, this also meant there would be no problems in terms of licensing because WPI is covered within a site license for the SunViewer software from Heliotronics.

When examining the logistical aspects of this project, the feasibility of the kiosk at WPI was compromised. The first roadblock we encountered was funding. A project of this magnitude was going to cost well over five thousand dollars. The kiosk alone from Heliotronics was quoted at roughly $4500. When we communicated with an outside manufacturer, Affordable Kiosks, we received a quote of $4025, which did not include the software cost. The Heliotronics quote is in appendix 1 and the affordable kiosk quote is in appendix 2. Another cost, which would be inherent with having a kiosk, would be the maintenance. Wear and deterioration over time would cause the need for upgrades and physical maintenance. Due to the time constraints within which this project must be completed we realized that obtaining such funding would be difficult.

The first thing taken into consideration was the educational limitation of a kiosk. A significant problem is that only one individual can interact with the kiosk at a time. Although this is not as significant of a problem if the kiosk is used with smaller groups, having a class surrounding a small screen still makes it difficult for all students to interact individually.

A kiosk on the WPI campus would be designed to benefit students in the 9th grade and beyond. We felt that there would be minimal exposure towards younger children with this kiosk since they are unlikely to visit campus. The various outreach and summer enrichment programs would however benefit from having the kiosk on campus as a resource

The last and notably largest problem, in terms of practicality of this project idea, was time. We found it infeasible to locate a source of funding, receive all the required approval, and produce a completed display and kiosk in the amount of time allowed for our IQP project. Alone, the time required for locating and securing funds, whether it be from within WPI or from outside grants, could take well over a year.

Kiosk at the Ecotarium

The second idea we examined in terms of feasibility was placing a Kiosk at the Ecotarium in Worcester. The main reason we attempted this idea was the unique advantages gained by working with a well-established place of learning. By placing a kiosk along with a small display to enhance it, we determined that students of all ages would be exposed to our solar information in an interactive method. Exposure to solar education would also be expanded from just students to the many groups that visit the museum each year.

When we began to study the technical aspects of a kiosk being off site from WPI, we realized issues that would affect the feasibility. First it too has the same limitation that only one individual can use it at a given time. The next problem with the kiosk was transmitting live data from the WPI network to the kiosk. Although ideas were proposed to use a VPN in conjunction with internet access to allow the kiosk to talk to the WPI network, the reliability would be low and the security risk to WPI would be high. The last problem was that the license to the SunViewer software displaying the solar panel data was for on-campus use only. This meant another license would need to be purchased for the Ecotarium to use the software. In addition, there were unclear issues concerning whether there was any part of the server side software agreement that allowed us to send data to off campus locations.

When examining the logistical aspects of this project idea, the feasibility of the kiosk in the Ecotarium became truly hindered. As with the kiosk at WPI, funding was a major issue. In addition to the cost of the kiosk, creating a museum display would incur additional costs. The cost of setting up a professional display was not quoted, but was understood to cost at least several hundred dollars. Another cost, which would be inherent with having a kiosk in a museum, would be the maintenance. Wear and deterioration over time would cause the need for upgrades and physical repair, especially in a museum environment.

The next issue we came across in terms of practicality of the kiosk was approval for the project. Although our initial proposal of the idea to the Ecotarium was received with great enthusiasm, their board would have to meet and decide if they liked the idea. Even if they agreed to accept our idea, they would still need to see the completed project to make a final decision for use. The other place we would need approval from was WPI. Our advisors had to approve working on the project. WPI administration would also have to give their approval for a WPI-sponsored project at the Ecotarium. It did not seem practical to complete this within our allotted fourteen-week project term.

Portable Computers with SunViewer Software

The third outreach tool examined was using portable laptop computers with the SunViewer software by Heliotronics. This idea had potential because it eliminated many of the issues that hindered the feasibility of both kiosk ideas. Unfortunately, many concerns arose with the project that ultimately made this idea outside of our constraints.

The first area we analyzed was the educational effectiveness of the project idea. When we determined that slideshows, videos, and the SunViewer software was able to run on a laptop and could gain access to the WPI network for access to the live data, we felt there would be no problems using this as a solar education resource. The other positive aspect of using laptops was that they would be designed to display on a projector so that a large group of students could benefit from the presentation at the same time. The downside to this however was its loss of some of the interactive benefits of the students exploring on their own.

When studying the technical aspects of this idea, we found many favorable traits. The most apparent is that laptops are portable. They have the ability to move from classroom to classroom and set up for a presentation within minutes. This portability would allow the information to be shared not only on the WPI campus, but also in surrounding schools if a teacher requested to borrow a laptop. In addition, the fact that the laptop belongs to WPI means it would have privileges to connect to WPI through a VPN for the live data and be part of the WPI computer network.

When examining the logistical aspects, the idea's feasibility greatly reduced. Although the cost would be greatly less than a kiosk if only one laptop were used, problems with maintenance were foreseen. The laptop would have to be left in the care of someone in WPI. This would require many levels of approval because we would in essence be creating a new outreach program that WPI would have to support. If there was an issue with the laptop, it would be expected that WPI would repair, which could be a large undertaking in terms of time and money. This is the main reason this idea was not feasible for our group to complete.

Interactive Website to Educate

Of the various alternatives evaluated, the interactive website is the most feasible for the team. While studying its feasibility, the website seemed to surpass the previously examined tools in multiple ways. In terms of the educational effectiveness, it surpassed the kiosk in many ways.

The skills learned by using the site are more extensive than a kiosk, especially with younger students. Students are able to learn using tables, graphs, animation, and videos. The website also allows the educational material to be more organized and makes it easier to find specific information.

Another big advantage to the website is that we can make it conform to statewide standards such as MCAS standards. This allows the teachers to integrate the material into the classroom and not diverge from the frameworks that they must satisfy. In our site, we have devoted a section of the website to display each of the MCAS standards we cover in the site. On this page we give the code for the standard, if one exists, along with the full text of the standard as seen in the curriculum frameworks. There is also the list of MCAS standards within each of the lesson plans for teachers to refer to.

In terms of the technical aspects, there are also many advantages. The first and biggest difference from the other ideas is an unlimited amount of students can be using the site at one time. The other major advantage is there is no deterioration with use of the materials used in the product. The other big advantage is there are no licenses to address by our team when creating the product.

The logistical and time issues, which had been associated with the prior ideas studied, do not exist with the interactive website. There are no costs associated with producing the website, for implementation by schools, or to WPI for sponsoring it. There is also limited approval needed in order to create the site. Only the advisors need to approve the concept to begin the creation of the site. However if we choose to have the site hosted or used in specific schools, approval from each may be required. In the case of our site, we sought out the approval of Dr. Martha Cyr, Mr. Joseph Buckley, and the Worcester Public Schools for the site content. Lastly, in terms of our short time span, we concluded that an educational site with some structured solar activities that are mapped to MCAS standards could be completed in seven weeks. This fits into the remainder of our allotted time to complete the project.

4.2 Description of the "as-is" Website

Websites currently available to teachers and students, specifically www.teachengineering.com, do not have materials for elementary students in an interactive form about solar energy. More sources of information are required to effectively educate students about this topic. Our website will benefit and further enhance the www.teachengineering.com site to cover the topic of renewable energy and improve knowledge of material covered in MCAS standards.

Teach Engineering Website (www.teachengineering.com)

Professors have developed a website that will outreach to worldwide teachers about up-to-date technology and engineering content for teachers to convey to students. The site, www.teachengineering.com, has many different curricula that use science and mathematical concepts through hands-on engineering activities. The website has a unique tool that allows an educator to look at curricula that has been cross-referenced to the teacher's own state standards. The team that worked on the site went through the tedious task of creating a matrix that looks through the lesson plans and activities and matches them against national and statewide standards alike. This matrix reveals which standards and frameworks the lesson plan or activity covers so the teacher knows exactly what they are teaching and can locate material needed to fulfill their own requirements. The site, www.teachengineering.com is completely user friendly for all educators that plan on teaching mathematics and science topics to enhance their student's knowledge of engineering. The site is geared toward educators teaching children in the K-12 grades because the team believes that the young children can improve their conceptual knowledge of engineering and expand their intellectual creativity through the curricula on the site.

Once a user goes to the www.teachengineering.com site, they can choose from a series of menu items that can take them to different curricula, activities, lessons, and subject areas. The user can scroll through different options or use a keyword search to find a particular area. Then the user can find what they were looking for by clicking on a link and it will bring the user to a page that describes exactly what it is about, what standards it covers, what grade level the material is adequate for, and some key vocabulary that is within the content. This site makes it very user friendly and easy for educators to know exactly what they are looking at without spending countless hours reading each individual activity or other educational resource.

What Currently is in Place

Currently, there is a lack of interactive educational material about solar and renewable energy on the www.teachengineering.com. When searching the database of solar activities hosted by www.teachengineering.com, eleven activities were found, but none were designed for elementary students. In the interactive portion of the www.teachengineering.com website, known as the living labs, there was no content focusing on solar energy either. There was, however, a location for wind energy that is currently under construction. To promote solar and renewable energy education, more interactive content should be made available to students, especially those currently in elementary grades.

What is Necessary for Completion

Our website is currently in complete working order, ready for students to take in the knowledge it provides. We would like to see the content be further developed into a more interactive learning experience. In the Recommendation Chapter, we discuss the ideas we recommend to expand on our content and graphics to make it more child-friendly. The teacher's resources page can always have more linked sites, lesson plans, and creative ideas to add to our base page. As more knowledge is cast upon renewable energy ideas, the website will have to be updated for both the teachers and students. The FAQ page will also have to be updated with many more questions that people may have about the site as well as renewable energy. As the future of renewable energy comes closer to expectations, the content and knowledge of our site will have to be updated to keep up with the constant changing times.

4.3 Website Developed by this Project Team

Our IQP project involved the construction of an interactive website to educate students in grades three through five about solar and renewable energy. We wanted our website to be well accepted and well used by educators in Massachusetts and across the country. The web site was designed to attract the attention of students and effectively educate them about solar and renewable energy. We used a graphical website design with some integrated animation to develop our educational tool.

Purpose

After assessing all of the directions that our project could have taken, the interactive website, as shown before, was the best pathway to achieve a more complete goal. The website will serve to educate consumers, educators, and especially young students who will become the workers and energy consumers of the future.

The website will have a complete interactive journey that will intrigue the young students to learn more about the importance of renewable energy. The journey will capture the child's attention with familiar graphics of his/her everyday life. A classroom will be integrated that is full of general knowledge and activities that the children can go through that will teach them about renewable energy and its benefits. The content of the journey adheres to many MCAS standards, including math, science, and open-ended questions that will allow the student to put conceptual ideas of renewable energy onto paper.

The website incorporates a teachers' section that will have many different tools and links to provide educators with a preview of the content of the journey as well as many lesson plans that can be used to teach students about renewable energy. Because most of the activities and content from the website contain many MCAS related information and is standardized to the MCAS test, the teachers will greatly benefit from implementing the website in their classroom. Educators will be able to realize all of the MCAS standards that the website covers.

Structure

The website is a multi-part interactive site that is useful to both educators and students of all ages. Our site gears its content towards 3rd through 5th grade, but will be useful to others as well. The site's homepage contains options to jump-start the interested user. Offered on the main page is a journey that a person can easily navigate through; it follows a child's routine school day. Through the journey, the user will be able to link to educational materials from different objects on the page to teach the user about different renewable and non-renewable energies. In addition, it offers a teachers' section and a Frequently Asked Question section as well.

The journey will be set up as a linked-based program, where each click of the mouse will bring the user to a different page teaching an integral part of energy and its benefits and problems. The user will choose a character and start in a bedroom where there are multiple objects that can teach the user about the different types of energy. Selecting the door of the bedroom brings you to the kitchen where there are abundant concepts that compare the use of fossil fuels to objects that children can more easily relate to. The next page shows a school bus on its way to school that passes by a power plant, a solar array, and a wind turbine. Each of these will have adequate information on their respective subjects that will allow the child to see the benefits and problems with certain types of energy. After the bus ride, the children arrive in the classroom where different objects will link not only more information, but also activities that the user can do to visualize the information that they learned throughout the journey. All of the content that is found during this journey is designed to comply with MCAS standards, which allows the children not only to learn about a real problem that they will have to encounter when they become consumers, but it will help them on the MCAS test that they will need to pass to graduate.

The teachers' section will be linked to other sites that have lesson plans and useful information that educators can utilize for their own personal knowledge or to educate others. The content will be the most useful for teachers of third through fifth grade, but can be manipulated to inform any audience. The links of this section will give the teacher many different lesson plan options. It will also allow the teacher to view the MCAS standards and the specific standards that our content and activities cover.

The frequently asked questions section is a brief part of our interactive website that will display questions that we feel will better help our audience understand the purpose for this website. The section is a simple question and answer format where the audience can get a better understanding of often misunderstood or usually un-taught energy topics. The frequently asked questions will likely increase with more questions and answers as the website gets used.

Content Currently Posted

The content for the website has many important aspects that will not only appeal to an educator, but will capture the attention of the student. All of the content is up to MCAS standards, which will allow educators to teach about serious future problems in energy production and consumption, but will also abide by the guidelines of MCAS. The students will be challenged with open-ended questions similar to the MCAS format that will allow them to brainstorm and put their thoughts in writing. Our research revealed that the open-ended style questions were a struggle for most students taking the MCAS tests, simply because they were not familiar with the format. The content will test the student's knowledge of mathematics and science while creating a fun graphical environment to capture the student's attention while learning. Many students learn in different ways. Some students learn visually, some learn in a lecture style, and some learn by writing. The website has all of those components and more. The site by itself is a useful tool, but educators can create their own lesson plans using the site as part of there design. Columbus Park School, a local elementary school has previewed our site with some students and their teachers. The curriculum coordinator of the school, Jayne Cardin has written a letter to the usefulness and easy navigability of the interactive site as seen in Appendix N.

Recommended Material for Completion

The time constraint that this project posed has left us with some material that will be unfinished or unrefined. The content completed is to the best of our ability and will be critiqued by our previous contacts for approval. The website will not really have a limit or end to the amount of content that it can teach to students. Some of the recommendations for the material are trivial but important. The content, once refined by our contacts, may be needed to be revised more. Any new content that will go into the website will need to be up to MCAS standards. The website content will have to be updated to newer MCAS standards and Worcester Public school frameworks.

Plans for Future Content

Our approval board consisting of our advisors, Dr. Martha Cyr, and Mr. Joseph Buckley will analyze the website's content towards meeting the Worcester Public School Department frameworks and MCAS standards. As the educational field expands and the standards are updated, the future content maybe quite different for our website.

4.4 Design of Website

One key to an effective web site is the use of attractive and easy to navigate content. With our target audience for the site being students in the 3rd and 5th grades, we decided that a graphically enriched site that is easy to navigate would be the best choice. The basic part of the site is an interactive story-based approach towards teaching. Other sections include teacher resources, facts and questions, site map, and the use of other tools to further enhance the site and educational effectiveness.

Layout of Site

In order to effectively achieve our educational goal for the web site, we decided to design a theme that would be carried throughout the entire site. This would eliminate possible distractions from randomly constructed pages and allow for a convenient navigation scene. We laid out the site in the most logistical manner possible. The site was divided into three major sections: the interactive lesson, teacher resources, and frequently asked questions. The lesson is designed to be navigated through using a series of links, the teacher resources section is a series of pages linked to the main resources page, and the frequently asked questions section is a single page containing all of our frequently asked questions. In addition, we also provided the user with a site map so they can understand the layout of the site and navigate to any section of the site easily.

Purpose of Creating in Current Layout Design

Professional website designers make use of site layouts to display their content in an effective manner. We decided to take the same approach to the design of our web site. The layout was designed by hand to suit the specific needs of our site. We have implemented various menus where required and set up all of our content to flow together and be easily navigated by the user. By using this approach, we are able to effectively educate students about solar and renewable energy and keep their attention simultaneously.

4.5 Site Design and Applications Utilized

We have chosen to use Macromedia MX suite to build and integrate our website. Dreamweaver was the main program used to combine, integrate, and link our website. Fireworks was used to design and improve the graphics and backgrounds. Flash was used to design and run animation which can be seen through a Flash viewer. The site can still be viewed even if the viewer does not have a Flash viewer; they just cannot see the animation, which is limited because of our skill to begin with. A copy of all files will be kept on CD with our project advisors for future updating and improvement, knowledge of these programs are necessary though.

Macromedia Dreamweaver

Macromedia Dreamweaver is a professional website creation tool. It allows us to create and edit the website in a graphical environment while it creates the necessary code. This is an advantage because it allows the user to create web content without having any programming experience. Dreamweaver incorporates many advanced features and tools, which facilitate the construction of an interactive site like the one that we have constructed. In addition to aiding in page development, Dreamweaver also controls all file management tasks necessary to the construction of a complete website.

Macromedia Fireworks

Macromedia Fireworks is a graphic design application intended for web graphic development. Fireworks contains many advanced graphics tools needed to create graphic rich web media. The tools available are comparable to those of other high-end graphic design applications such as Adobe Photoshop and many others. With Fireworks, we were able to do a lot of the graphic design for our website. The program works hand in hand with Dreamweaver to create the graphic rich site that we were aiming for.

Macromedia Flash

Macromedia Flash is a graphics program used to create animated graphics. Flash allows multiple images to be combined into a movie-like animation for use on the web. This is an advantage within a website because it allows the creator to make flashy content that is easy to navigate. We used this program to create animated content for our web site that helps keep the attention of our audience and get our point across.

Purpose and Reasoning behind Using this Software

The Macromedia Studio MX suite was a good choice for use on our website. Our site design required us to make interactive and flashy graphical content that keeps the users attention and was interactive and educational. The applications in the suite allowed us to design and create the content and assemble it in a way that was beneficial to our audience.

4.6 Efforts towards SunViewer Setup in Atwater Kent Building

The recommendations from the earlier project asked future teams to create a solar learning lab. The learning center would connect to the solar panel above Morgan Hall at WPI and display all of the information the panel obtains through the SunViewer software. This information, displayed in a user-friendly way, demonstrates the energy being produced by the solar panel throughout the course of the day. The previous solar IQP teams recommended that this data be shown on a kiosk on the WPI campus. We have looked over the proposals of hosting the kiosk in the campus center, where a high volume of traffic is always present, in the “wedge” of Morgan Hall right outside the net-ops facility where many students go for meals, and in the Atwater Kent building that had a previous kiosk set up inside already.

Although we were unable to setup a kiosk in the campus center or in the "wedge" of Morgan Hall, we remembered that an old touch screen used to be in the ECE department building, Atwater Kent. The building gets a lot of traffic and the campus tours always go through the building passing right by the kiosk. Currently the space was boarded over with corkboard and the computer and screen was removed for storage. Our new plan was to use this existing space and equipment to display the SunViewer software that WPI has a site license for. First, we talked to Dean Daigneault, Lab Manager for the ECE department for permission to use the space and equipment. He thought it was a great idea to display information from the solar panels. When he went looking for equipment, he was unable to find the touch screen. From this point, we scheduled a meeting with Sean O'Connor to attempt to track down the touch screen and computer. Mr. O'Connor explained that the touch screen was property of the ECE department and he had no knowledge of its location.

Our group then decided that we would contribute our own money to purchase an 18" LCD touch screen monitor with an integrated computer. By buying our own monitor for the display, we would save the time needed to find funding and have it approved. At the same time it would allow us to get a monitor with the exact specifications needed for the display. We also obtained first approval from James O' Rourke, the ECE shop supervisor, to use the space in Atwater Kent.

Appendices N, O, P, Q give the details of our purchase of the 18" flat panel touch screen PC, as well as the specific features of the unit. The cost of 452.88 was equally shared by our four team members. Although we purchased this unit at the end of February and had already made arrangements with the ECE department to install the unit so that users could see the display and navigate through different pages that display the Solar Sun viewer software that allows the user to see the solar panel information. We encountered a setback. The inappropriate and insignificant packaging by which the unit was shipped through UPS to us, cause damage to the touch screen monitor. When we received the touch screen, it was not functional while the PC and all other components were in working order. Since then our group has contacted the seller and are receiving a replacement touch screen soon. As of the time we are required to complete our project, the replacement unit did not arrive and so the installation of the kiosk remains to be completed. Our group, however, has agreed to take this task beyond the time frame of this IQP project to ensure the final installation of the kiosk is completed.

4.7 Efforts on a Kiosk at the Ecotarium

Our project could have headed many directions, although our final product was the website. Significant work was also completed toward installing a kiosk installation at the Ecotarium. Even though there was no final product to show our effort, we hope that this work will aid the efforts of future teams.

The idea to install the kiosk at the Ecotarium was formed while our group contemplated ways in which to educate to a larger audience on our topic of renewable resources. We knew that just a stand-alone kiosk would not suffice for a full museum exhibit. Our ideas envisioned a three-fold display surrounding the kiosk to display educational material and information on how to use the information provided on the kiosk.

In terms of requirements, we found the need for both electricity and an internet connection to communicate with WPI. We visited the Ecotarium to inspect the possible location and availability of these requirements, and there were a few excellent locations to choose from. If time had permitted and funding was easily accessible we would have loved to accommodate this facility with the kiosk.

After our visit, we setup a meeting with Betsy Lauring, the director of exhibits. During this meeting, we discussed our ideas and she was very enthusiastic and willing to aid our efforts in any way. In the event that the display is fully funded by outside sources, she believed that there would be no issue in installing the fixture after the content was approved. There also would be no issue in having the WPI logo displayed for advertising purposes and supporting the WPI mission.

There is also research on purchasing kiosks outside of Heliotronics to reduce costs. The need for a virtual private network to communicate with WPI was also addressed and research was completed to prove the possibility of this working. We concluded our efforts on this idea through a feasibility analysis, which pointed in the direction of our website.

5 RECOMMENDATIONS

Recommendations to Our Project Advisors and Future Project Teams

"We recommend that an effort be made to enhance the website through further project effort."

We feel that future projects should read about our efforts and be given the option to continue work on our website. The areas that the future teams should be instructed to enhance is the content and graphics of the site. Content that would be designed should try to follow the pre-existing content. The future teams should also have the independence on creating graphics to portray the content in a friendly way for children in the 3rd through 5th grades.

"We recommend that an effort be made to possibly install a kiosk at the Ecotarium or other museum."

Although our team did not find setting up a kiosk at the Ecotarium feasible, other teams should continue from where we left off with them. If the team starts to work towards this project and plans to complete the project over three terms, the project could be completed.

"We recommend future work be done to promote the website."

To ensure the efforts from this IQP is not in vain, the website should be promoted within future projects. If there is a way to integrate the existing material or improve the site to be used in future projects. Promotion of the site can also be accomplished by seeking media coverage such as a news article. Future teams can also work on distribute information to various school systems in and out of the state.

"We recommend continuing communication with Martha Cyr."

In order for this project to be widely used, the future teams need to work closely with Martha Cyr. Martha Cyr has created a nationwide teacher resource website called www.teachenginerring.com, where educators can receive lesson plans for teaching engineering and science technology to young students. Along with Dr. Martha Cyr, we are interested to get out website onto her nationwide site to spread the importance of renewable energy.

Recommendations to WPI Network Operations

"We recommend an effort to aid the publishers of the www.teachengineering.com site in launching our website."

In order for our website to be published on the www.teachengineering.com website as anticipated it would first have to be approved by the owners and then launched from their servers. An effort would have to be made on their part to actually have this site launched. Even if the site is hosted by a WPI server, the link to the site would have to be set by the publishers of www.teachengineering.com and a page would have to be created to address the material covered and what curriculum and MCAS standards our website incorporates.

Recommendations to Martha Cyr

"We recommend an installation of our website on the www.solarengineering.com site."

Although the content is not as sufficient to be posted onto Martha Cyr's website teachengineering.com, as we originally planed, we feel that the information and design of the site will be beneficial for the teachers. We ask future project teams stress their efforts on making the content and future content adequate for the teachengineering.com website.

"We recommend an effort to boost the site's awareness."

We would like future groups to try to distribute and promote the interactive website and the teachengineering.com site to broaden the education of renewable energy among schools. A copy of the website should be kept on reference so that it can be distributed to any school or teacher that may request it. Future groups that promote the sites will be providing educators will good tools to teach students about the important energy conflicts for the future.

"We recommend that the MCAS standards be compared to national standards and that these standards be shown on our website."

The MCAS standards that are mentioned on the site should be cross-referenced with the national standards. These matched standards should be placed in a document and be on a reference page for the teachers to let them see what kind of lessons the website will teach their students. The matching of the MCAS standards to national standards will allow educators outside of Massachusetts to use this site.

6 REFERENCES

1. “A brief Explanation of PV”, Sunwise Technologies
   <http:/www.sunwize.com/baoutpv/swaboutpv.html>

2. "Annual Energy Outlook 2004 with Projections to 2025"Released: January 2004, Page last modified on Wed Sep 22 11:58:15 EDT 2004, Energy Information Administration: Department of Energy
   <http://www.eia.doe.gov/oiaf/aeo/electricity.html>

3. “Education Programs: Junior Solar Sprint”
   <http://www.nrel.gov/education/student/natjss.html>

4. "Energy Consumption by Source", Energy Information Administration/Monthly Energy Review November 2004,Energy Information Administration: Department of Energy
   <http://www.eia.doe.gov/emeu/mer/pdf/pages/sec1_7.pdf>

5. “Experts: Childhood Asthma 'Epidemic' Among Inner-City Youths Seen in Absence of Steps to Curb Global Warming, Fossil Fuel Use”, 05/08/2004, Medical News Service
   <http://www.medicalnewsservice.com/fullstory.cfm?storyID=2257>

6. “Feasibility Study of a Solar Learning Lab™ at WPI”, Haitham Al-Beik & Joseph Chapman & Joseph Ledue & Jason Wailgum, Advisors: Richard F. Vaz & Kankana Mukherjee, , Interactive Qualifying Project: WORCESTER POLYTECHNIC INSTITUTE

7. “For Consumers”, ...", Solar Energy Technologies Program, U.S. Department of Energy
   <http://www.eere.energy.gov/solar/pv_consumers.html>

8. “Fossil Fuels Presentation”, Osman Chughtai and David Shannon, Earth and Society
   A GS265-1998 web-based project on the interaction between Earth Processes and Society, "How to Build a Habitable Planet"Geological Sciences 265 – 1998, University of Michigan
   <http://www.umich.edu/~gs265/society/fossilfuels.htm>

9. “Fuel Cell Installed At Park”, Dinosaur State Park
   <http://www.dinosaurstatepark.org/page6.html>

10. “Greenhouse gas emissions endanger the public's health today”, November 7, 1997, WRI news releases
    < http://climate.wri.org/newsrelease_text.cfm?NewsReleaseID=104>

11. “GreenUp renewable energy companies”, 2004 National Grid
    <http://www.nationalgridus.com/masselectric/home/energychoice/3_renewable.asp>
    <http://www.nationalgridus.com/non_html/shared_greenupoptions.pdf>

12. “Grid Connected PV… What's It Worth?”, James R. Udall, 1998

<http://www.aspencore.org/Solar/grid.htm>

13. "How Solar Cells Work", Scott Aldous, How Stuff Works,
< http://www.howstuffworks.com/solar-cell.htm>

14. "Implications of PV Manufacturing and Production", Solar Energy Technologies Program, U.S. Department of Energy
<http://www.eere.energy.gov/solar/man_pro_implications.html>

15. "Introduction to concentrating solar power", National Renewable Energy Laboratory
<http://www.nrel.gov/clean_energy/concentratingsolar.html>

16. "Introduction to passive solar heating and daylighting", National Renewable Energy Laboratory
<http://www.nrel.gov/clean_energy/passivesolar.html>

17. "Introduction to photovoltaic (solar cell) systems", National Renewable Energy Laboratory
<http://www.nrel.gov/clean_energy/photovoltaic.html>

18. "Introduction to solar process heat and space heating and cooling", National Renewable Energy Laboratory
<http://www.nrel.gov/clean_energy/solarprocessheat.html>

19. "Introduction to solar hot water", National Renewable Energy Laboratory
<http://www.nrel.gov/clean_energy/solarhotwater.html>

20. "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2001; Energy" April 15, 2003,U.S. Environmental Protection Agency,
<http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/LHOD5MJTKQ/$File/2003-final-inventory_ch2-energy.pdf>

21. Massachusetts Incentives for Renewable Energy, *08/06/2004* , The Database of State Incentives for Renewable Energy
<http://www.ies.ncsu.edu/dsire/library/includes/map.cfm?State=MA&CurrentPageId=1>

22. "Massachusetts Science and Technology/Engineering Curriculum Framework", May 2001, Massachusetts Department of Education
<http://www.doe.mass.edu/frameworks/scitech/2001/0501.pdf>

23. Plastics, Encarta Online
<http://encarta.msn.com/encyclopedia_761553604/Plastics.html>

24. "Protection Against Electricity Price Instability", American Wind Energy Association
<http://www.awea.org/greenpower/gp_why3.html>

25. "Renewable Energy > Biomass", NC GreenPower :: Types of Renewable Energy
<http://www.ncgreenpower.org/types/biomass.html>

26. “Renewable Energy Trends 2003 With Preliminary Data For 2003”, July 2004, Fred Mayes, Team Leader, Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels: U.S. Department of Energy
<http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/trends.pdf>

27. “Renewable Energy > Water”, NC GreenPower :: Types of Renewable Energy
<http://www.ncgreenpower.org/types/water.html>

28. “Renewable Energy > Wind”, NC GreenPower :: Types of Renewable Energy
<http://www.ncgreenpower.org/types/wind.html>

29. “Rising fossil-fuel costs boost renewable energy”, Terence Chea, Thursday, October 28, 2004, Associated Press
<http://deseretnews.com/dn/view/1,1249,595101295,00.html>

30. “SOLAR ENERGY AND PHOTOVOLTAICS EDUCATION IN WORCESTER”, Devin Brande & Michael LaBossiere & Sid Rupani & Ye Wang, April 26, 2004, Project Number: RXV SOL2, Advisors: Richard Vaz & Brian King, Interactive Qualifying Project: WORCESTER POLYTECHNIC INSTITUTE

31. “Solar Opportunity Assessment Report”, Joel Makower & Ron Pernick & Andrew Friendly, Clean Edge, 2003 Solar Catalyst Group
<http://www.cleanedge.com/reports-soar.php>

32. “Solar Roofing Systems”, United Solar
<http://www.hamcontact.com/unisolar/roof.html>

33. "So You Want to Put PV on Your Roof...", Solar Energy Technologies Program, U.S. Department of Energy
<http://www.eere.energy.gov/solar/want_pv.html>

34. “STATE-OF-THE-ART BUILDING INTEGRATED PHOTOVOLTAIC SYSTEM INTRODUCED IN ZERO ENERGY HOME”, Mike Keesee, November 20, 2003, Solar Advantage Home Program, Sacramento Municipal Utility District
<http://www.californiasolarcenter.org/pdfs/forum/2003.11.20-SolarForum_Keesee.pdf>

35. "TECHNOLOGY EDUCATION", Syllabus for teaching Technology Education (State developed), NYS Education Department
<http://www.emsc.nysed.gov/ciai/mst/pub/techedoutline.pdf>

36. "Technology, Manufacturing, and Market Trends in the U.S. and International Photovoltaics Industry", Peter Holihan, Page last modified on 10/09/2003 14:38:28, Energy Information Administration: Department of Energy
<http://www.eia.doe.gov/cneaf/solar.renewables/rea_issues/solar.html>

37. “The Hidden Cost of Fossil Fuels”, Page Last Revised: 10.29.2002, Union of Concerned Scientists
<http://www.ucsusa.org/clean_energy/health_and_environment/page.cfm?pageID=88>

38. "The Need for Finance and Fiscal Incentives", staff of the IEA Clean Coal Centre, The International Energy Agency's Working Party on Fossil Fuels <http://www.iea.org/dbtw-wpd/textbase/papers/2003/Finance_Fossil_Fuels.pdf>

39. "Typical RV System with 1500 watt inverter", Northern Arizona Wind & Sun, 02/11/2004 <http://www.solar-electric.com/noname.html>

40. "What Is Geothermal Energy?" <http://lsa.colorado.edu/essence/texts/geothermal.htm>

7. APPENDICES

APPENDIX A – List of Important Contacts

Arner, Matt
Heliotronics Business Development
Email: marner@heliotronics.com
Telephone: 617-730-5436

Buckley, Joe
Science Curriculum Liaison for Worcester Public Schools
Email: buckleyjw@worc.k12.ma.us
Worcester Public Schools
Main Building
20 Irving Street
Downtown Worcester
Telephone: 508-799-3205

Cardin, Jane
Technology and curriculum director
Columbus Park Elementary School
Worcester Public Schools
Telephone: 508-799-3490

Dr. Cyr, Martha
Director of K-12 Outreach at WPI
Email: mcyr@wpi.edu
Higgins House
Telephone: 508-831-6709

Daigneault, Dean
Lab Manager at Atwater Kent
Email: deand@ece.wpi.edu
Office: AK111a
Telephone: 508-831-5341

Juisto, Scott
Assistant Professor
IGSD building
Email: sjiusto@WPI.EDU
Telephone: 508-831-5393

Loring, Betsy
Manager of Ecotarium Museum Exhibits
Email: bloring@ecotarium.org
222 Harrington Way
Worcester, MA 01604
Telephone: 508-929-2700

Mukherjee, Kankana
Assistant Professor
Management Department
Office: Washburn Shops 305
Email: kmukher@WPI.EDU
Telephone: 508-831-5192

O'Connor, Sean
Manager of Network Operations at WPI
Email: soconnor@wpi.edu
Office: Morgan, Network Operations
Telephone: 508-831-5115

Salter, Chris
Manager of Technical Trades at WPI
Email: csalter@wpi.edu
Office: Daniels Hall 012
Telephone: 508-831-6060

APPENDIX B – Interview 1 with Martha Cyr

ATTENDANCE
Interview Date: 10th December, 2004
Interviewee(s): Dr. Martha Cyr, Director, K-12 Outreach
Interviewer(s): Jason Sargent, Gregory Panagiotou, Larry Nelson

We wanted Dr. Martha Cyr's opinions on our ideas for the kiosk at WPI, the kiosk at the Ecotarium, or the possibility of laptops. After explaining each of the ideas, she explained how these ideas were not the correct direction to go because not enough people would see and make use of the kiosks. Her suggestion was to target a specific age group. She felt that 3^{rd} through 5^{th} grade was a good target because the students stay in one classroom at that age. She wanted us to make sure to show the teachers which standards in the frameworks we are covering. We brainstormed creating content and activities for a site that Dr. Cyr has been working on. The site is named Teach Engineering and it hosts activities from many different sources for grades K-12. If we were to create solar activities with worksheets, lesson plans and videos that had engineering within them, we could have our information posted on the site.

One of the biggest keys to this site was defining what MCAS standards we were covering. Dr. Cyr said the lesson plans should be designed to be done in short but interactive stages. Another important thing she said we needed to consider when designing content was to ensure it would interest girls and minorities so we would be gender neutral and politically correct. She wanted to meet with us again once we had furthered our efforts on the project so she could ensure the content was high enough quality for schools to use.

APPENDIX C – Interview 2 with Martha Cyr

ATTENDANCE
Interview Date: 8th February, 2005
Interviewee(s): Martha Cyr, Director, K-12 Outreach
Interviewer(s): Michael Conrad, Larry Nelson

The purpose of this meeting was to discuss the progress our team has been making on the website. We explained to Martha Cyr our layout for the interactive site and some of the content planned for the site such as the video tour of the WPI solar array. She thought the videos and a walk through a day in the life of a child was a good idea. Then we went on to explain how we intended to match our work to MCAS standards, which were posted on the Mass Education website. When we showed Dr Cyr the specific 3rd and 5th grade standards we intended to address she became enthusiastic. She noted that in upcoming years, 3rd grade students would be tested heavily in math and there was little material that the teacher could draw upon. She felt the layout of our site would benefit teachers because of the ability to find which standards each activity applied to. She also felt our site should allow future project groups to develop very detailed lesson plans and content that could be added to the site with little work. At the end of the meeting, she requested to see the final product to ensure our content was at an appropriate level for the grade levels we are targeting.

APPENDIX D – Interview with Joe Buckley

ATTENDANCE
Interview Date: 10th December, 2004
Interviewee(s): Joseph Buckley
Interviewer(s): Jason Sargent, Gregory Panagiotou, Larry Nelson

The purpose of this meeting was to discuss the content and design of the website along with seeking approval for use in the Worcester school system. Mr. Buckley was enthusiastic about the age group we were targeting because from his experience, there is little being done to teach the students in 3rd through 5th grade about the physical sciences and the topic of energy. He thought it was a good idea to work with the Columbus Park School when designing the website and content because of the school's diverse population and teaching style. Mr. Buckley requested to see our finished product so he could make suggestions. He would show it to his colleagues who currently work with elementary school children.

APPENDIX E – Interview with Sean O'Connor

ATTENDANCE
Interview Date: 10th December, 2004
Interviewee(s): Sean O'Connor
Interviewer(s): Jason Sargent, Gregory Panagiotou, Larry Nelson

We scheduled a meeting with Sean O'Connor to attempt to track down the touch-screen monitor from the old ECE department kiosk. Mr. O'Connor explained that the touch screen was property of the ECE department and he had no knowledge of its location. However, he did say he could get us a computer that could support the SunViewer software. The computer would be a Pentium II, an acceptable machine to run the software. When we mentioned that we were looking into purchasing our own touch screen, he said it was a good idea if we could find one for around three hundred dollars. An attempt to show our progress and idea on the website was made by our group, but a meeting time was never established.

APPENDIX F – Interview with Ecotarium

ATTENDANCE
Interview Date: 10th December, 2004
Interviewee(s): Betsy Loring
Interviewer(s): Michael Conrad, Gregory Panagiotou

During this meeting, we discussed the possibility of providing a kiosk to view the SunViewer through outside funding for the Ecotarium. Betsy Loring approved of the idea but brought to our attention that it would have to pass through the board of directors, and this process could take a significant amount of time. She was very enthusiastic because to date there are no exhibits that shows the issues of pollution, benefits of renewable energy, or anything else on this subject.

The Ecotarium has a gas generator that provides the electricity for the entire campus, and though they make efforts to promote energy conservation, there is nothing to show their efforts. Mrs. Loring assured our group that there are plenty of locations where our exhibit could fit, and that they have the proper connections to run the system. A requirement would be to match the display to those currently in place to keep a consistent appearance throughout.

APPENDIX G – Interview with Columbus Park

ATTENDANCE
Interview Date: 10th December, 2004
Interviewee(s): Jane Cardin, Donna Sargent,
Interviewer(s): Jason Sargent, Michael Conrad

In order to complete our requirement for peer and expert approval, we needed to go to a potential final user; a Worcester Public School, where this interactive website and lesson plans would be used. We made contact with the secretary, who is the mother of one of the group members. She put us in contact with Mrs. Jane Cardin, who is the curriculum coordinator of Columbus Park School and the principal Delores Gribowski. We were able to sit down with them and talk about our project. We spoke to them about what we were trying to accomplish with the interactive website and the importance of educating the students about renewable energy like solar energy.

The administration for the school thought the idea was a good step forward to spread the knowledge of renewable energies for the future of the world. The administration asked to become a part of the project by reviewing the content and giving advice as we design the website. They let us interview some children and get a feel for what they knew about energy and the different kinds of ways the world can consume energy. They also provided us with textbooks and copies of a previous MCAS tests.

APPENDIX H – Meeting with ECE Lab Manager

ATTENDANCE
Interview Date: 10th February, 2005
Interviewee(s): Dean Daigneault
Interviewer(s): Michael Conrad, Gregory Panagiotou, Larry Nelson

We met with Mr. Daigneault to propose our idea of using the old ECE kiosk which had been put into storage. He thought it was a great idea to use the space to display data from the solar panels on Morgan hall. After we talked with him, he went looking for the computer used for the kiosk. He was able to find the computer, but he did not find the touch screen in any of the storage locations. An effort to look into who had possession of the kiosk and whether we would be allowed to use it was made.

APPENDIX I – Affordable Kiosk Quote

AffordableKiosks
Our kiosks are public proof!

430 West First Street
Tempe, AZ 85281

1(877) KIOSKS-1
www.affordablekiosks.com

Kiosk Quotation

Date	Quote #
11/16/2004	50639

Name / Address
Larry Nelson Jr

Terms	Rep	Lead Time
100% on order	ZB	4-6 Weeks

Item	Description	Qty	Rate	Total
SK070-15	Slabb 7 Floor Standing Kiosk: indoor design, full metal enclosure (16 Gauge Steel), 15" LCD Monitor (1024 X 768 Max Res), Internal Powered Speakers, Internal Cooling Fan(s), Internal Power Strip, Doors/Locks/Keys, Pallet/Shipping Box, FCC/UL/ADA Compliant, Powdercoat Finish, Slabb 1 year warranty, No PC	1	2,495.00	2,495.00
TS500	Slabb 15" Resistive Touchscreen Overlay	1	355.00	355.00
PC510	Slabb Basic Kiosk PC: Dell Optiplex GX270 (small form factor case): 2.4 GHz Celeron, 400 GHz front side bus, 128K onboard cache, 256MB RAM, 40GB HD, 24X Slim CDROM, No Floppy, Onboard 16 bit Sound AC '97 Audio, Intel Xtreme Graphics with 64 MB shared memory, 10/100 Ethernet, 1 serial, 8 USB 2.0, Mic, Stereo In, Stereo Out, 1 parallel, 2 PS/2, 1 PCI, 1 AGP expansion slots, Windows XP Home, 3 year next day parts and labor on site warranty	1	895.00	895.00
Optn X500	USB To DBP Adapter	1	55.00	55.00
Shipping & Handling	Estimated Freight, Subject to Change	1	225.00	225.00
	Total			$4,025.00

Quote valid for 30 days only, and is subject to change without notice.

APPENDIX J – Affordable Kiosk Brochure

AffordableKiosks

Our kiosks are public proof!

One of the most popular selling kiosks, the Slabb 7 has a very small form factor and a minimalist design. Many finishing options are available for this unit included a beveled aluminum front face plate.

applications

- Information Kiosk
- Public Internet Kiosk
- E-commerce Kiosk
- Human Resource Kiosk
- Bill Payment Kiosk
- Gaming Kiosk
- Trade Show Kiosk

standard kiosk features

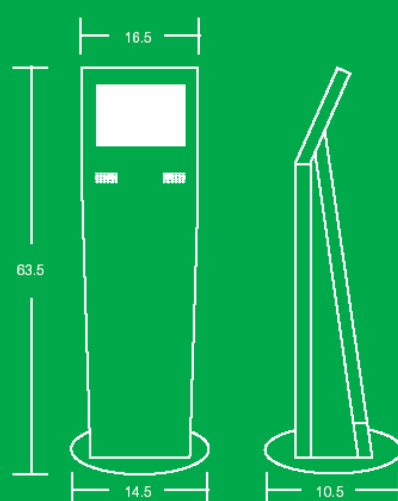
- Floor Standing Kiosk
- indoor design
- full metal enclosure (16 Gauge Steel)
- 15" LCD Monitor (1024 X 768 Max Res)
- Internal Powered Speakers
- Internal Cooling Fan(s)
- Internal Power Strip
- Doors/Locks/Keys
- Pallet/Shipping Box
- FCC/UL/ADA Compliant
- Powdercoat Finish in your choice of colors
- 110 lbs. / 61kg
- 110V or 220V power
- Slabb 1 year warranty

optional kiosk features

- Slabb 15Ó SAW Touchscreen Overlay
- Slabb 15Ó Resistive Touchscreen Overlay
- Slabb Vandal Resistant Trackball and Keyboard (ABS Keys and Trackball)
- Slabb Bar Code Scanner (1D/2D, USB)
- Slabb 17Ó SAW Touchscreen Overlay
- Slabb 17Ó Resistive Touchscreen Overlay
- Slabb Telephone Auto-Dialer
- Slabb Ruggedized Telephone Handset (RJ40/Phonejack)
- Slabb Ruggedized Telephone Handset (Sound Card)
- Slabb Kiosk Maintenance Contract: 4 business hour on-site repair, AK-provided replacement parts (US Only)
- Slabb Kiosk Maintenance Contract: Next business day on-site repair, AK-provided replacement parts (US Only)
- Slabb Kiosk Travel Case: Steel Reinforced Hardened Plastic, Heavy Duty Casters, Custom Foam Inlay
- Slabb Insert Magnetic Card Reader (Serial/RS232)
- Slabb Hybrid Smart Card/Credit Card Reader (Serial/RS232)
- Slabb 80mm Thermal Receipt Printer
- 3 Year Extended Warranty for 80mm or 112mm Thermal Printer
- Slabb Basic Kiosk PC

Don't see what you need? Ask one of our kiosk consultants. We'll work with you to create the perfect solution for your application.

slabb 7



APPENDIX K – MCAS Standards and Links

MCAS Standards

Standard

Paragraph on how the site meets this standard

Link to worksheets applying to standard if available

Link to page described in paragraph

Link to resource page

activity links:

http://www.fsec.ucf.edu/ed/SM/ch5-pv/anglesmeter_teacher.htm
http://www.fsec.ucf.edu/ed/SM/ch5-pv/anglesmeter_student.htm

http://www.eeexchange.org/solar/frameset.htm
http://www.eeexchange.org/solar/activities.html

http://www.fsec.ucf.edu/Ed/AFM/activity2.htm

http://www.nrel.gov/education/energized.html
http://www.nrel.gov/education/pdfs/limits_energized.pdf

3.D.3
3.D.2

3.M.1
3.M.4

3.M.1 Demonstrate an understanding of the attributes length, area, and weight, and select the appropriate type of unit for measuring each attribute using both the U.S. Customary (English) and metric systems.

3.M.2 Carry out simple unit conversions within a system of measurement, e.g., hours to minutes, cents to dollars, yards to feet or inches, etc.
This standard is intentionally the same as standard 4.M.2.

3.M.4 Estimate and find area and perimeter of a rectangle, using diagrams and grids, or by measuring.length, area, weight, temperature, and time.

3.D.1 Collect and organize data using observations, measurements, surveys, or experiments, and identify appropriate ways to display the data.
This standard is intentionally the same as standard 4.D.1.

http://www.fsec.ucf.edu/ed/SM/ch5-pv/anglesmeter_teacher.htm

3.D.2 Match representations of a data set in the forms of tables, line plots, pictographs, tallies, or bar graphs with the actual data set.

3.D.3 Construct and draw conclusions from representations of data sets in the forms of tables, line plots, pictographs, tallies, and bar graphs.

http://www.fsec.ucf.edu/ed/SM/ch5-pv/anglesmeter_teacher.htm

5.G.1 Identify, describe, and compare special types of triangles (isosceles, equilateral, right) and quadrilaterals (square, rectangle, parallelogram, rhombus, trapezoid), e.g., recognize that all equilateral triangles are isosceles, but not all isosceles triangles are equilateral.

5.M.1 Apply the concepts of perimeter and area to the solution of problems involving triangles and rectangles. Apply formulas where appropriate.

5.M.2 Identify, measure, describe, classify, and draw various angles. Draw triangles given two sides and the angle between them, or given two angles and the side between them, e.g., draw a triangle with one right angle and two sides congruent.

http://www.fsec.ucf.edu/ed/SM/ch5-pv/anglesmeter_teacher.htm

5.D.1 Given a set of data, find the median, mean, mode, maximum, minimum, and range, and apply to solutions of problems.

http://www.fsec.ucf.edu/ed/SM/ch5-pv/anglesmeter_teacher.htm

5.D.2 Construct and interpret line plots, line graphs, and bar graphs. Interpret and label circle graphs.

http://www.fsec.ucf.edu/ed/SM/ch5-pv/anglesmeter_teacher.htm

Skills of Inquiry

Recognize simple patterns in data and use data to create a reasonable explanation for the results of an investigation or experiment.

http://www.fsec.ucf.edu/ed/SM/ch5-pv/anglesmeter_teacher.htm

- Record data and communicate findings to others using graphs, charts, maps, models, and oral and written reports.

Physical Sciences

- Identify the basic forms of energy (light, sound, heat, electrical, and magnetic). Recognize that energy is the ability to cause motion or create change.

  http://www.fsec.ucf.edu/Ed/AFM/activity2.htm

  http://www.nrel.gov/education/pdfs/limits_energized.pdf

- Recognize that electricity in circuits requires a complete loop through which an electrical current can pass, and that electricity can produce light, heat, and sound.
- Identify and classify objects and materials that conduct electricity and objects and materials that are insulators of electricity.

Technology/Engineering

- Describe different ways in which a problem can be represented, e.g., sketches, diagrams, graphic organizers, and lists.

APPENDIX L – MCAS Standards and Curriculum to be Used

Mathematics MCAS Curriculum

Number Sense and Operations

Grade or Grade Span	Learning Standard *(grade-level standards are indicated by shading)*
1-2	Name and write (in numerals) whole numbers to 1000, identify the place values of the digits, and order the numbers.
3	Exhibit an understanding of the values of the digits in the base ten number system by reading, modeling, writing, comparing, and ordering whole numbers through 9,999.
3-4	Exhibit an understanding of the base ten number system by reading, modeling, writing, and interpreting whole numbers to at least 100,000; demonstrating an understanding of the values of the digits; and comparing and ordering the numbers.
5	Demonstrate an understanding of place value through millions and thousandths.
5-6	Demonstrate an understanding of place value to billions and thousandths.

Grade 3 Standards

MEASUREMENT STRAND

Students engage in problem solving, communicating, reasoning, connecting, and representing as they:

3.M.1 Demonstrate an understanding of the attributes length, area, and weight, and select the appropriate type of unit for measuring each attribute using both the U.S. Customary (English) and metric systems.

3.M.2 Carry out simple unit conversions within a system of measurement, e.g., hours to minutes, cents to dollars, yards to feet or inches, etc.
This standard is intentionally the same as standard 4.M.2.

3.M.3 Identify time to the minute on analog and digital clocks using a.m. and p.m. Compute elapsed time, using a clock for times less than one hour (i.e., minutes since), and using a calendar (e.g., days since).

3.M.4 Estimate and find area and perimeter of a rectangle, using diagrams and grids, or by measuring.

3.M.5 Identify and use appropriate metric and U.S. Customary (English) units and tools (e.g., ruler, scale, thermometer, clock) to estimate, measure, and solve problems involving length, area, weight, temperature, and time.

DATA ANALYSIS, STATISTICS, AND PROBABILITY STRAND

Students engage in problem solving, communicating, reasoning, connecting, and representing as they:

3.D.1 Collect and organize data using observations, measurements, surveys, or experiments, and identify appropriate ways to display the data.
This standard is intentionally the same as standard 4.D.1.

3.D.2 Match representations of a data set in the forms of tables, line plots, pictographs, tallies, or bar graphs with the actual data set.

3.D.3 Construct and draw conclusions from representations of data sets in the forms of tables, line plots, pictographs, tallies, and bar graphs.

3.D.4 List and count the number of possible combinations of objects from two sets, e.g., how many different outfits can one make from a set of two sweaters and a set of three skirts?

Grade 5 Standards

GEOMETRY STRAND

Students engage in problem solving, communicating, reasoning, connecting, and representing as they:

5.G.1 Identify, describe, and compare special types of triangles (isosceles, equilateral, right) and quadrilaterals (square, rectangle, parallelogram, rhombus, trapezoid), e.g., recognize that all equilateral triangles are isosceles, but not all isosceles triangles are equilateral.

5.G.2 Identify, describe, and compare special types of three-dimensional shapes (cubes, prisms, spheres, pyramids) based on their properties, such as edges and faces.

5.G.3 Identify relationships among points and lines, e.g., intersecting, parallel, perpendicular.

5.G.4 Using ordered pairs of whole numbers (including zero), graph, locate, and identify points, and describe paths on the Cartesian coordinate plane.

5.G.5 Describe and perform transformations on two-dimensional shapes, e.g., translations, rotations, and reflections.

5.G.6 Identify and describe line symmetry in two-dimensional shapes, including shapes that have multiple lines of symmetry.

5.G.7 Determine if two triangles or two quadrilaterals are congruent by measuring sides or a combination of sides and angles, as necessary; or by motions or series of motions, e.g., translations, rotations, and reflections.

MEASUREMENT STRAND

Students engage in problem solving, communicating, reasoning, connecting, and representing as they:

5.M.1 Apply the concepts of perimeter and area to the solution of problems involving triangles and rectangles. Apply formulas where appropriate.

5.M.2 Identify, measure, describe, classify, and draw various angles. Draw triangles given two sides and the angle between them, or given two angles and the side between them, e.g., draw a triangle with one right angle and two sides congruent.

5.M.3 Solve problems involving simple unit conversions within a system of measurement.

5.M.4 Find volumes and surface areas of rectangular prisms.
This standard is intentionally the same as standard 6.M.6.

5.M.5 Find the sum of the measures of the interior angles in triangles by measuring the angles, and without measuring the angles.

DATA ANALYSIS, STATISTICS, AND PROBABILITY STRAND

Students engage in problem solving, communicating, reasoning, connecting, and representing as they:

5.D.1 Given a set of data, find the median, mean, mode, maximum, minimum, and range, and apply to solutions of problems.

5.D.2 Construct and interpret line plots, line graphs, and bar graphs. Interpret and label circle graphs.

5.D.3 Predict the probability of outcomes of simple experiments (e.g., tossing a coin, rolling a number cube) and test the predictions.

Science/Technology MCAS Curriculum

Inquiry and Experimentation

Skills of Inquiry

Grades 3-5

- Ask questions and make predictions that can be tested.
- Select and use appropriate tools and technology (e.g., calculators, computers, balances, scales, meter sticks, graduated cylinders) in order to extend observations.
- Keep accurate records while conducting simple investigations or experiments.
- Conduct multiple trials to test a prediction. Compare the result of an investigation or experiment with the prediction.
- Recognize simple patterns in data and use data to create a reasonable explanation for the results of an investigation or experiment.
- Record data and communicate findings to others using graphs, charts, maps, models, and oral and written reports.

Physical Sciences

- Differentiate between properties of objects (e.g., size, shape, weight) and properties of materials (e.g., color, texture, hardness).
- Compare and contrast solids, liquids, and gases based on the basic properties of each of these states of matter.
- Describe how water can be changed from one state to another by adding or taking away heat.

- Identify the basic forms of energy (light, sound, heat, electrical, and magnetic). Recognize that energy is the ability to cause motion or create change.
- Give examples of how energy can be transferred from one form to another.
- Recognize that electricity in circuits requires a complete loop through which an electrical current can pass, and that electricity can produce light, heat, and sound.
- Identify and classify objects and materials that conduct electricity and objects and materials that are insulators of electricity.
- Explain how electromagnets can be made, and give examples of how they can be used.
- Recognize that magnets have poles that repel and attract each other.
- Identify and classify objects and materials that a magnet will attract and objects and materials that a magnet will not attract.

Technology/Engineering

- Identify materials used to accomplish a design task based on a specific property, i.e. weight, strength, hardness, and flexibility.
- Identify and explain the appropriate materials and tools (e.g., hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) to construct a given prototype safely.
- Identify and explain the difference between simple and complex machines, e.g., hand can opener that includes multiple gears, wheel, wedge gear, and lever.
- Identify a problem that reflects the need for shelter, storage, or convenience.
- Describe different ways in which a problem can be represented, e.g., sketches, diagrams, graphic organizers, and lists.
- Identify relevant design features (e.g., size, shape, weight) for building a prototype of a solution to a given problem.
- Compare natural systems with mechanical systems that are designed to serve similar purposes, e.g., a bird's wings as compared to an airplane's wings.

Selected Websites for Science and Technology/Engineering Education

Website	URL
General Science and Technology/Engineering Resources	
Center for Improved Engineering & Science Education	www.k12science.org/
Curriculum Library Alignment and Sharing Project (CLASP)	www.massnetworks.org/clasp/clasp.html
Eisenhower National Clearinghouse for Mathematics and Science Education	www.enc.org
Flinn Scientific	flinnsci.com
Laboratory Safety Institute	labsafety.org
Massachusetts Department of Education	www.doe.mass.edu
PALMS Initiative	www.doe.mass.edu/palms
Science and Technology/Engineering Curriculum Framework	www.doe.mass.edu/frameworks/current.html
Massachusetts Comprehensive Assessment System (MCAS)	www.doe.mass.edu/mcas/
Mathematics Curriculum Framework	www.doe.mass.edu/frameworks/current.html
NASA Classroom of the Future	www.cotf.edu/
NASAexplores (lessons and articles based on current research and developments)	www.nasaexplores.com/cgi-bin/index.pl
National Science and Technology Week	www.nsf.gov/od/lpa/nstw/start.htm
National Science Education Standards: An Overview	www.nap.edu/readingroom/books/nses/html/overview.html
National Science Foundation	www.nsf.gov
National Science Teachers Association's Scope, Sequence and Coordination Project	www.gsh.org/nsta_ssandc/
Public Broadcasting System's (PBS) TeacherSource database	www.pbs.org/teachersource/
Science & Safety: Making the Connection	sargentwelch.com/html/pdfs/ScienceandSafety.pdf
Science and technology news and discussion	www.bottomquark.com/
TERC (mathematics, science, and technology/engineering curriculum programs)	www.terc.edu
The Futures Channel	www.thefutureschannel.com/home.htm
The Jason Project	www.jasonproject.org
Third International Mathematics and	www.ustimss.msu.edu

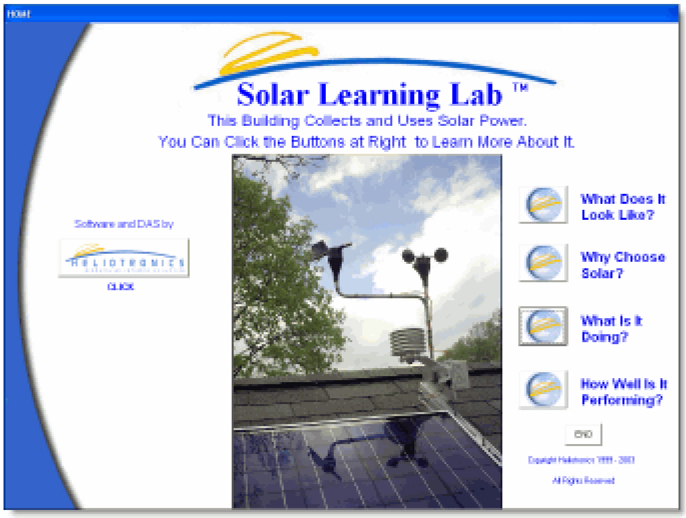
Science Study (TIMSS)	
World Book online database	www.school.discovery.com/homeworkhelp/worldbook/atozscience/
Earth and Space Science	
Aeronautics and space resource for education	www.spacelink.nasa.gov/
Christa Corrigan McAuliffe Center for Education and Teaching Excellence	www.christa.org
Incredible Journey/Project WET	www.montana.edu/wwwwet/journey.html
Learning Adventures in Environmental Science	www.umn.edu/bellmuse/mnideals/belllive.html
Science and Technology-Consortium for International Earth Science Information Network	www.ciesin.org/
Up-to-the-minute images and news flashes of NASA's planned mission to Mars	www.mars.jpl.nasa.gov/2001/
Life Science	
A guide to biology and chemistry educational resources on the web	www.biochemlinks.com/bclinks/bclinks.cfm

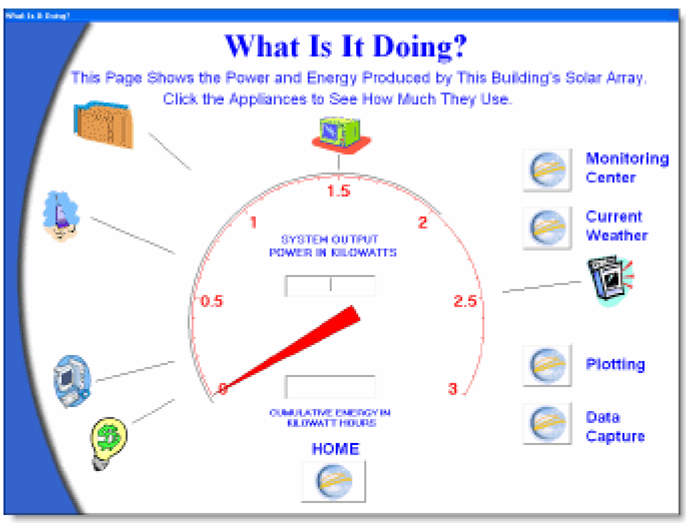
Website	URL
Food Science and Technology	www.foodscience.unsw.edu.au/
Resources for Food Science	www.members.tripod.com/~kburge/HomeEc/foodscience.html
U. S. Food and Drug Administration Center for Food Safety and Applied Nutrition	www.vm.cfsan.fda.gov/~dms/educate.html#educators
Physical Science	
Amusement park physics	www.learner.org/exhibits/parkphysics/
Technology/Engineering	
Design It! Engineering in After School Programs	www.edc.org/CSE/projects/destech.html
Discover Engineering	www.discoverengineering.org
Education Development Center, Inc. (science and technology/engineering projects)	www.edc.org
FIRST (For Inspiration and Recognition of Science & Technology) Robotics Competition	www.usfirst.org
FIRST Lego League (integrates robotics technology into the LEGO building system)	www.legomindstorms.com/first/
How Stuff Works	www.howstuffworks.com
International Technology Education Association	www.iteawww.org
Internet Science Technology Fair	www.istf.ucf.edu/
Journal of Technology Education	www.vega.lib.vt.edu/ejournals/JTE/jte.html
Junior Engineering Technical Society	www.jets.org
Massachusetts Institute of Technology's *Technology Review*	www.techreview.com
Massachusetts Pre-Engineering Program	www.masspepinc.org
National Engineers Week Future City Competition	www.futurecity.org
PBS's Building Big series	www.pbs.org/wgbh/buildingbig/
Preview of The New York State Department of Education's 8th Grade Technology Assessment	www.emsc.nysed.gov/ciai/mst/techedtest/online.html
Project Lead the Way	www.pltw.org
Tech Directions Online	www.techdirections.com
Technological Horizons in Education	www.techweb.com
Technological Literacy Assessment	www.sasked.gov.sk.ca/k/p_e/eval/tl_overview/
Technology Student Association	www.tsawww.org
TechWeb	www.techweb.com

Texas Elementary Technology Education Lesson Plans	www.texastechnology.com
The Great Technology Adventure: Technology Literacy for Elementary School Children	www.tsaweb.org/competition/adventure.htm#Introduction
United States Department of Transportation	www.education.dot.gov

APPENDIX M – Solar Learning Lab

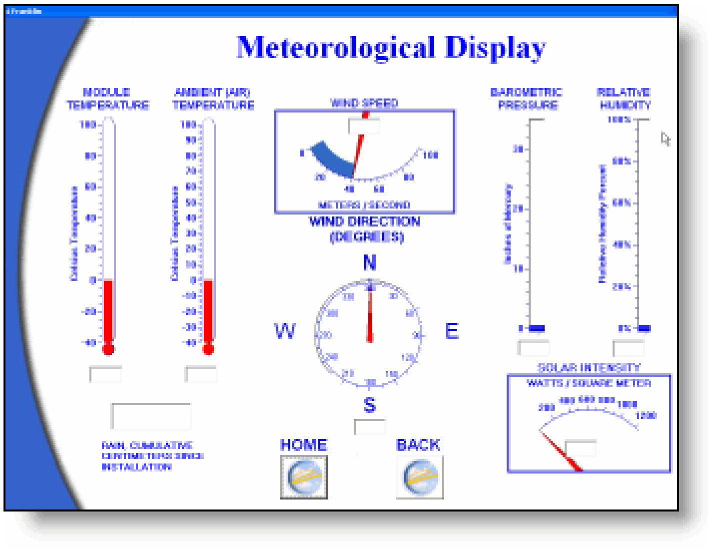
SunViewer™ 5.0 Display Software





***SunViewer™ 5.0* Software** - *SunViewer*™ display software is the most visible part of the *Epiphany*™ series data acquisition system. This is the software that displays the performance of the photovoltaic (PV) array and describes the different parts of the PV array. Our software is rich in graphical and technical content enabling students to move from simple to detailed displays. Multiple seats of the *SunViewer*™ display software can be bought to allow students to view it on multiple LAN connected computers located throughout a school.

***SunServer*™ Software** - *SunServer*™ software is the heart of Heliotronics EpiphanyTM series display software. It retrieves the data from the Sunlogger data logger, over a dedicated serial connection. It sends the data, in real time, to all open *SunViewer*™ displays on the local area network (LAN). It also averages the data over 15 minute intervals and places it in an ACCESS compatible database. *SunServer*™ can easily be configured to upload the 15 minute average data to Heliotronics' remote server making it available on *SunViewer.net*™, Heliotronics' Internet based database and display service.


Meteorological Display
MODULE TEMPERATURE
AMBIENT (AIR) TEMPERATURE
WIND SPEED
METERS / SECOND
WIND DIRECTION (DEGREES)
N
W
E
S
BAROMETRIC PRESSURE
RELATIVE HUMIDITY
SOLAR INTENSITY
WATTS / SQUARE METER
RAIN, CUMULATIVE CENTIMETERS SINCE INSTALLATION
HOME
BACK

APPENDIX N – Comments on Website, Columbus Park School

WORCESTER PUBLIC SCHOOLS

COLUMBUS PARK PREPARATORY ACADEMY

DR. DOLORES M. GRIBOUSKI
PRINCIPAL

75 LOVELL STREET
WORCESTER, MASSACHUSETTS 01603-2514
(508) 799-3490 School Telephone
(508) 799-8213 Fax Telephone

April 19, 2005

Dear Solar IQP Team,

I have received your email informing us that the test website was up and running for review. I have reviewed it myself from a student's point of view and found it very knowledgeable and user friendly. I have also had a variety of students from our 3rd through 5th grades interact with the program, as well as the teachers, and have received great reviews. From the children's point of view the interactive journey is an excellent teacher in Solar and Renewable Energy. The journey fed the students with an abundant amount of information. The graphics also kept them interested through the program.

I had the teachers review the worksheets and the teacher section of the website. Some of the teachers have said that the information in the section was very useful to them, and they were able to utilize it with their lessons. Other teachers would have liked more information, or links to create a couple lessons using the material you provide. The 3rd grade teacher has told me she would like to see a couple more links within the journey, but she is aware your schedule constraints . Maybe a future group, as we discussed earlier could tackle this objective.

I would like to congratulate you in your efforts to outreach the knowledge of Renewable Energy to the community. I speak for Columbus Park Preparatory Academy when I say that we welcome any future groups into our school to teach renewable energy awareness to our teachers and students. Your team has been very professional and the quality of your website and work has shown your commitment and excellence in your studies at Worcester Polytechnic Institute. Thank you for choosing our school to review your on going project, we are honored.

Sincerely,

Jayne Cardin

Jayne Cardin,
Curriculum/Technology Facilitator

APPENDIX O – Kiosk Item Won Email Invoice

```
-----------------------------------------------------------------
Congratulations - You Are The Winning Buyer!
-----------------------------------------------------------------
Dear greg_p83,
you have committed to buy this eBay item from salesatbigkey. This
seller
prefers PayPal.

Click here to pay now and you can receive the item sooner:
https://payments.ebay.com/ws/eBayISAPI.dll?UnifiedCheckoutShippingDispa
tcher&item=5168698572&transactionid=0&quantity=1&level=1&editAddress=0&
newpurchaseok=0&ssPageName=ADME:B:EOAB:US:1

-----------------------------------------------------------------
LISTING DETAILS
-----------------------------------------------------------------
Item name:                             18 Inch Flat Panel Touch Screen
PC
Item number:                           5168698572
Seller:                                salesatbigkey (C Stark - Bonham,
TX United
States)
End date:                              Feb-25-05 13:06:12 PST
Buyer:                                 greg_p83
Buyer email:                           gregp@townisp.com

-----------------------------------------------------------------
PAYMENT DETAILS
-----------------------------------------------------------------
Sale price:                            US $399.00
Quantity:                              1
Subtotal:                              US $399.00

Shipping and handling:
http://payments.ebay.com/ws/eBayISAPI.dll?EmitBuyerShippingCalculator&i
temId=5168698572
- Insurance per item:

Sales tax:                            8.250% in TX
```

Ship-to zip code: 01545*

APPENDIX P – Kiosk Seller Confirmation Email

You are the winning buyer for the item(s) below. Thank you for your business!

Item title: 18 Inch Flat Panel Touch Screen PC
Web Address:
http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&item=5168698572
Item number: 5168698572
Buyer User ID: greg_p83
Seller User ID: salesatbigkey

Your total is:
$399.00
$53.88 shipping/handling via UPS Ground

$452.88 = Total

We accept the following forms of payment:
Paypal, Western Union Auction Payments (www.auctionpayments.com)-formerly Bidpay,
money order, cashiers check, company check, or personal check (may be held 7 days
for clearance).

If you want to mail your payment, please send it and include a copy of this page to:
Bigkey
P.O. Box 800
Bonham, TX 75418

We will email you to confirm receipt of payment. Thank you again for your purchase!

Thank you,
Bigkey

APPENDIX Q – Kiosk Seller Payment Received Email

```
We hope you enjoy your purchase. Your payment has been received for the
following item:

Item title: 18 Inch Flat Panel Touch Screen PC
Web Address:
http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&item=5168698572
Item number: 5168698572
Buyer User ID: greg_p83
Seller User ID: salesatbigkey
Your total: $452.88

We will email you with shipping information once this ships. Thank you
very much.
Your business is much appreciated.
```

Bigkey

APPENDIX R – Kiosk Seller Shipping Confirmation Email

We have shipped the following item to you.

Item title: 18 Inch Flat Panel Touch Screen PC
Web Address:
http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&item=5168698572
Item number: 5168698572
Buyer User ID: greg_p83
Seller User ID: salesatbigkey
Total: $452.88

Shipped Via: UPS Ground
Tracking Number: 1Z87A82R0348498059

Once your item arrives in satisfactory condition, please leave feedback for us.

Thank you again!
Bigkey

APPENDIX S – Pictures of Purchased Kiosk

FRONT

LEFT SIDE

Right Side (All I/O, notice no drive bays)

APPENDIX T – Website

WEBSITE

Link at conclusion of project (posted 5/1/2005):

http://users.wpi.edu/~gregp/solar/