01C020I 01C020I

Project Number: 42-RWT-LON2

World Energy Use Virtual Exhibit

An Interactive Qualifying Project
Submitted to the Faculty of

Worcester Polytechnic Institute

In partial fulfillment of the requirements for the
Degree of Bachelor of Science

Submitted by:

James Partridge

Brian Pitreau

Zachary Swick

Alex Proshchitskiy

Sponsoring Agency: The National Museum of Science and Industry
On-Site Liaison: Sophie Duncan, Science Museum Content Co-Ordinator

Date: 26 February 2001

Approved:

Robert Thompson, Ph.D., Project Advisor

Laura Menides, Ph.D., Project Co-advisor

I. Abstract

The National Museum of Science and Industry in London sponsored this project to create a series of prototype exhibits on world energy use. The students researched world energy use, museum exhibit design, and interviewing techniques. Museum visitors were interviewed to determine their knowledge of energy use. This information was used to develop a prototype exhibit in the form of a web page. The prototype then underwent a process of revision and summative evaluation before being presented to the museum staff.

II. Executive Summary

The National Museum of Science and Industry is planning an energy gallery and commissioned this project to explore world energy use. The team created a prototype world energy use exhibit in the form of a web site. The site contains games, activities, and animations to excite and educate visitors, as well as a text version with somewhat more information on world energy use.

The team started their work in Worcester, Massachusetts researching many aspects of energy and exhibit design. The topics explored include museum exhibits, interview techniques, web design, human-computer interaction, Macromedia Flash, energy sources, and energy use. The team also conducted interviews with some museum experts while still in Worcester.

Once in London the first step for the team was to complete visitor awareness training at the museum. After training the team was ready to design a front-end interview protocol. The front-end evaluation was intended to show the team the level of knowledge of museum visitors as well as common misconceptions about world energy use. The evaluation consisted of nine questions dealing with energy, energy use in the U.K., and energy use around the world. Seventy-seven interviews were conducted containing a complete cross section of museum visitors.

The front-end evaluation provided the team not only with visitor perceptions and misconceptions about energy use; it led the team to make useful content decisions. For example, due to a high visitor interest in how energy use might change in the next 20 years, the team decided to develop an exhibit titled "An Energetic Future" that dealt with this issue. In this

game the visitor chose an energy source and predicted its future use. Similarly, questions in "Who Wants to be Top of the Class" were included to clarify some of the misconceptions found from the front-end evaluation. Also, "The Energy Size-O-Matic" included information dealing with the current U.K. energy situation, which was a main topic of the knowledge-based questions on the front-end questionnaire. The Energy Size-O-Matic changes the size of certain objects relative to their energy use. The "Fun-Facts" display focused on the future of energy use due to this topics high regard in the survey data.

The group created much of the site with Macromedia Flash, a web animation tool. The team made two games, "Who Wants to be Top of the Class?" and "Design Your Own Energy Efficient Country," and two activities, "The Energy Size-O-Matic" and "An Energetic Future." The activities were not as interactive as the games but still included animations and interactivity. Also using Flash, the team created an opening animation and main index area for the web site.

The virtual gallery itself, as the focus of the project, provides online visitors with an interactive, educational, and fun way to learn about world energy use. The visitors will benefit from the interactive style of the exhibits themselves. The team designed the exhibits to demonstrate energy use in the U.K., world energy use, the concept of energy, how energy is used in daily life, and the future of energy use. In essence, the overall purpose of the interactive exhibits was to both educate and interest the public on energy use issues.

The summative evaluation was effective in that the team was able to de-bug and improve both the main index navigation system and the interactives themselves. By testing the games and activities on museum visitors, the team found problems inherent with the way the exhibits were structured. This was accomplished by designing a small questionnaire to ask the visitors after they had used the site. We then prioritised these problems and discussed solutions to them. Finally, the team corrected these problems to improve the quality and usability of the exhibits.

The final product delivered to the museum staff consisted of five main parts: the virtual gallery, the background research, the front-end conclusions, the summative conclusions, and recommendations for further exhibit development. As requested, the entire virtual gallery was given to the museum staff on zip drive disks because of file size issues. The evaluation conclusions were included in the final report.

III. Acknowledgements

The team would like to thank many people for helping us with this project. We would like to thank our primary advisor Prof. Robert Thompson for all of his help, comments, and inspiration throughout our project. We would like to thank our co-advisor Prof. Laura Menides for her input on our proposal and final document. We would also like to thank Dr. Creighton Peet for all his input on the proposal for this project. The team would like to thank Ben Gammon, head of visitor research at the museum, for the huge amount of help he gave us with our visitor research and helping us throughout the interview process. We would like to thank Nicky Lewis and Ben Russell for helping us get to know the museum. The team would also like to thank our liaison, Ms. Sophie Duncan. Without Sophie, none of this would be possible. She gave us lots of help throughout the project; she always had intelligent criticism and made us laugh when we needed it. Thank you everyone.

IV. Table of Contents

V. List of Tables

VI. Authorship

Section	Author(s)	Editor(s)
I. Abstract	All	All
II. Executive Summary	ZS, JP	BP, AP
III. Acknowledgements	ZS	JP, BP
IV. Table of Contents	---	---
V. List of Tables	---	---
VI. Authorship	---	---
VII. Introduction	All	All
VIII. Background Research	---	---
Sections 1 to 1.2.8	AP	JP, BP
Sections 1.3 to 1.4.2	ZS	BP, AP
Sections 2 to 2.2	JP	ZS, BP
Sections 3 to 3.2.4	BP	JP, ZS
IX. Methodology	BP	JP, ZS
X. Results and Discussion	---	---
Section 1	JP	BP, ZS
Sections 1.1 to 1.5	BP	JP, AP
Section 1.6	JP	ZS, BP
Sections 2 to 2.2	ZS	JP, AP
Sections 2.2.1 to 2.2.3	BP	ZS, JP
Section 2.2.4	JP	AP, BP
Section 2.2.5	ZS	AP, BP
Section 2.3	AP	ZS, JP
Section 3	JP	BP, AP
XI. Conclusions	---	---
Sections 1 and 2	JP	BP, ZS
Section 3	ZS	BP, JP
Section 4	AP	BP, ZS
XII. Appendices	---	---
XIII. Bibliography	---	---

Final overall report edited by all team members

VII. Introduction

Energy powers every facet of our lives. There are countless sources of and uses for energy prevalent throughout the world. Energy exists everywhere, from the outer reaches of space to the subatomic level. It is used to heat homes, power cars, make dinner, and run the human body. As such a vast and encompassing concept, energy can often seem confusing to the general public.

The National Museum of Science and Industry in London hopes to create an exhibition on energy. Within this exhibition there will be many exhibits on different aspects of energy. The Museum staff plans to inspire the public to consider the importance of energy and energy use in their daily lives, as well as the global implications. The exhibition will explore the types of energy sources available in the past, the present, and the future in addition to the use of these sources by different cultures. The exhibit hopes to answer three main questions concerning global energy. These questions are: "Why is energy important?", "Where does energy come from?", and "Will we have enough for our needs?"

Our team has created a web-based prototype of the world energy use section of the proposed physical exhibition. We developed several interactive exhibits geared towards seven to fifteen year old children, as well as interactive virtual exhibits that will be useful for other interested visitors. We have created games and other interactive attractions that will serve to educate the audience in a manner that will be easily absorbed and retainable. In order to present the most interesting data in the best possible way, we interviewed a cross section of the audience and designed exhibits according to their interests and recommendations. The team learned and made use of the Macromedia Flash software package (a website development computer program that focuses on interactive displays) in order to create interesting animations for the website. The product of our work is an online exhibit that will give the online visitors a sense of this part of the museum as well as a useful source of information. This information on the website will be useful to people aged seven and up and will hopefully be useful for visitors of other ages as well.

Before creating the online exhibition, we developed methodologies for achieving our goals. We planned our time in London in order to conduct our project efficiently. The team learned Flash and HTML before arriving in London as well. We also designed an interview protocol to gather information from the Museum visitors on what energy information they already understood in addition to what they would like to learn. We also gathered the necessary information pertaining to the content of the exhibition, allowing us to spend our time in London developing the presentation of the information. Before finalising the project, the team evaluated and tested all aspects of the web-based exhibition, making any necessary improvements.

VIII. Background Information

1. Issues Concerning World Energy Use

1.1 Importance of Energy

Energy is one of the most important fundamental elements of the universe. Without energy there would be no life. Energy is used every day for countless purposes including sustaining the human body, which cannot function without it.

For many years humans relied only on their muscles to work (U.S. Department of Energy, 2000). Then, humans started discovering technologies that could ease everyday tasks and improves their quality of life including burning wood to provide warmth or using windmills to grind grain. Later, technologies further developed, and humans were able to build engines, use electricity, and, as a result, tremendously increase their ability to work.

1.2 Sources of Energy

1.2.1 Hydropower

Hydropower consists of a process that uses kinetic energy from moving water to generate electricity. A turbine and generator convert the energy of falling water to usable mechanical and electrical energy. According to the U.S. Department of Energy (July 1997), there are three ways to operate a hydropower project: run-of-river, peaking, or storage mode. However, many projects utilise more than one model. Run-of-river projects use the natural flow of the river to generate energy. Peaking projects hold and release water when energy is required, and finally storage projects hold and store water constantly in order to increase the amount of water available during the low-flow periods.

The main advantages of using hydropower as a source of electricity are absence of pollution, ability to respond quickly to large energy demands and low operating costs (U.S. Department of Energy, 2000). Some disadvantages may include the high initial costs of hydropower construction. Also the cumulative environmental effects such as altered flow of water, mortality of fish, or flooding of terrestrial ecosystems, which may result in displacement of populations, need to be considered. The complete environmental effects of hydropower are still not fully understood (U.S. Department of Energy, 2000).

Hydropower provides approximately 6 percent of the world's annual energy supply. As recently as 1993, hydropower is one of the major sources of electricity generation within Europe and the U.K. (O'Donnell & Johnston, 1993).

For the U.K, one of the first turbines was installed in Greenock, Scotland, in 1885 to provide public electricity supply (O'Donnell & Johnston, 1993, p. 107). The capacity of the turbine was 30 kW. Over the years large turbines with storage reservoirs have been built. However, in the 1990's due to increasing opposition of large-scale turbines the technology is mainly in the form of small installations of several hundred kilowatts.

1.2.2 Wind Power

Wind provides usable energy as a result of kinetic energy from streams of air produced by the earth's weather system. It can be converted to electrical or mechanical forms of energy (California Energy Commission, 2000).

Wind power has been utilised for approximately 3000 years. Until the 20th century, mechanical energy from wind had been used primarily to pump water or to grind grain. Interest in wind power re-emerged in the early 1970's after the first oil price shock, but this time the focus shifted from the traditional mechanical uses to electrical power generation (Ackermann & Lennart, 2000). The main advantages of using wind as energy source include limited use of land, good energy balance and no direct atmospheric emissions. Some disadvantages include noise emission, the impact on birds, erosion and visual impact on landscape (Andersen, 2000).

1.2.2.1 Mechanical Power Generation

Ackermann, & Lennart, (2000) state that the earliest recorded use of wind power to generate mechanical energy was in the seventh century BC. This early form consisted of vertical-axis windmills. Details about horizontal axis windmills first appeared in the documents from Persia, Tibet, and China, about 1000 AD. This type of windmill consisted of a horizontal shaft and blades that rotated on the vertical plane. Horizontal axis windmills spread from Asia across the Mediterranean into Europe. Windmill performance continued to improve in Europe throughout the centuries, and by the end of the 19th century, a typical windmill used a rotor and had stocks that reached up to 30 meters. The windmill further evolved after its introduction to the settlers in North America. These American windmills were automated and contained a mechanism that pointed the rotor to the direction of the wind during high-speed winds.

1.2.2.2 Electrical Power Generation

A Danish engineer Poul LaCour built the first wind turbine that generated electricity in 1891(Ackermann, & Lennart, 2000). Since then the technology has been greatly improved by Danish and American engineers and during World Wars I and II was used to overcome energy shortages. The pre-World War II Danish design consisted of an upwind rotor with stall regulation that operated at a slow speed. An American design was based on a downwind rotor that had variable pitch regulation (Ackermann, & Lennart, 2000). After World War II, the interest in wind turbines declined and only returned in the early 1970's with the oil crisis. Throughout the years the capacity of a standard wind turbine has increased from about 50 kW in the 1970's to about 200 kW by the end of 1980's. During the 1990's financial support for wind turbines decreased in the U.S. but increased in Europe and India. Currently, the capacity of a state-of-the-art turbine reaches 1.5 MW.

1.2.3 Solar Power

Solar energy is a type of renewable energy, which is obtained from heat and light emitted from the sun. In order to generate electricity or heat, solar power systems use cells or other types of solar collectors such as mirrors and lenses (California Energy Commission, 2000).

1.2.3.1 Power from light

One of the fastest growing solar energy technologies is photovoltaics (NREL, 1998). Photovoltaics devices are also known as solar cells. Solar cells use semiconductor material to convert sunlight directly into electricity. When sunlight hits the semiconductor material of the solar cells, it creates electric current, and power is produced. Photovoltaic systems are cost-competitive source of electricity when there is a high cost of connecting to a power grid. Also, powering machinery with high energy requirements increases costs and might not be practical.

1.2.3.2 Power from heat

Concentrating solar power systems use heat from the sun to generate electricity (NREL, 1998). Concentrating solar collectors use optical devices such as mirrors and lenses to focus sunlight onto a receiver, which is mounted at the system's focal point. The receiver converts sunlight into heat, which is then transported to an engine and converted to electricity. The three main types of concentrating solar power systems include parabolic troughs, dish/engine systems and central receiver systems.

Solar power technologies provide a clean and renewable source of energy that is cost-competitive with fossil fuels (NREL, 1998). One of the major cost reduction aspects of solar energy systems is that the plants use much of the same equipment as conventional power plants. (Energy Efficiency and Renewable Energy Network (EREN), 2000)) Solar power systems can be constructed to fit any necessary size requirements and tailored to accommodate changing energy needs. The U.S Department of Energy

(2000) estimates that the capacity of concentrating solar power plants will increase to about 500 megawatts world-wide in the next 5 years.

1.2.4 Fossil Fuels

Fossils fuels consist of decomposed animal and plant matter that can be used as energy sources. The major types of fossil fuels are coal, oil, and natural gas (California Energy Commission, 2000).

Coal is the most abundant fuel in the fossil family and has been utilised the longest (U.S. Department of Energy, November 2000). Coal has been used by humans since the early civilisations. Researchers also found evidence of coal use by Romans in England between 100 and 300 AD. The industrial revolution played a very important role in development of coal technologies. James Watt invented a steam engine, which ran on steam produced by burning coal. During the second half of 19th century more uses of coal were found such as in the steel and weapon industries. Coal was first used to generate electricity in the 1880's.

Coal is obtained by underground or surface mining, depending on its location (U.S. Department of Energy, November 2000). Shafts are cut underground to the mining area for ventilation and transportation of workers, and the coal itself is loaded into small carts, which carry it outside of the mine.

Earliest evidence of oil use dates back to 4000 BC in the Caspian Sea region (U.S. Department of Energy, November 2000). The modern oil industry started approximately 150 years ago. Oil is obtained by drilling underground wells and pumped out. After primary production, a substantial amount of oil can be left behind, and there exist several secondary methods for obtaining trapped oil. These include water flooding, injection of carbon dioxide underground, and growing bacterial colonies between the rocks to force the trapped oil out. Until the late 1880's natural gas was mainly used as fuel for lamps. However with growing use of electricity the focus of natural gas use has shifted.

Natural gas can be considered an ideal fossil fuel, since it burns relatively clean, easy to transport, and convenient to use (U.S. Department of Energy, November 2000). When used as a fuel, natural gas combusts almost completely, and is therefore considered a very clean fuel. Obtaining natural gas involves a similar process to oil in the sense that it flows freely from underground and some needs to be forced out by different methods. These methods include, pumps that bring gas to the surface and creating fractures in rocks for easier gas flow.

1.2.5 Nuclear Power

Nuclear energy is contained within the atom. Two types of nuclear energy are nuclear fission and fusion (California Energy Commission, 2000). The former derives energy from splitting the nucleus of an atom, whereas the latter combines the nuclei of atoms, also generating heat.

When the nucleus of an atom is split apart, it releases energy in the form of heat and light (California Energy Commission, 2000). Releasing energy gradually gives off large amounts of heat that can be converted to electricity by creating steam to power turbines and generators. Radioactive elements such as Uranium are a good source of fission energy. Inside an atomic reactor, radioactive atoms are split in a controlled chain reaction. In order to regulate the rate of nuclear splitting, rods of different elements are used to absorb neutrons.

Combining nuclei of several atoms can give off heat, light, and other radiation (California Energy Commission, 2000). The sun produces energy by nuclear fusion of hydrogen and helium atoms. The use of nuclear fusion to produce electricity is currently in the development stage and not yet commercialised. Nuclear fusion theoretically generates less radioactive waste than nuclear fission, and its potential supply of fuel can last longer than the sun.

1.2.6 Biomass

Biomass is a renewable energy source that is obtained from remains of living matter such as forest deadwood or purposely grown crops (Sims, 2000). It that can be converted into a usable form of energy such as heat, power, or transportation fuels. Biomass can potentially replace fossil fuel sources of energy, because it can be used as a feedstock in production of petrochemicals and materials that are derived from coal, oil, and natural gas.

Biomass can be converted into a variety of forms such as heat, steam, electricity, hydrogen, ethanol, methanol, and methane (Chynoweth, Owens & Legrand, 2000). Under most circumstances of product conversion, methane is the ideal type of fuel. Methane, which is the principle component of natural gas, is a relatively clean fuel, and compared to other fossil fuels, it generates less carbon dioxide and produces very few air pollutants.

Biomass provides approximately 13 percent of world's energy, however, because of its widespread use in third world countries the exact value is unknown (Sims, 2000).

1.2.7 Fuel Cells

Fuel cells were first invented by a British scientist, Sir William Robert Grove, approximately 160 years ago (Thorstensen, 1999). However, it wasn't until the 1960's when another British scientist showed the usefulness of alkaline fuel cells. Even though fuel cells are not a form of energy themselves, they are a recent technology that can provide energy. People have been interested in the development of fuel cells for the last few decades, and the technology is in progress. However, it does not yet offer a competitive alternative for the world energy market.

There are different types of fuel cells depending on the type of electrolytes used (Thorstensen, 1999). Electrolytes can be solid or liquid and determine the temperature of operation. Two major solid types include solid polymer and solid oxide, and two major liquid types include phosphoric acid and molten carbohydrate. Fuel cell use should grow steadily in the near future.

1.2.8 Geothermal Power

Geothermal power involves using interior heat from the Earth (The Energy Efficiency and Renewable Energy Network (EREN)). There exist five geothermal resources: hydrothermal fluids, hot dry rock, geopressured brines, magma, and ground heat. Only hydrothermal fluids are currently used commercially for power generation. In the U.S, geothermal power provides approximately 2700 megawatts of electric power, which is less than .4% of the electricity used there. Geothermal resources can be used directly for heating homes and commercial industries. The direct use involves a well that brings hot water to the surface from underground reservoirs, a mechanical system that delivers the heat, and a disposal system that receives the cooled fluid. EREN (2000) estimates that a reduction in cost of up to 80 percent could be realised in using direct geothermal energy over traditional fossil fuels.

Geothermal energy can also be used for electricity generation at power plants. The type of technology used in a power plant depends on the temperature of the reservoir (EREN, 2000). Types of power plants include dry steam, flash steam for high temperature water, and binary cycle for moderate temperature water.

According to EREN (2000), geothermal power provides a clean and cost-effective source of energy. Beside hydrothermal, other geothermal resources such as hot dry rock can offer big potentials for electricity generation in the future.

1.3 Energy Source Breakdown

1.3.1 Developed World

The "developed" world refers to countries that have fully developed industries and economic systems (EIA, 2000, p. 178). These countries have a low population growth rate, generally low economic growth, as well as a high life expectancy, and quality of life. Examples of countries in this group include, the United States, Canada, much of Western Europe, Japan, and Australia.

1.3.1.1 Energy Distribution Factors

The factors that effect the distribution of energy use are related mostly to quality of life and industry, and include location, local fuels, and population density. (EIA, 2000). For instance, a higher quality of life in developed countries is a direct result of their ability to use energy residentially. This is only possible in these countries because they have an established economic and distribution infrastructure. This higher quality of life usually results in more energy use, because people travel more, use more electricity, and purchase more material goods in general. This is the largest difference between developed countries and developing countries. Developing countries use a much smaller amount of residential energy. In the United States 35 percent of the energy used goes to the residential sector, while industry consumes another 35 percent, and transportation uses the remaining 30 percent. Transportation in the U.K. uses 32 percent of its energy resources. The U.S. and U.K are rather unusual, however, using much more transportation energy than other developed countries (EIA, 2000).

1.3.1.2 Distribution of Fuels

Among industrialised countries the distribution of fuels used to fill energy needs can be very different. In most developed countries oil is used far more than any other fuel, with around 40% of the market (EIA, 2000, p.178). This is partly due to the larger amount of transportation needs in the industrialised world. North America uses about 20% natural gas for its needs, whereas Europe only uses natural gas for around 15% of its needs. Industrialised parts of Asia use more than half oil, and less than 10 % natural gas.

The reasons each country uses different fuels are numerous. The largest reason is generally the location of the fuel. Natural gas, for example, is naturally found in North America and is easily piped to homes; this explains why the US uses more natural gas than any other country. Oil, on the other hand, is imported by most countries from regions such as the Middle East and Asia. Therefore, location cannot always be a factor for oil use. Nuclear power accounts for about 10% of the total energy used in the developed world. North America uses relatively less nuclear power than Europe and other parts of the world. North America also uses relatively more alternative energy sources such as hydropower than other industrialised countries, at about 10% of the total.

1.3.1.3 Distribution of Use

The distribution of fuels used in the world will most certainly change. The availability of certain fuels will rise and fall, drastically changing the makeup of the worldwide fuel breakdown (EIA, 2000, Appendix 2). For instance, the use of natural gas is projected to increase by 1.6 % per year in North America and 2.9% per year in Europe over the next 10 years, by far the largest growth rate of any fuel in those regions. This means that Europe, for example, will use twice as much natural gas in the year 2010 than in the year 2000. Nuclear power is expected to see a decrease in use in both Europe and North America.

In developed nations the fuels that make up the energy sources have general uses that are common throughout. For example, nuclear power is used exclusively for electrical generation. Oil is used primarily for transportation in industrialised nations, with some use in industry and residential heating.

1.3.2 Developing World

The developing world makes up the remaining areas of the world; they are still developing their industries and their economic infrastructure (EIA, 2000). These countries have higher population growth rates, higher economic growth rates, lower quality of life, and lower life expectancy. Among the most populous of these countries are China, Brazil, and India.

1.3.2.1 Factors

The factors that contribute to energy uses are the same as in developed countries. These countries by definition have not developed a solid economy and have an industrial base that is still growing (Birol & Agiri, 1999). This means that these countries will use relatively much less residential energy and an increased level of energy usage in the industrial sector.

Population growth is a large factor in energy consumption. Developing countries have a higher population growth rate than developed countries (Sheffield, 1998, p. 61). This also frequently means that the country's infrastructure is growing very fast. The implications of high growth are that in the future these countries will have much larger populations, with many more industries, and use much more energy than they do now.

The "quality of life" is a hard figure to quantify and compare. Quality of life is a term mentioned quite often and is important in energy considerations (Sheffield, 1998, p. 62). The quality of life is high in industrialised countries, because there is an established economy and residents have more money. A product of a higher GDP is that more homes have electricity and cars. This translates directly to higher energy use per capita. In developing nations the quality of life is lower on average, because there is no distinct economic base, and therefore the average resident has less money. In these developing countries most energy use is used for commercial and industrial growth, not residential purposes. In the near future when many of these developing nations are developed, their energy consumption profiles will be much different.

1.3.2.2 Distribution of Fuels

The distribution of fuels used in developing countries is quite similar to that of developed countries with some exceptions (EIA, 2000, p.178). For instance oil makes up about 40% of the fuel used for energy in developing countries as a whole. This is quite close to the 42% for industrialized nations. Natural gas use also has a similar distribution percentage between the two divisions. One difference between the two is that there is much more coal used in developing countries. Coal accounts for almost 40% of the total energy use in the developing countries. In developed countries coal is only about 15% of the total, the difference being filled by Nuclear power, Natural Gas and Oil. Nuclear energy sources are used hardly at all in the developing world, only about 1.3%. These countries by definition do not have the economic base to be able to support nuclear power. Developing countries in total use about 8 percent renewable and natural sources.

Each developing country has a slight variation to these totals (EIA, 2000, p.178). One large anomaly is that coal is widely used in Africa and Asia, and only slightly in other developing areas. Another example of an inconsistency is that in South America renewable energy accounts for about 30% of the energy use. This is due largely to massive hydroelectric plants in Brazil.

1.3.2.3 Distribution of Use

Developing countries do not use their energy sources in the same way that developed countries do. Transportation is a big factor; in developed countries most of the oil use goes to transportation. However, in developing countries oil is not used nearly as much for transportation. Developing countries use relatively more of their oil for industry and electrical power generation as opposed to vehicle fuels; they do this by not having as many vehicles in use. Natural gas is used primarily in industrial and electrical power generation in developing countries, whereas in the developed world natural gas may be used for residential heating and cooking as well. Developing countries use biomass sources for most of their residential needs; this includes wood, dried dung, etc.

1.4 Energy Sustainability

1.4.1 Growth Rate

In order to evaluate the supply of energy resources, one first has to know how much is needed by the world. This information is related to the world population growth rate, however this issue includes other factors such as improvements in quality of life, which increases energy requirements. In general, when there are more people, more energy will be required (Kadoshin, 2000). The annual growth rate of the world's population is currently about 2 percent. This means that the population of the world will double within the next century. Therefore, there will be a huge increase in the amount of energy needed in the relatively near future assuming the efficiency stays the same. The issue is not about actually having sufficient sources of energy, but where that energy will come from.

Many of the developing nations will probably be developed in the next twenty years. The process that those countries go through will require a large amount of energy (Kadoshin, 2000). These countries will see a gain in energy use relatively much higher than their population growth rates. Meanwhile, developed countries are expected to see energy increases proportional to their population growth.

Oil is forecasted to still be the largest energy source in the coming decades (EIA, 2000, p. 40). Coal is currently the second largest source of energy consumed in the world. However, it will be replaced by natural gas sometime in the next 10 years. It is forecast that nuclear power will see a worldwide decline in use in the future, while the use of renewable sources will see a steady but slow increase in the next 20 years.

1.4.2 Efficiency

As technology improves and fuels inevitably become more expensive, people will naturally develop more efficient methods for energy use (Birol & Argiri, 1999). There is a direct correlation between technology and efficiency, as one increases, the other increases as well. All fossil fuels are going to increase in price (greater than inflation), with the rise in transportation costs and decrease in availability. Therefore, the efficiency of energy use is inevitably going to increase for suppliers to stay in business. The rate of increase in the efficiency could drastically change the amount of energy used in twenty years. Efficiency will be very important in the future for environmental reasons, as well as for reasons of long term energy availability issues.

2. Information on Museum Exhibits

2.1 Methods of Presentation

With any form of presentation, information is displayed for the audience to learn. How much of this information the audience absorbs, however, is almost entirely dependent on the manner in which the information is presented. Hull and Jones (1961, p. 9) consider the level of interest in the subject of little importance as compared to the attractiveness of the presentation itself. There are three main types of display methods that are generally helpful in creating an efficient exhibition. Simple visual methods can sometimes be the most cost- and time-effective and in some cases are the best options for the information being displayed. Interactive displays involve more work to develop; yet the learning processes involved produce better retention of both general concepts and minute details. Lastly, World Wide Web page production incorporates both visual methods and interactive components. Web sites also generally have easy accessibility, leading to vast information relay.

2.1.1 Visual Methods

The main goal of any visual display is to cater to the eye of the audience (Belcher, 1991, p. 30). Visually pleasing presentations will hook the audience and encourage them to learn more about the information presented. Conversely, visually dull displays will be uninteresting and drive the audience away. To prevent unattractive presentations, there are two fundamental concepts inherent with any exhibition. These factors are lighting and colour and are vital to the appeal of the presentation.

Lighting as defined by Belcher (1991, p. 125) is the installation of light sources around a target object to create a desired illumination. This process is important since certain lighting schemes can create moods and influence perceptions of the target object. Texture and shape of the target object can be misconceived easily without proper lighting. The skill of lighting includes an understanding of both the technical aspects of light sources as well as an awareness of behavioural psychology (Belcher, 1991, p 127). For instance, lack of light in an exhibit can result in a poor display of an object and therefore might lose the attention of the audience. Also, using different angles of light can demonstrate the texture of an object, and having different strengths of light can focus on different objects for emphasis. Lighting can even be considered an art; most often it simply facilitates vision, but it can also affect the visitor through the aesthetic creation of moods.

Colour, the second visual concept, is similar to lighting in that the development of schemes and tones can affect perception of the target object. For example, an audience may subconsciously view a painting or other work of art being displayed on a red background differently than the same artwork on a blue background. Also, the lightness or darkness of a particular colour, known as tone, can help to clarify the outline of the target object (Belcher, 1991, pp. 128-132). The importance of colour is apparent in almost any exhibition. Colour can affect various people differently, depending on the psychological factors and preferences.

Other visual elements in exhibitions include graphics and models. Graphics, pictures, graphs, and other visual representations convey large blocks of information in a form that is attractive to the audience. Effective communication is made easy with such aids, as they provide a direct approach to holding the audience's attention. Belcher (1991, p. 136) states that photographs are the cheapest and most frequently used substitutes for reality. Unfortunately, drawbacks of photographs include misconceptions of scale and distractions of irrelevant information. However, photographs are visually exciting and add a new and more dynamic edge to any presentation. Maps, charts, and graphs are other types of graphics. These visual aids are effective in summarising vast amounts of information and presenting them in a visually efficient manner (Belcher, 1991, pp. 132-137). Statistical trends and analytical observations become increasingly apparent with these visual aids. As a result, these graphics are useful for information relay.

Models, defined as scaled replicas presented in a three-dimensional medium, are effective in displaying concepts or processes less perceptible in the authentic object. There are three main reasons to incorporate a working model into a presentation. First, the enlargement of objects may be needed if the natural object is too small to see. This happens frequently in the display of biological material, such as single celled organisms and insects. Second, the reduction of objects too large for the presentation space may be required. Reduction happens often when displaying transportation vehicles or architectural works. Third, models might be necessary when representing objects too difficult to show in their natural state due to their large or small magnitude (Belcher, 1991, p 138). To illustrate, one might use a model of an aeroplane instead of the real machine. Similar to graphics, models exemplify large quantities of information and make it easily absorbable.

In essence, the visual elements in any presentation are crucial to making the presented information easily interpreted. Colour and lighting, the two basic visual factors, can influence how the target object is perceived. Additionally, graphics and models can aid in the dissemination of data, important concepts, and other qualitative amounts of information. Visually effective presentations can make relatively uninteresting subject matter easier to absorb.

2.1.2 Interactive Displays

The more interactive a presentation is, the greater the interest of the audience will be (Weil, 1990, p. 49). Interactive displays include anything that requires audience participation and ideas that the audience can personally relate to. Interactive displays such as a game or a computer program allow an audience member to learn at a preferred pace. The utilisation of such displays is vital in any information relay.

When a presentation is interactive, the audience perceives a personal interest in the subject matter. As a result, the topic becomes more interesting and attractive. Weil (1990, p. 49) considers that the audience's involvement has a direct relationship to the amount of information the audience digests. Any way in which a presentation can relate to the audience increases relevance, which in turn increases interest.

2.1.3 Website Design

Web pages provide an excellent medium for relaying information (Haggard, 1998, pp. 47-51). In essence, the World Wide Web is a communication tool made available to the masses with relatively little development time. Websites provide a universal medium, which can easily display large amounts of information. Not only do they combine both visual and interactive displays, they also provide easy accessibility to those with a networked computer. The layout of web pages should follow the same visual rules as with any presentation. Once again, lighting and colour schemes play an important role in dealing with the aesthetics of the website. There should not be an excess of text, or else the audience (or browser) would quickly become uninterested. Communication is mainly done through graphic design.

The website should be organised and structured in such a way that the browser can navigate easily to obtain desired topical information (Lemay, 1996, pp. 24-35). Once such a structure is achieved, the website is already interactive by design. One type of website design that should be avoided is a linear design, that is, a site that is straight text flowing downward, with no organisation whatsoever. A website should have some system of hierarchies or layers, where different levels of information are presented at each layer. This structure allows the reader to go as deeply into the information as he/she desires. Another consideration involves accessibility backward through previous layers. Visitors to a website might find it irritating if navigating the site is not smooth.

Since a large part of the audience for our website is children between the ages of 7-15, we have to consider design issues in order to cater our site to this audience. Wimpsett (1998), has underlined a set of basic rules and considerations when designing websites for kids. One of her major points is to include interactivity. Interactive games attract children's attention and increase the chance that they will visit the site again. Another major point is not to use overly complicated icons and conventions. It is better to provide simple graphics and language because children take things more literally.

2.1.4 Non-technical Aspects of Macromedia Flash

To develop an interactive website, the most useful software currently available is Macromedia Flash (Mohler, 2000, p. 5). Flash, designed by the Macromedia Corporation, is a complex program that can generate graphics and animations used in websites. As a result of website animations incorporated with hyperlinks, websites become interactive. The program is flexible and is well known for its user-friendly interface. Flash was one of the first computer programs developed that can generate vector-based graphics instead of scalar-based graphics. Scalar-based graphics require more description, as every single pixel included needs to be catalogued. With vector-based graphics, lines of colour are simply described as a direction, a magnitude, an origin, and a colour. As a result, file sizes of vector graphics are smaller and require less loading time.

Flash is also useful to the overall look of a website (Mohler, 2000, pp. 8-10). Graphics designed using Flash can help convey information that would go unread or get lost in excessive text. Flash also helps to generate buttons and icons that can make a website more interactive. The other main component of Flash includes animation. Flash develops animations with relatively small files through a series of vector-based graphics. These animations can range from screen size to icon-size, depending on the developer's purpose. Sounds can also be incorporated using Flash in order to add an extra dynamic to the animation.

Other benefits of Macromedia Flash include its compatibility, its learning tutorials, and its interface (Ulrich, 1999, p. 419). Files created in other programs, such as graphics, animations, and sounds are easily importable into Flash media. Similarly, the media files created in Flash are easily exportable into other programs. Most importantly, Flash files can be interpreted quickly and easily in most web browser programs. These capabilities make Flash a highly compatible program that allows the user more creativity. Also, Flash offers several learning tutorials and lessons that take novice Flash users step by step through the rudimentary elements of the program. Taking roughly two hours, the user can gain a sufficient starting knowledge of the software. Another aspect of Flash is its flexible interface. In other words, the program itself is easy to operate regardless of the level of knowledge and skill the user has. Both inexperienced and professional users of Flash software find that navigating the program is rarely a problem. Other computer programs often lack such features.

In summary, Macromedia Flash is a dynamic website development tool that focuses on graphics, animation, and interactivity. Flash is useful for its compatibility with other programs and different types of users. This program is undoubtedly almost a necessity for website design.

2.1.5 Human-Computer Interaction

Another important topic is the modern relationship between humans and computers. The way people perceive computers as learning tools is changing rapidly. Interfacing with computers is a complicated and acquired skill. By adding an interactive computer display to a presentation, a new dimension of learning and a new set of problems are introduced (Scheiderman, 1992, p 33). The multimedia and graphical possibilities of a computer display are a significant benefit in any exhibit. However, a majority of people have an under-appreciation of technology, which can sometimes develop into fear, or dislike of computers. Children and adults alike can have problems interfacing with such computer showcases due to lack of experience with computers.

To solve such problems, the web page or interactive component of a presentation should be simplified and user friendly in order to cater to all audiences (Scheiderman, 1992, pp. 107-110). Those people with little computer experience should be able to interact with ease and comfort. As a result, the interface will allow more information to be digested by the audience.

2.2 Effective Science Museum Exhibits

Science museum exhibits are a prime example of information relay. They are designed to teach the audience about highly complicated and technical subjects. Belcher (1991, p. 132) believes that the objective of a museum is to educate and not just to collect objects and artefacts. Problems arise since the average person considers the nature of the subject matter in museums somewhat boring. Therefore, the need for effective displays to retain the audience's interest is a high priority. Information needs to be analysed and redisplayed in a way that would cater to the target audience's learning capabilities.

In the case of a science museum, the presentation can be defined as the exhibit itself. The audience can also be defined as the average museum patron. In an interview with Professor James P. Hanlan, [personal communication, Nov. 2000] he described the average museum visitor as having an attention span and education of a junior high school student. An effective museum exhibit should cater to this audience. The challenge of a museum is to present legitimate and valid principles to all audiences without oversimplifying them or being too technical. Professor Hanlan said there is a window, albeit a relatively small one, of diction and description so as to sustain interest long enough to disseminate information. Exhibits with too much text will generally go unread. Poor lighting, colour, and presentation will drive patrons away. Also, catering to the wrong audience can insult the patron's intelligence. Hanlan and Ljungquist (2000, p. 5) have found that museum visitors have a diverse range of interests and education. To cater to all visitors is nearly impossible, but to cater to most of them is still highly feasible.

Mr. Jesse Anderson [personal communication, Dec. 2000], the senior design engineer for the Ecotarium in Worcester, MA, expressed similar viewpoints. He believes that the key to any exhibit is its layout. An exhibit that is designed to tell a story while appearing visually natural is the most effective way to convey information. Anderson also considers the entrance of an exhibit to be important, as it sets the initial mood for the exhibit as well as entices patrons to enter. Sometimes a personal tie to the audience can make an exhibition more interesting. For instance, an exhibit on global pollution doesn't exactly relate to everyday life, but if the exhibit were focused on how pollution can affect the home (transportation, electricity, etc…), the exhibit would have more impact. However, even when an exhibit is interesting and exciting, only a few basic facts are truly passed on to the visitor.

Anderson [personal communication, Dec. 2000] has also discovered a difference in the concepts of interaction and manipulation. Exhibition interaction includes some form of communication between a patron and a display. A computer display that asks patrons questions, receives answers, and then relays feedback is a prime example of interaction. Manipulation in exhibits consists of directing or manoeuvring a display in order to gain more information. Examples of manipulation include light switches to illuminate more of a display or drawers that one can open to access artefacts. Anderson believes this difference is important to be aware of when designing an exhibit, for both concepts cannot be used interchangeably. One general guideline for making an exhibit interactive is to cater to multiple senses of the human body. That way a patron can interact with the exhibit on multiple levels. At the very least a museum exhibit should be manipulative, but interaction is usually preferable.

Most science museum websites have certain inherent problems. While these web sites are interactive, visually pleasing, and easily accessible, if all information was found on the museum web site, there would be no reason to pay museum admission to see the exhibit in person. Hanlan [personal communication, Nov. 2000] believes the solution to this problem lies in the amount of information presented on the web. The web page should be modelled as a sample of the information presented in the exhibit. Similar to a "coming attractions" movie trailer, the web page should entice the audience to visit the museum to learn more about the subject matter.

3. Scope of the Project

3.1 Target Audience

The target audience is not only important for the exhibit itself, but also for the written report. Both must be at the proper level of content and intelligence for the target audiences, which may be different. One must determine the target audiences through a survey or through already available information, depending on the size of the audience. Determining the target audience correctly can guide the process of creating an exhibit and the written report, improving the quality and efficiency of the final product.

3.1.1 Audience for Exhibit

According to Ms. Sophie Duncan, the content co-ordinator for the exhibition, the primary audience for this exhibit is key stage 2-3, which is children aged 7-14, as well as families with children aged 5-14. The secondary audience is comprised of all other age groups. By using both a graphically appealing setup as well as a database, with more in-depth information, we will accommodate all audience members.

3.2 The Interview Process

Many steps are needed in choosing the proper type of interview as well as choosing the types of questions that are to be asked. Many aspects such as time, money, and ethics, to name a few, must be considered. Ben Gammon, the head of visitor research at the Science Museum has performed research concerning the most effective methods of interviewing museum visitors. In order to collect data one might choose to provide a self-completion questionnaire or decide to do face-to-face interviews. Self-completion questionnaires are easy to distribute and are low in cost. They are usually left at specific locations and visitors can fill them out if they wish. However, such questionnaires tend to provide biased data for qualitative research, because few people are interested in providing comments if they are satisfied, and those that do respond tend to leave more negative comments. In general, this type of data gathering does not represent all the visitors to the Museum. Face-to-face interviews are more time consuming, however they provide good qualitative data and represent all types of visitors.

3.2.1 Scope of the Data Collection

When considering what should be put into a qualitative interview, Rossman (1998, p. 61) says there are three aspects that need to be considered. The first is "do-ability". "Do-ability" refers to the ability to complete what you propose. This includes time constraints, schedules, and money. The researcher must be capable of completing the interviewing and analysing the data within the available research time. He/she also must consider whether he/she has access to the proper subjects necessary for his/her research.

The next aspect to consider, according to Rossman (1998, p.62), is "want-to-do-ability". The researcher must consider how much he/she really wants to get from his/her subjects. The researcher must also consider what is actually important to the research. Unnecessary information will create unimportant data and will also decrease time for the rest of the interview process and project.

The final aspect that should be considered, according to Rossman (1998, p.62), is "should-do-ability". In conducting an interview, one must be careful not to offend anyone or step over ethical borders. It is very important to discuss all possible ethical issues with any team members and technical advisors prior to conducting any interviews.

If all of these steps are followed, an ethical and productive interview process should result. Every aspect of the interview will be covered, and, with the exception of unforeseen complications, it should go smoothly.

Gammon (2000) believes that before any evaluation is performed, it is important to ask several questions pertaining to the project. This process will help to define the project and lead to the most suitable type of evaluation. The most important question to ask before any evaluation is "What do I want to find out?" This question helps to define the purpose for the evaluation. The next two questions are "Why do I want to find this out?" and "How will this information be useful?" Only after answering these three questions should one start thinking about methodologies and how the evaluation should be conducted. Gammon states that a common mistake that novice evaluators make is choosing methodologies before asking themselves what information they desire out of the evaluation.

3.2.2 Types of Data Collection Methods

Gammon (2000) has categorised science museum exhibition evaluation into three main stages. Preliminary evaluation is known as "front-end evaluation." This type of assessment is done before the exhibition is designed, to determine the audience's level of knowledge and interest into the exhibition subject matter. The next type of evaluation is called "formative evaluation," which is performed while the exhibition is being designed and fabricated. Similar to front-end evaluation, formative evaluation is used to assess visitor interest in the exhibition topic(s). The third type of evaluation is known as "summative evaluation." This evaluation is performed after the exhibition prototype is completed. Visitors are asked to experience the exhibition for a predetermined time. Then the visitors' impressions and opinions are assessed during a brief interview. The resultant data can then reveal certain problems (not solutions) the exhibition has.

There are several types of interviews that can be conducted, all of which offer advantages and disadvantages. In order to choose the right one for the purpose, all of them must be understood and considered. According to Gammon (2000) the best type for science museum exhibition evaluation are face-to-face interviews. They provide qualitative data and the best representative sample. Additionally, Gammon believes that sample size (i.e. The number of people interviewed for a given survey) does not need to be more than 50, if performed correctly. Gammon stated that amateur surveyors think that the bigger a sample, the more representative that sample is. This is not always true because one might select a large sample from a particular group and the data will not reflect the other groups.

Semi-standardised open-ended interviews are one type of interview (Rossman, 1998, p.125). In this case the interviewer asks a set of predetermined questions of the respondent in a set order. The results may come in the form of multiple choice or open answers.

3.2.3 Recording Data

From Berg (1998), it was determined that recording data in the field is a very technical task. It involves several different steps that will result in a complete interview and uncontaminated data. The first step that Berg discusses is recording keywords and phrases while in the field. It is unproductive to stop a respondent in the middle of an interview to record everything that he or she has said. It also may not be helpful to use a tape recorder of some sort because it may make the respondent uncomfortable and result in inaccurate answers.

Another technique to use is taking notes on the observations and time of the survey (Berg, 1998, p. 147). Researchers often find it helpful to jot their notes down in the order that they happened. This is useful because the sequence can be used subsequent to the interview to reconstruct what took place. This leads to a more complete set of field notes after the fact and will result in a better analysis.

Next, Berg (1998, p. 147) discusses the 4:1 time ratio that field researchers generally observe. This ratio says that for every hour you spend in the field, you will need to spend about four hours writing comprehensive field notes. Because of the large amount of time spent writing notes, a researcher, particularly a novice, will need to limit the intervals spent interviewing. Time intervals of about 10-15 minutes work best followed by roughly an hour of writing. This number can be increased once the researcher gains experience.

According to Berg (1998, p. 148), the researcher should also write comprehensive field notes immediately after leaving the field. This is to prevent memory erosion and allow for the most detailed and accurate field notes. The final rule to observe is to write field notes prior to sharing them with anyone (Berg, 1998, p. 148). Not only does this prevent memory erosion, but it also prevents possible unintentional embellishment.

3.2.4 Analysing Data

According to Janesick (1998, p. 59), gathering data is only the warm up before the real research begins. In the analysis process, all of the meaningless unorganised data become useful information. In order to successfully interpret the data, one must use several techniques that will help to bring out the true meaning of the data.

The first decision that needs to be made regarding analysis is whether to do ongoing analysis or analysis at the end. For the novice, it may be easier to perform most of the analysis at the end. This way, the researcher can focus on one step at a time. However (Rossman, 1998, p. 173), it is often helpful do to a small amount of analysis during the interview process in order to become comfortable with the task of analysis and make the final analysis task a little less daunting. Ongoing analysis often creates better results since the information is a bit fresher, however, many researchers find it too difficult to do both steps at the same time.

Rossman (1998, p. 173) offers several things to keep in mind regardless of when the analysis is done. First, the researcher must stay focused on finding the data that will answer the questions. Straying from this may result in poor analysis. Second, the researcher must always write analytical memos during the interview process to help aid in the analysis at the end. This helps to keep the ideas fresh. Also, after each session of data collection, the researcher should always discuss the data with his colleagues or partners to get their ideas on them. Another key point is to consider what other professionals have said on the topic. It is helpful to refer to the literature review to see what has already been found on the topic to aid in one's own analysis. Finally, being creative is very helpful. Use of visuals, images, concept maps and metaphors during analysis may help understand the data and lead to better results.

The next major aspect of analysis is the amount of structure the analysis will have. Rossman (1998, p. 174) says the analytical questions can be either, very focused and predetermined, or they can be very open-ended. If using a structured form, the questions should be designed in advance in order to guide responses into certain categories. For a more open-ended structure, the questions should be left general to allow for many different answers and possibilities.

Finally, one must proceed with the analysis of data. According to Rossman (1998, p.176), this involves six main steps. First, the data must be organised. By creating an inventory of the data collected, the information will become easily accessible. Next, the researcher must reread all of the data collected a few times to become better familiar with it. The next step is to create themes, patterns, and categories to place all of the data into so that it is easier to develop questions for data analysis, and to dissect the data. After creating categories and placing the data into them, all the data must be coded. This will help to organise the data further and help decide what goes in various sections when writing the research report. The next step is to search for alternative understandings of the data. The researcher must take all possible meanings he or she has explored and put it aside to find other ideas. The final argument that is created will be based on the stronger ideas that are found. In order to find these, one must look at every possible argument.

IX. Methodology

The National Museum of Science and Industry is designing a large Energy Gallery to educate people about all aspects of energy such as types of energy, where it comes from, and when it might become depleted. As part of the gallery, the Museum staff would like to develop a series of exhibits on World Energy Use. The purpose of our project was to design the World Energy Use section, in the form of a virtual web-based prototype. Before we actually designed the exhibits themselves we needed to do some background work. We had already determined that our audience was seven to fifteen year olds, and researched different aspects of energy use that they might find interesting. We consulted many different sources containing information that we might be able to display in our exhibits.

We had also developed a set of questions (found in appendix B.) and interviewed potential audience members to determine what they wanted to know and what they already knew. We also determined what information our target audience was capable of absorbing during these interviews. With that done, the exhibit was designed and created using Macromedia Flash and HTML code as well as Adobe Photoshop. Finally, we evaluated the exhibits for content, style and effectiveness. We did this by allowing visitors to use the exhibit for as long as they wished. We then asked them questions to see what they liked and what they didn't like. From this information we made the necessary changes.

1. Front-end Evaluation

We first developed a set of questions for a preliminary interview while we were in Worcester, which can be found in appendix B. The purpose of these questions was to gather information on what the museum visitors would find interesting to have in our web exhibit. In order to generate an appropriate questionnaire we answered Ben Gammon's three questions. We wanted to find out what visitors knew about energy use and what would be interesting for them to learn. We wanted to find this information, because it would help us decide what content to emphasise in the exhibit. We used the data gathered to help us include appropriate and interesting information in the exhibit. We then discussed these interview questions with our liaison and other energy project staff members to determine the effectiveness of the questions. We then revised the questions to increase the productivity of the interviews.

Next, we tested this interview on several members of the museum staff. This allowed us to obtain initial reactions from people who did not work on the questions with us. We made a few changes based on the responses obtained and suggestions given by these interviewees. Next, we interviewed a few museum visitors to get an idea of some of the reactions that we would receive. Once the questions were optimised, we entered the museum and spread out into separate galleries working individually. We interviewed a total of 77 visitors from all age groups over a period of 4 days. The majority of the interviews took place between noon and 16:00, near the exit of the Space Gallery. Out of 76 surveys, 57 were done from Wednesday to Friday. The remaining interviews were conducted on Saturday. For further visitor sample information, see Table 1, located in

Section X.1. Each interview lasted approximately 5 minutes. We then categorised the data, identifying misconceptions and considering interest levels in particular topics.

While conducting the interviews on the museum floor, the team followed the museum's guidelines for obtaining a proper and random sample of the visitor population. The interviewing team member would ask every tenth visitor to pass by. If the visitor declined the interview, the team member would kindly thank that visitor, wait for another nine visitors to pass by, and ask the next person. This process was developed by the museum staff to ensure randomness of the interview sample.

Midway through the evaluation process, the team noticed that none of the interviewed visitors had been in the 50+ male age and gender group. Since the team considered that obtaining results from all age and gender groups was a high priority, the team conducted interviews with several 50+ male visitors in various other galleries of the museum. While this might have slightly biased the results, the museum staff was satisfied with the visitor sample demographics.

2. Content and Web Development

The results of the interviews were organised and analysed. We then went through the data and developed ideas for the web exhibit. Through a series of brainstorming sessions, we developed a list of possible activities and games. We narrowed the list of ideas and developed a few trial interactives using Macromedia Flash. When developing the games and activities, we took into account lighting schemes, page layout, navigation, and general human-computer interaction techniques as reviewed in section 2.1.3. We also made the games and activities as interactive as possible by incorporating complex animations and Flash buttons. We also tried to create a balanced combination of graphics and information that would hold audience interest while also disseminating important information.

The team also constructed a main index page for the exhibit, so that users could easily navigate through the various activities, games, and other elements of the exhibit. We also developed an opening animation with Flash to introduce the web exhibit. To cater to users searching for detailed information on energy sources and the global distribution of energy, we created a text version of our website. Since we made this version without using Flash, this site also served as a non-Flash version. Finally, we created other miscellaneous parts of the website, including an "about" page, a site map, and a references page.

3. Summative Evaluation

We reviewed the evaluation questions that we developed during preliminary work. Using the same method that we used for the first set of interview questions, we revised the evaluation interview protocol. We also answered Ben Gammon's three questions for creating a questionnaire. We wanted to find out if the virtual prototype was intuitive, easy to navigate, interesting, informative, and fun. We needed to find this information in order to recognise possible flaws and problems in our exhibit. Using the results of this interview, the team improved the aspects of the exhibit that were flawed. To test the preliminary exhibits that we had created, we set up a computer station in the museum, which allowed willing participants to explore the virtual exhibition for an unlimited amount of time. We then observed their actions, errors, frustrations, and confusions during use. We then asked them the questions that we had previously developed to gather their opinions and what they learned from the exhibit. These questions can be found in Appendix C.1. We analysed the data from our second questionnaire categorising the flaws of our virtual prototype into priorities and levels of severity. The team then discussed possible ways to improve these aspects in the order of their importance. The results of the summative evaluation can be found in Section X.3.

Using the information gathered from the tests, we made improvements to the interactives, the main index page, and the text version. During this time, the exhibit content was also discussed with the energy gallery staff. We made changes where the staff felt necessary. We also debugged all of the technical and content problems and finalised the exhibit. Next, the team compiled all of the files necessary to the web exhibit in a format that would be easily transferable to the World Wide Web. We then presented the website files to the museum staff, along with the Flash editing files. Since the museum staff was very familiar with web pages, we simply explained to the staff how to maintain the page and deal with any possible problems that may arise.

X. Results and Discussion

1. Data Analysis of Front-end Interviews

After the front-end interviews were performed on the museum floor, the team compiled the responses into tables. The team had conducted interviews with seventy-seven museum visitors over a period of several days (See Data Collection Section VI.1.2.). Table 1 includes all the ages and amounts of people interviewed.

Table 1. Male and Female Distribution

			Male			
Age Group	8-12	13-18	19-35	36-50	50+	Total
Number Interviewed	6	4	12	9	8	**39**
			Female			
Age Group	8-12	13-18	19-35	36-50	50+	Total
Number Interviewed	14	9	7	3	5	**38**

Each set of responses was then thoroughly analysed by the team for qualitative trends. For each question, we separated our analysis into three main stages. The first stage was an overall analysis of the entire sample's responses. The team performed this type of analysis to notice any general trends or overall patterns to the data. The second stage of analysis involved comparing responses from male visitors to the responses of female visitors. The team carried out this analysis to detect any inconsistencies with the overall data. The third stage of analysis included examining the responses from different age groups for both male and female respondents. This intricate process was an effective way to analyse each question's set of responses.

1.1 Analysis of Questions 1 and 2

1. *What sources of energy can you think of?*
2. *In what ways do you use energy in your daily life?*

The team included these questions for the purpose of discovering the visitors' perceptions about the sources of energy and how energy is used in daily life. Additionally, these questions acted as an opener to make the participant feel comfortable and willing to give honest responses. Overall, the sample had a fairly knowledgeable understanding of common energy sources. The renewable energy sources, particularly solar, wind, and hydro were the most frequently named sources. Nuclear was the third named source as seen in Table 2. Electricity was mentioned more often than the fossil fuels, which was a major misconception. Additionally, several visitors named invalid energy sources, such as industrial, paraffin, pressure, geological flight, and warp drive energy.

The visitors also had an accurate view of how energy is used in daily life. Transportation, electricity, heating, and cooking were the most frequently named ways in which energy is used in their life. Table 3 and Table 4 include the data for Question 2. The fifth most frequent response was that energy is used in every aspect in daily life, which is the most accurate outlook. Also, computers were mentioned more often than television. Every visitor was able to name at least one way in which energy is a part of his or her everyday life.

Table 2. Question 1 Results and Totals

	Male						Female						Over-all
Response	8-12	13-18	19-35	36-50	50+	Total	8-12	13-18	19-35	36-50	50+	Total	
Solar	6	3	7	4	2	22	8	6	3	3		20	42
Hydro	3	2	7	4	5	21	5	4	5	2	3	19	40
Nuclear	4	2	7	3	4	20	7	4	5	2	2	20	40
Wind	4	1	6	5	6	22	6	3	5		2	16	38
Electrical	1	1	5	3	3	13	3	4	2	4	4	17	30
Coal	4	1	6	2	3	16	5	3	2		2	12	28
Gas	2	2	7	3	2	16	3	1	1	1	5	11	27
Oil	2	1	5	3	2	13	2	3	1		1	7	20
Fossil Fuel	1		5	2	1	9	2	3				5	14
Heat			2	1	2	5	3	1			2	6	11
Light		1	1		2	4	3	2			1	6	10
Steam			2	2	2	6	2	1			1	4	10
Wave	2		1	2	1	6	3		1			4	10
Kinetic			1	1	1	3		3				3	6
Chemical		1				1	1	3				4	5
Potential	1		1		1	3		2				2	5
Tidal		1		2	1	4	1					1	5
Wood	1		1	1	1	4					1	1	5
Fuel				1		1			2		1	3	4
Animal			1			1		1			1	2	3
Geothermal	1					1	1		1			2	3
Gravitational	1				1	2		1				1	3
Organic			1	1		2		1				1	3
Petrol				1	1	2					1	1	3
Biological							2					2	2
Sea				1	1	2							2
Alcohol								1				1	1
Bike Generators							1					1	1
Body								1				1	1
Combustion										1		1	1
Diesel											1	1	1
Flight			1			1							1
Food								1				1	1
Geological				1		1							1
Human											1	1	1
Industrial			1			1							1
Life					1	1							1
Magnetic			1			1							1
Mass	1					1							1
Mechanical											1	1	1
Muscle								1				1	1
Paraffin											1	1	1
Plants								1				1	1
Power Station											1	1	1
Pressure		1				1							1
Pure		1				1							1
Sound					1	1							1
Thermal								1				1	1
Warp Drives			1			1							1
Waste								1				1	1
X-Ray					1	1							1

Table 3. Question 2 – Female Results and Overall Totals

	Female					Female	Overall
Response	8 to 12	13 to 18	19 to 35	36 to 50	50+	**Total**	**Total**
Transportation	10	4	3	1	4	22	47
Electricity	7	3	3		1	14	29
Heating	4	3	1	2	3	13	29
Cooking	5	2	1		5	13	27
Everything	4	4	3	1	1	13	22
Lighting	2	1	2	2	1	8	20
Computer	3		2			5	10
Movement	3	4				7	9
Television	1	1	2			4	8
Walking	1	1	3			5	7
Body		3		1		4	5
Gas						0	4
Shower	1	1	1		1	4	4
Domestic		1				1	3
Life		1				1	3
Machines		1				1	3
Power						0	3
Sunlight	1	1				2	3
Washing					1	1	3
Air Conditioners						0	2
Appliances		1	1	1	1	4	2
Cleaning	2					2	2
Fire	1					1	2
Fuel	2					2	2
Lifts					2	2	2
Microwave						0	2
Sleeping				1		1	2
Tea			1		1	2	2
Work						0	2
Biological						0	1
Business						0	1
Combustion						0	1
Construction						0	1
Entertainment						0	1
Factories						0	1
Fan						0	1
Flight						0	1
Iron					1	1	2
Listen to Music	1					1	1
Mechanical						0	1
Propellers						0	1
Refrigeration					1	1	1
Talking	1					1	1
Telephone		1				1	1
Ventilation						0	1

Table 4. Question 2 – Male Results and Totals

	Male					Male Total
Response	8 to 12	13 to 18	19 to 35	36 to 50	50+	
Transportation	2	2	8	7	6	25
Electricity	2	1	4	3	5	15
Heating	1	1	4	6	4	16
Cooking	2	1	2	5	4	14
Everything	2	1	4	1	1	9
Lighting	3		2	4	3	12
Computer	2		2	1		5
Movement	1			1		2
Television	3	1				4
Walking			1	1		2
Body			1			1
Gas			1	1	2	4
Shower						0
Domestic				2	1	3
Life			1	1		2
Machines			1		1	2
Power	1		1			2
Sunlight			1			1
Washing	1				1	2
Air Conditioners				2		2
Appliances			1			1
Cleaning						0
Fire			1			1
Fuel						0
Lifts						0
Microwave	1	1				2
Sleeping					1	1
Tea						0
Work			1	1		2
Biological				1		1
Business				1		1
Combustion				1		1
Construction				1		1
Entertainment					1	1
Factories			1			1
Fan	1					1
Flight				1		1
Iron						0
Listen to Music						0
Mechanical		1				1
Propellers				1		1
Refrigeration				1		1
Talking						0
Telephone						0
Ventilation			1			1

1.2 Analysis of Questions 3 and 4

3. *Could you name any energy sources that are used for generating electricity in the U.K.?*
4. *Which of these sources do you think provides the U.K. with the most electricity?*

The team designed questions 3 and 4 as knowledge-based questions to gauge how much the museum visitors know about the current U.K. energy situation. After providing several responses for question 3, the visitor selected one of those responses as the answer to question 4. In question 3, nuclear was the most frequent response. Fossil fuels and renewable sources were also frequently mentioned as seen in Table 5. Several participants said gave a response of "power stations" as a source of electrical participation. Also, several participants were unable to give an answer for various reasons. These visitors were most often from foreign countries and wished not to guess. These responses indicated a small misconception and a lack of knowledge about the United Kingdom's current energy situation.

Additionally, when asked to pick the most prominent source, most visitors were unable to pick the correct response of either oil or fossil fuels. Most participants chose Nuclear as the most used source of energy for U.K. electrical generation, as Table 6 shows. This question illustrated the depth of the visitors' knowledge about the current U.K. energy use situation and the level of misconception. While most visitors could describe the types of energy used to generate electricity in the United Kingdom, they could not name which source was used the most.

Table 5. Question 3 Results and Totals

	Male					
Response	8 - 12	13-18	19-35	36-50	50+	**Total**
Nuclear	4	2	10	6	8	30
Coal	3	1	7	5	5	20
Hydro	1		6	5	3	15
Wind	3	1	4	5	5	18
Gas	2	1	5	2	4	14
Oil	2	1	4	2	3	12
Solar	2	1	2	1		6
Fossil Fuels			1	3	3	7
Waves			2	2	1	5
Power Stations			2			2
Steam				1	1	2
Electrical						0
Fire						0
Heat				1		1
Light						0
Methane					1	1
Petrol				1		1
Tides				1		1
NO ANSWER		1	1			2

	Female						Overall
Response	8 - 12	13-18	19-35	36-50	50+	**Total**	**Total**
Nuclear	10	7	5	3	2	27	57
Coal	5	3	5	3	3	19	39
Hydro	4	3	4	2	3	16	31
Wind	3	4	1	1	3	12	30
Gas	6	2	1	2	4	15	29
Oil	1	2	2	1	2	8	20
Solar	1	5	1			7	13
Fossil Fuels		2	2			4	11
Waves	1	1				2	7
Power Stations	1					1	3
Steam	1					1	3
Electrical		1				1	1
Fire			1			1	1
Heat						0	1
Light	1					1	1
Methane						0	1
Petrol						0	1
Tides						0	1
NO ANSWER	1	1				2	4

Table 6. Question 4 Results and Totals

	Male					
Response	8 - 12	13-18	19-35	36-50	50+	**Total**
Nuclear	1	2	4	2	1	10
Coal	1		4	3	1	9
Gas	1	1	1	1	2	6
Fossil Fuels			1	2		3
Hydro	1			2	1	3
Oil	1				1	2
Electrical					1	1
Power Stations			1			1
Solar						0
Fire						0
Petrol						0
Steam						0
Wind	1					1
NO Answer	1	1	1		1	4

	Female						Overall
Response	8 - 12	13-18	19-35	36-50	50+	**Total**	**Total**
Nuclear	4	1	1	1		7	17
Coal	1	2	3	1		7	15
Gas	3		1		4	8	14
Fossil Fuels		3				3	6
Hydro	1			1		2	5
Oil					1	1	3
Electrical		1				1	2
Power Stations	1					1	2
Solar	1	1				2	2
Fire			1			1	1
Petrol			1			1	1
Steam	1					1	1
Wind						0	1
NO Answer	2	1				3	7

1.3 Analysis of Questions 5 & 6

5. *How much of the generated electricity in the U.K. comes from nuclear power?* 12% 26% 49% 74% 93%

6. *How much of the total energy consumed in the U.K. is used for transportation?* 4% 23% 31% 59% 88%

Table 7. Question 5 Results and Totals

Response	Male					
	8 to 12	13 to 18	19 to 35	36 to 50	50+	**Total**
12%	3		4	5	5	17
26%	2	3	3	3	1	12
49%			2	1	1	4
74%	1	2	2		1	6
93%						0

… = Correct Answer

Response	Female					
	8 to 12	13 to 18	19 to 35	36 to 50	50+	**Total**
12%	1	1	2	2	3	9
26%	5	5	2	1		13
49%	3	2	2		2	9
74%	5	1	1			7
93%						0

Overall Total
26
25
13
13
0

Table 8. Question 6 Results and Totals

Response	Male					
	8 to 12	13 to 18	19 to 35	36 to 50	50+	**Total**
4%			1	2		3
23%	1		1	3		5
31%	5	4	5	4	3	21
59%			4	1	4	9
88%					1	1

… = Correct Answer

Response	Female					
	8 to 12	13 to 18	19 to 35	36 to 50	50+	**Total**
4%			1	1		2
23%	3	3			1	7
31%	2	2	2		3	9
59%	7	4	4			15
88%	2			2	1	5

Overall Total
5
12
30
24
6

Questions 5 and 6 were knowledge-based questions presented in a multiple choice format. In question 5, approximately one third of the visitors chose the correct answer of 26%, as displayed in Table 7. No one chose 93% as the amount of electricity generated by nuclear power. In general, male visitors thought this percentage was lower. In question 6 almost half of the participants chose the correct response of 31% as being the percentage of energy in the U.K. used by transportation purposes, as shown in Table 8 above.

The team gained limited information from questions 5 & 6, since they were multiple-choice questions. Some of the correct responses could have been either educated or complete guesses. However, the team found that the visitor sample did have a relatively accurate knowledge of the current energy situation in the U.K.

1.4 Analysis of Questions 7 and 8

7. *Which of these countries do you think uses the most energy per person?*
8. *In what ways do you use energy in your daily life?*

The seventh and eighth questions were designed by the team to measure the visitors' awareness of global energy usage. When asked either question, the visitor was handed a list of 8 randomised countries (See Appendix B.2.). The visitor then picked one of the countries. Upon analysis, the team found that question 7 revealed a major misconception the visitors had. As seen in Table 9, almost all of the participants believed that the United States was the country that used the most energy per person, when in fact Iceland, Luxembourg, and Canada use more energy per person mainly due to heating needs. The only participants to name either Canada or Luxembourg were 8-12 year olds. No visitors picked the correct answer, Iceland. As seen in Table 10, almost all participants chose the United States as the country that uses the most energy as a whole, which was the correct answer.

Table 9. Question 7 Results and Totals

	Male					
Response	8 - 12	13-18	19-35	36-50	50+	Total
Russia						0
Iceland						0
Luxembourg	1					1
United States	3	3	12	7	8	33
China						0
Canada	1					1
Brazil						0
United Kingdom	1	1		1		3

... = Correct Answer

	Female						Overall Total
Response	8 - 12	13-18	19-35	36-50	50+	Total	
Russia		1	1			2	2
Iceland						0	0
Luxembourg						0	1
United States	12	6	6	3	5	32	65
China	1					1	1
Canada	1					1	2
Brazil						0	0
United Kingdom		2				2	5

Table 10. Question 8 Results and Totals

	Male					
Response	8 - 12	13-18	19-35	36-50	50+	Total
Russia				2		2
Iceland						0
Luxembourg						0
United States	6	3	10	5	8	32
China		1	2			3
Canada						0
Brazil						0
United Kingdom				1		1

... = Correct Answer

	Female						Overall Total
Response	8 - 12	13-18	19-35	36-50	50+	Total	
Russia						0	2
Iceland						0	0
Luxembourg						0	0
United States	13	7	6	3	5	34	66
China		2				2	5
Canada						0	0
Brazil	1					1	1
United Kingdom			1			1	2

1.5 Analysis of Question 9

9. On a scale of one to five, where one is not interested at all and five is very interested, how interested would you be in finding out about the following:

A. Different energy sources used around the world?
B. The amounts of energy that different countries use?
C. How energy use might change in the next 20 years?
D. When and which energy sources might run out first?

Table 11. Question 9 Results and Totals

	A. Male					
Response	8 - 12	13-18	19-35	36-50	50+	**Total**
1			1		1	2
2		2		1	1	4
3	3		6		1	10
4	2		3	3	2	10
5	1	1	2	5	2	11

	Female						Overall
Response	8 - 12	13-18	19-35	36-50	50+	**Total**	**Total**
1		1	1		1	3	5
2						0	4
3	3		2		2	7	17
4	6	6	3	4	2	21	31
5	5	3	1			9	20

	B. Male					
Response	8 - 12	13-18	19-35	36-50	50+	**Total**
1		1		1	1	3
2			3	1	2	6
3	1	1	2	1	1	6
4	4	1	5	3	3	16
5	1		2	3		6

	Female						Overall
Response	8 - 12	13-18	19-35	36-50	50+	**Total**	**Total**
1		2	1		1	4	7
2	2		1		1	4	10
3	2	3	2	2	1	10	16
4	6	5	1	1	2	15	31
5	4		2	1		7	13

Table 11. Question 9 Results and Totals (Continued)

C.	Male					
Response	8 - 12	13-18	19-35	36-50	50+	Total
1					1	1
2		1		1		2
3		1	2			3
4	2	1	5	1	4	13
5	4		5	7	2	18

	Female						Overall
Response	8 - 12	13-18	19-35	36-50	50+	Total	Total
1		1	1			2	3
2						0	2
3	2	1			2	5	8
4	3	2	1		1	7	20
5	9	6	5	4	2	26	44

D.	Male					
Response	8 - 12	13-18	19-35	36-50	50+	Total
1	1	1			1	3
2			1			1
3	1		3	2		6
4	2	2	5	2	3	14
5	2		3	5	3	13

	Female						Overall
Response	8 - 12	13-18	19-35	36-50	50+	Total	Total
1			1		1	2	5
2		2				2	3
3	1	1			1	3	9
4	6	4	1			11	25
5	7	3	5	4	3	22	35

The team included question 9 in the interview to gauge visitor interest levels in various aspects of energy use. Question 9 generated limited conclusions, as this was strictly an interest scale question. Ben Gammon, head of visitor research, at the National Museum of Science and industry suggested caution when using such an interest-based question since visitors often don't know exactly what they might find interesting. As seen in Table 11, topic C was found to be the most interesting while topics A, B and D were found to be the less interesting. The team found this question to be only mildly effective, but took its results into consideration when deciding on content.

1.6 Overall Analysis of Survey

Upon completion of the front-end analysis, the team examined the overall effectiveness of the interview. The team had accurately assessed the visitor awareness on a variety of energy topics, including U.K. energy use, global energy use, energy sources, energy and its role in everyday life, and interest in energy aspects. The team found this survey to be quite effective and was vital for content development. The team was confident with the quality of the data, although there might have been slight biases with the 50+ age group (See Section IX.1). When comparing male and female responses, as well as age groups, the data were consistent with the overall trends, concluding that the results were not biased. Overall, the team found the front-end evaluation to be extremely effective to the overall project.

2. Exhibit Development

When the interview process was finished and all of the data were interpreted, the content and themes of the online exhibition were developed. Elements of the opening animation and main index page were developed during the interview process, but most all of the interactive features were designed with the interview results taken into consideration.

2.1 Web Site Components

2.1.1 Opening Animation

The team used Macromedia Flash to create a vivid animation welcoming visitors to the gallery and displaying animation techniques. The animation is not interactive and is just for the entertainment of the online visitors.

When online visitors first load the web site they are presented with a plain page that gives them the choice to play the introduction or skip right to the index of the site. If the viewer chooses to play the introduction, the animation will load. The animation starts with space background and a picture of the sun that moves across the screen and shrinks, as the sun moves away, the Earth moves in from the right. At this point eight energy icons, in a circle, come from the back of the screen and then change colours individually as the name of the energy source is displayed. The sources include fossil fuels, nuclear, solar, and biomass to among others. The icons then break out of the circle into lines as another line of six icons moves onto the screen. These icons are pictures of people representing different races and both sexes. All three lines then fade into the words "World Energy Use." The title then fades away and the elements of the main index page move or fade onto the screen. Colour screen shots of parts of the animation are included in Appendix D.1.

The team developed the animation by first deciding on elements and ideas that we wanted to include. Those ideas were then put into a simple storyboard for organisation, so elements could be created independently. All of the icons and elements were created and then assembled together into the animation. As the team moved forward the specific design and motions used in the animation evolved into the final product.

2.1.2 Main Index Page

The main index of the web site is the part of the site that people will use to navigate the site. This page has links to most all the other parts of the web gallery. The background of the page is the last frame of the opening animation, which is the earth on the right side and the sun in the distance on the left. There is a title at the top of the page as well as a welcome statement. There are links to games and animations on the right of the screen and links to the non-Flash site and science museum on the bottom of the page. Also, on the bottom of the main index page the energy source icons from the opening animation are located as links to more information on those sources in the non-Flash site.

The main index page was created in Flash and HTML. The look of the page was derived from the opening animation and includes many of the same elements. The links included are all the necessary links to navigate the site fully as well as to the non-Flash site and back to the Science Museum. Screen shots of the main index page can be seen in Appendix D.2.

2.2 Interactives

2.2.1 "Who Wants to be Top of the Class?"

The team decided to develop an energy quiz to let visitors test their own knowledge. The user is asked a series of questions that relate to world energy use. As visitors answer the questions, they move up the ladder of grades. The questions all relate to either common misconceptions or interesting facts that were generated during the content development stage. After each correct question, a fun fact is given to relate the answer to everyday life. One example of this is when answering a question about the amount of energy that the U.S. uses yearly, the user is rewarded by displaying the equivalent number (45 Trillion) of Mars bars required to provide the same amount of energy. Screen shots of "Who Wants to be Top of the Class" can be seen in Appendix D.3.

2.2.2 "Design Your Own Energy Efficient Country"

This interactive game was based on similar interactives around the museum floor. All of the games allowed the visitors to create different objects such as a rocket, a shirt, or a bicycle. In "Design your own Energy Efficient Country", the user is given an option of choosing one of three different countries to rule. Each country has different resources, population, and wealth. The user then chooses either nuclear, oil, or wind as the main source of energy. They must also choose a secondary source of energy. After a short synopsis of how the country spent its money on the power plants, time is advanced 50 years. An animation is displayed representing how the country fared with the chosen power sources. There are both winning and losing scenarios. Screen shots of "Design Your Own Energy Efficient Country" can be seen in Appendix D.4.

2.2.3 "An Energetic Future"

"An Energetic Future" focuses on the future of energy in the year 2020. The user is presented with a representation of the amount of oil, nuclear, gas, or overall electricity use in the year 2000. They are then asked to predict what they think the amount will be in 2020. This is done by dragging representative symbols into a pile until the user feels that it is the right amount. The user is then shown the correct amount based on the International Energy Outlook 2000 and given more information about future predictions. Screen shots of "An Energetic Future" can be seen in Appendix D.5.

2.2.4 "Fun Facts"

This exhibit was designed by the team to display numerous fun, exciting, and interesting facts about world energy use. The screen simply displays one fun fact at a time; the user can either cycle forwards or backwards through the facts. The only other option the user has is an exit button that leads back to the main index page. Due to the relatively high visitor interest, a majority of the facts dealt with how world energy use might change in the future. This activity was relatively easy to fabricate using Flash due to its low level of interactivity.

The transitions between the facts each consist of a small Flash animation, such as a simple fade or movement across the screen. The intent of this exhibit was to display a relatively large amount of information in an interesting manner. Since each fact is intended to be unusual, surprising, or appealing in some fashion, the user becomes motivated to view more of them. While some users might only read a few of the facts before exiting, other viewers might be compelled to cycle through all of the facts. Screen shots of "Fun Facts" can be seen in Appendix D.6.

2.2.5 "Energy Size-O-Matic"

The "Energy Size-O-Matic" was an activity designed by the team to show the relative scale of energy use in different countries. The goal of this interactive was to teach viewers about energy use and dispel misconceptions. The activity was in the form of a series of animations that the online visitor can navigate. These animations simply resize objects on the screen relative to their energy use. There are two main groups of animations that the visitor can chose to watch, the sizing of objects and the sizing of countries.

The *object* section resizes the sectors of energy use, homes, businesses, and transportation, for several different countries. The countries included were the United Kingdom, the United States, China, and Iceland. These countries were chosen because they seemed of particular interest to the viewers and gave a good cross-section of energy use.

The *country sizing* section sizes four countries on the screen to the relative size of the amount of energy that each country uses per person. The same four countries were used in this section as well. The U.K. was chosen because it is the home to most of the viewers and it is important to give the visitor something to relate to. The U.S. and China were included because they are at opposite ends of the spectrum of energy use. Iceland was also included to dispel the misconception that the United States uses the most energy per person, as it uses the most.

When the online visitor chooses one of these animations they see the Size-O-Matic come on to the screen and resize the pictures. The Size-O-Matic itself is a fun, colourful machine that lights-up and shoots a light beam at the objects on the screen. Once hit by the light beam the objects grow or shrink to the required size. When all the objects are resized the Size-O-Matic rolls off the screen and a block of text appears to explain to the viewer why the objects were sized the way they were. The actual statistics for those objects, including percentages, are also in the text. Restart and exit buttons are included throughout the game to make navigation easy. Screen shots of "Energy Size-O-Matic" can be seen in Appendix D.7.

2.3 Non-Flash Version, Source Descriptions, Miscellaneous

Although excessive text can be confusing and uninteresting to the visitor, lack of information can also be a drawback. The non-Flash version, or text version, of the virtual exhibit provides visitors with more in-depth information about each of the ten energy sources. As the visitor enters the site, s/he is presented with a graphical menu of energy sources. We organised the sources into two categories of renewable and non-renewable. Each of the energy sources was further divided into four sections: "history", "how does it work?", "distribution", and a section discussing the use of this source in the United Kingdom. We decided to divide the information about each source into four sections in order to present the material in an organised and logical manner. Besides the textual information, we included pictures to demonstrate ideas and concepts. As the user rolls the mouse over an image, an explanation of the picture appears near the cursor.

The non-Flash site includes a toolbar at the top of the screen to allow easy navigation throughout the pages. Another feature of the site is the site map that encompasses both the Flash and the non-Flash versions of the exhibit. The site map is organised into categories and provides every link available on the sites.

There is also an "About/References" page linked from the toolbar that briefly describes the reasons behind the design of the site and provides a comprehensive list of references that were used to present the material and images throughout the site.
An introduction page accessible from the site map encompasses both the Flash and non-Flash sites and addresses major questions that the exhibit tries to answer. Screen shots of the text version and its components can be seen in Appendix D.8.

3. Data Analysis of Summative Evaluation

The project's third objective was to design and implement a summative evaluation to learn of any content or technical problems within the virtual exhibit. When we finished the prototype versions of the games, activities, and website components of the virtual gallery, we developed a questionnaire for the evaluation. The team conducted this survey using the same data collection guidelines as in the front-end evaluation. The format of this survey included a brief introduction, a web exhibit viewing period, and a post-viewing interview. During the viewing period, the user had an unlimited time to explore the website, play the games and activities, and learn more about world energy use. While the visitor explored the website, the team member recorded any problems encountered. Afterwards, the team member asked the participant questions about the website. These questions can be found in Appendix C.1.

The team performed the evaluation during one full day during the London school system's half-term. During half-term all schools are on holiday for a week, and large numbers of families visit the museum. The museum often plans for multiple evaluations during this week, so the team had to reserve the day and gallery where the evaluations were to take place. Throughout the day, the team performed 32 evaluations, mostly with children from the ages of 8 to 12 years accompanied by their parents. Overall, the website prototype was a success and the visitors enjoyed the exhibit. After conducting the summative evaluations, the team analysed the results to generate a list of both content and technical problems. The team then prioritised the problems, and solved them accordingly. While there were several technical problems found, none of the games needed drastic modifications. A detailed list of these problems can be found in Appendix C.2.

XI. Conclusions

1. Project Problem, Goals, and Objectives

The National Museum of Science and Industry wished to create a virtual gallery on world energy use containing a series of educational and interactive exhibits. The museum also wished to gain an understanding for the average museum visitors' knowledge concerning world energy use. The team organised the project goal as consisting of three main objectives. The team's first objective was to conduct a front-end evaluation on the museum floor to find out visitors awareness of the concept of energy and about world energy use. Our second objective was to develop all elements of the online gallery, including the main index site, the interactives, and the non-flash version. Our final objective was to perform a summative evaluation of the online exhibition by testing the prototype on gallery with visitors. This three-staged process helped the team to decide and refine the content of the online gallery and its interactive exhibits.

2. Project Conclusions

From both the front-end and summative evaluations, the team discovered several trends in visitor perception and interactive education. By first performing Visitor Awareness Training, we gained a general understanding for the needs and expectations of the average museum visitor. We also learned of the various and unusual ways in which visitors can perceive exhibits in the museum. Most importantly, the team gained experience in developing interview protocols that would help us perform our evaluations.

Also, the team gained valuable interviewing experience when executing the evaluations on gallery.

Through the analysis of the front-end evaluation, the team developed a comprehensive view of how an average visitor thinks of energy as a part of his or her daily life. The team concluded that most visitors have an accurate view of what energy is and what types of energy sources exist. Additionally, most visitors understand how important energy is in their daily lives. A majority of the visitor sample was knowledgeable in the current U.K. energy use situation. Visitors could easily name the energy sources used for generating electricity in the U.K. Roughly half of the visitor sample knew the correct percentage of energy used for transportation in the U.K. Finally, almost all of the visitors knew that the United States used the most energy as a whole country. Overall, we concluded that visitors were both knowledgeable of energy concepts and informed about current world energy topics.

The team also found, however, that visitors had several common misconceptions about energy. Some visitors perceived electricity as a source of energy, while in fact it is not. Throughout their daily lives, people see their energy coming from electrical outlets and not from the fossil fuels used to deliver that energy to their home. Also, while most visitors knew of which energy sources were used for generating electricity in the U.K., most visitors did not know which source was used the most for this purpose. Finally, almost all visitors had misconceptions about which country used the most energy per person. Nearly all visitors confidently believed the U.S. used the most energy per person, when in fact this was incorrect. Iceland, Luxembourg, and Canada used more energy per person than the United States; all three countries were choices on the questionnaire.

In developing and testing the online interactives, the team concluded that the most effective way to convey information though an exhibit was to make it as personal, interesting and fun as possible. Interactivity generates curiosity, which lengthens the time a visitor will spend operating an exhibit. The team found that this could best be achieved in a simple feedback process. Having a feedback process entailed three steps: command, animation, and information (Schneiderman 1998). After the visitor makes a command, something animated and visually exciting happens which interests the visitor. Next, the interactive presents interesting factual information that the visitor will most likely remember. During the summative evaluation, the team concluded that all of the interactives were successful. Overall, the visitors enjoyed the exhibit. While we discovered several technical problems, none of the exhibit was in need of drastic changes.

3. Recommendations for Further Development

While the team was very satisfied with what we developed, we believe that the exhibit can be enhanced in several ways. The team recommends three main improvements to the virtual gallery. First, the current games and activities could be modified in either content or layout to make them more appealing. For example, more facts could be added to "Fun Facts." New questions could be incorporated into "Who Wants to be Top of the Class." Perhaps in "Design Your Own Energy Efficient Country," more options could be integrated into the game. In addition to a "See how your country is doing in 50 years" option, a 100 year option and a 200 year option would enhance the game considerably.

A second improvement would entail the integration of sound into the exhibit. The addition of sound effects would increase the quality of the games, and an audio narration of the exhibit would aid those visitors with either visual or reading impairments. If the museum staff decides to incorporate sound, however, they should be cautious of the increases in file size.

Finally, new games focusing on different aspects of world energy use could be developed. The museum should continue to look for new energy use trends and new sources. As information becomes available, the website and interactives should be updated accordingly. If the exhibit was left alone, it would be out of date in less than a few years. By updating it regularly, the information will be kept current and accurate.

The Non-Flash version of the website contains a large amount of information about energy sources and world energy use. This area could benefit, however, by having even more information and statistics about energy use, as provided the information was divided well, easy to understand, and relevant to the majority of online visitors. Additionally, the Flash activities and games could contain "More Information" buttons to direct visitors to the text version.

To aid the museum in updating the information and adding to the current information, we created a list of references. We compiled all of the sources that we used to find information that went onto the website. Each source was accompanied by a summary of the information that was available there. This reduced the amount of searching the museum staff would have to do. It also made the information more consistent since it was coming from the same sources.

4. Summation of Project Importance

The Science Museum believed that it was necessary to create a gallery on energy to educate the public. The staff thought that the average museum visitor could benefit from learning more about energy and energy use. This project was important because it will serve to educate many people on the topic of world energy use in an interesting manner.

To deliver the final product, the project involved use of different methods of presentation and qualitative research. The team conducted qualitative interviews in order to accommodate the needs of visitors the best possible way. Through a survey, we found what the visitors did and did not know, and what would be interesting for them to learn. Then, based on the input from the front-end evaluation, we created an interactive exhibit that provides visitors with valuable information presented through entertaining activities.

In order to produce the level of interactivity necessary, the team made use of Macromedia Flash software package. The virtual gallery was web-based, so it could accommodate both visitors that have access to the museum and those who do not or simply wish to visit the online exhibition. The exhibit was designed with flexibility, allowing the museum staff to change or update the content as necessary. Since the virtual gallery was delivered to the museum staff in a way which would be easy to integrate with the museum's main website, the staff expected the exhibit to be available to the public within four to six weeks after the project's completion.

XII. Appendices

Appendix A. National Museum of Science and Industry Mission Statement

The following is the mission statement of the National Museum of Science and Industry in London (NMSI), England. The statement is a direct quote from the museum and was developed though a collaborative effort to procure a mission statement.

"The Museum exists to promote the public's understanding of the history and contemporary practice of science, medicine, technology, and industry. Education implicit in the NMSI's mission is the use of the collections for a variety of educational purposes, for specialist scholars, particular educational groups, and the general public. This use of collections is extended and complemented by interactive exhibits and programmes that bring visitors in different ways into contact with the issues, processes and content of science, medicine, technology, and industry.

The core objective relating to this is to interpret the collections and engage the public in the contemporary issues of science, medicine, technology, and industry.

In order to engage with the visitor we seek to place the visitor, or learner, at the centre of the process and emphasise first-hand rather than mediated experience, active discovery rather than passive instruction, and the development of understanding in context rather than the abstract comprehension of scientific ideas. These principles build on the particular strengths of the NMSI, which lie in its collections and exhibitions, its long-standing expertise in the interactive or 'hands-on' techniques, and its expertise in informal interpretation in the galleries through, for example, explainers, actors, and warder-guides.

The approach is one that seeks to inspire the visitor and to create memorable environments and experiences that open people's minds to new ideas, new perspectives, and questions. The objective is to stimulate discussion and through, during the visit and subsequently, from which learning takes place.

The NMSI takes its place as a key institution for informal education. It provides means for visitors to develop the scientific and technological understanding that is a part of our contemporary culture so that they can participate more effectively in modern society, as voters, decision-makers, private consumers of science and technology, and as employees."

-The National Museum of Science & Industry
Collaborative Staff
London, England

Appendix B. Front-end Evaluation

Appendix B.1. Front-end Evaluation Questions

Age Group:	8-12	13-18	19-35	36-50	50+
Sex:	M	F			

Introduction:

"Hello, my name is ..... and I am doing some research for the Science Museum on an upcoming gallery on energy. We are asking visitors a few questions about energy to help us plan the exhibition. This is a not an exam in any way. There are no right or wrong answers; we would just like to get your opinions on some of the content. It should only take five minutes. Would you like to help?

Thank you.

1. What sources of energy can you think of? [Do any others come to mind?]

2. In what ways do you use energy in your daily life? [Do any others come to mind?]

3. Could you name any energy sources that are used for generating electricity in the U.K.? [Any more]

4. Which of these sources do you think provides the U.K. with the most electricity?

5. How much of the generated electricity in the U.K. comes from nuclear power?

   12% 26% 49% 74% 93%

6. How much of the total energy consumed in the U.K. is used for transportation?

   4% 23% 31% 59% 88%

7. Which of these countries do you think uses the most energy per person?

8. Which of these countries do you think uses the most energy as a whole?

9. On a scale of 1-5, where one is not interested at all and five is very interested, how interested would you be in finding out about the following:

   -Different energy sources used around the world?
   1 – 2 – 3 – 4 – 5

   -The amounts of energy that different countries use?
   1 – 2 – 3 – 4 – 5

   -How energy use might change in the next 20 years?
   1 – 2 – 3 – 4 – 5

   -When and which energy sources might run out first?
   1 – 2 – 3 – 4 – 5

Appendix B.2. List of countries for Questions 7 and 8

Russia

Iceland

Luxembourg

United States

China

Canada

Brazil

United Kingdom

Appendix C. Summative Evaluation

Appendix C.1. Summative Evaluation Questions

Age Group: 8-12 13-18 19-35 36-50 50+
Sex: M F Approx. time viewing:

Hello my name is…. And I work for the Science Museum. We are asking people to try out a new interactive website today. We would like people to use the site for a few minutes and then answer a few questions. This is not a test; we are just interested in your opinion. Would you like to help? Thank you.

Please take your time and look at the page as long as you wish. I am going to be watching to see you how you use the site. After you are finished I will ask you a few questions.

1. Which part of the exhibit did you like the most?

   1a. Why? [What did you like about that?]

   1b. Was there any other part that you liked? [Why?]

2. Which part of the exhibit did you like the least?

   2a. Why? [What could we do to improve it?]

3. Did you find any problems with this exhibit?

   3a. What was the largest problem?

4. Did you find any problems with the site navigation?[What?]

5. Did you find anything difficult to understand? [What?] [Anything else?]

6. Did you find any problems with the colors or graphics? [What?]

7. Did you find anything surprising in the exhibit?[facts, stats, things not included]

8. Do you have any other comments on the web site?

Appendix C.2 Summative Problems

"Who Wants to be Top of The Class"

- The final exit button after the A+ question does not work. [High Priority - Problem was solved.]
- There was a grammatical error and a spelling error in the C+ question. [High Priority – Problem was solved.]
- There was a spelling error in the A- question. [High Priority – Problem was solved.]

"Design Your Own Energy Efficient Country"

- On the country selection screen, visitors tried to click on the country icons rather than clicking on the text below [High Priority – Problem was solved. The country icons were converted to buttons that perform the same action as the text below.]
- In the country statistics during the country selection screen, the green text blended in with the darker green background. [High Priority – Problem was solved. The text was changed to white.]
- In the Breezeland/ Wind/ Nuclear combination, the animation does not completely clear the screen. [High Priority – Problem was solved.]
- Visitors confused the "Start Over" button with the "Try Again" button and often had to watch the opening animation repeatedly. [Medium Priority – Problem was solved. The "Start Over" button was removed from all scenes. The team decided it was not necessary to include the option of starting over.]
- The stick figure in winning animations appeared to be dead. [Low Priority – Problem was solved. Stick figure was modified to be sitting up. Also, the words "Good Job" were added.]

"Energy Size-O-Matic"

- On the light blue background, the white text was difficult to read. [High Priority – Problem was solved. The text was changed to black.]

“An Energetic Future”

- Several visitors failed to understand the “Blue Icon” concept. [High Priority – Problem was solved. The instructional text now appears in both the instructional screen and the prediction screen.]
- The drag and click concept was sometimes misunderstood. [High Priority – Problem was solved. The blue icon was changed to include a text overlay reading “Drag from Here.” Also, there is a black vertical line dividing the prediction screen in half. The words “Expert Prediction” and “Your Prediction” were added at the top of the screen in their respective halves.]

“Fun Facts”

- Graphics were suggested to improve the quality of the facts. [Medium Priority – Problem was solved. Several graphics were incorporated into this activity.]

Main Index Page

- One user tried to double click on buttons, which would make the button action cancel. [Low Priority – Problem was solved. In the welcome screen, the words “click on the…” were changed to “single click on the…”]

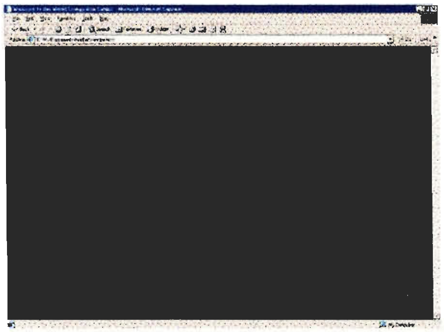
Text Version

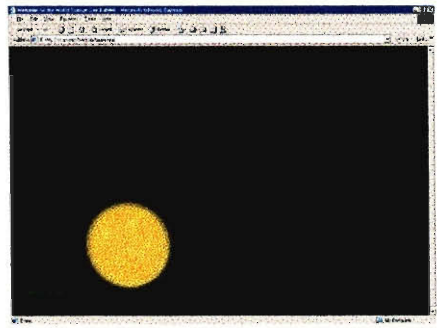
- After visiting an energy source description, the user had trouble navigating back. The icons at the top of the text version screen were confusing. [High Priority – Problem was solved. Picture icons were converted to text icons.]
- Visitors misunderstood the “Home” button to be the Flash version link, not the text version link. [High Priority – Problem was solved. “Home” was changed to refer to the Flash Verison and “Index” was changed to refer to the text version index page.]

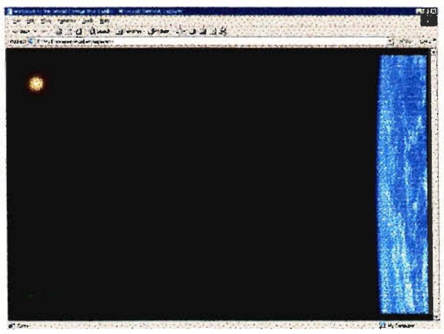
Appendix D.   Screenshots

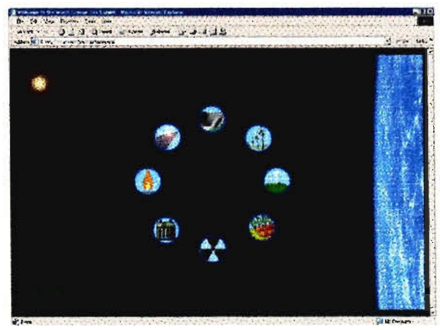
Appendix D.1 Opening Animation

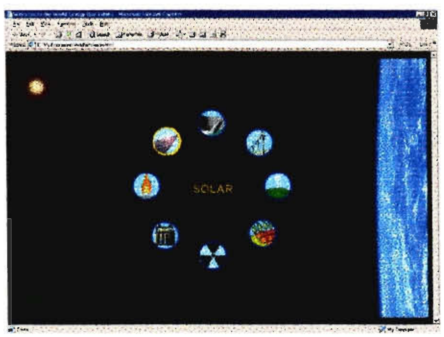
Primary Developers: James Partridge & Zachary Swick

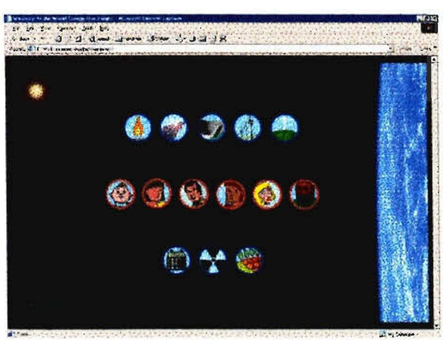


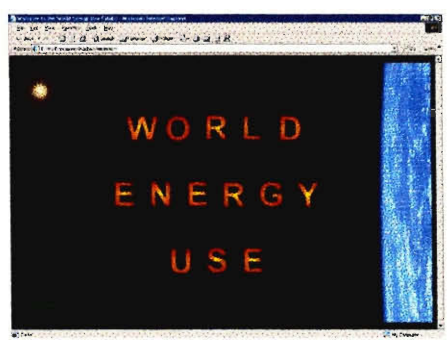






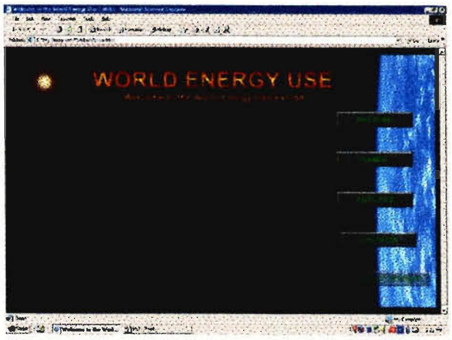


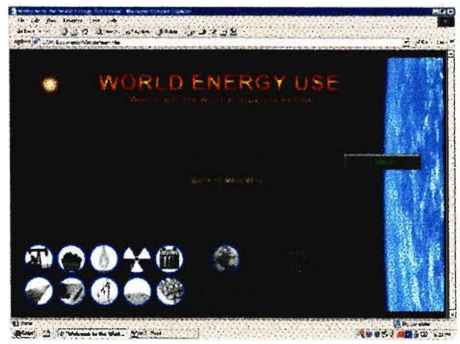


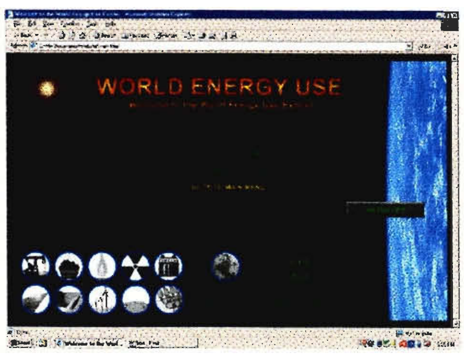


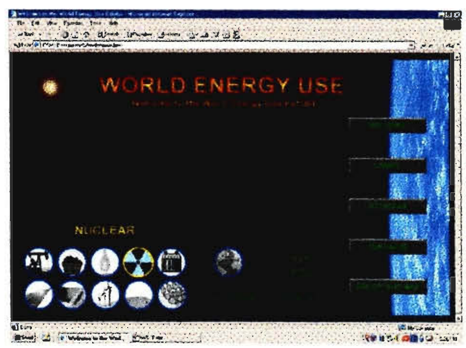
Appendix D.2 Main Index Page

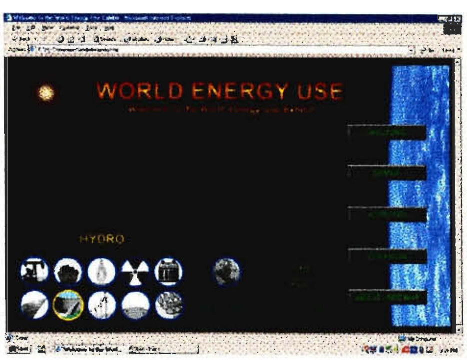
Primary Developer: James Partridge





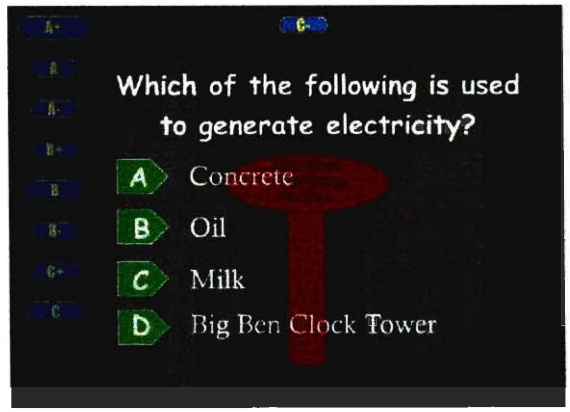


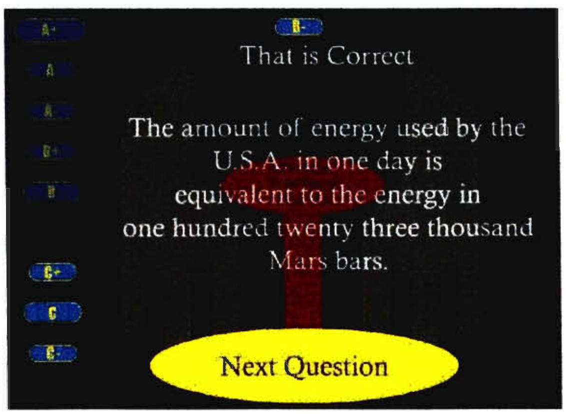


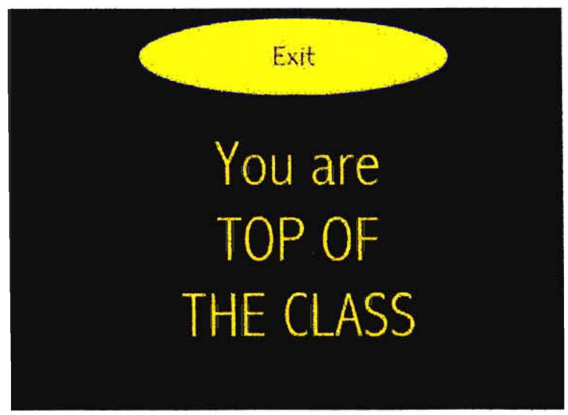


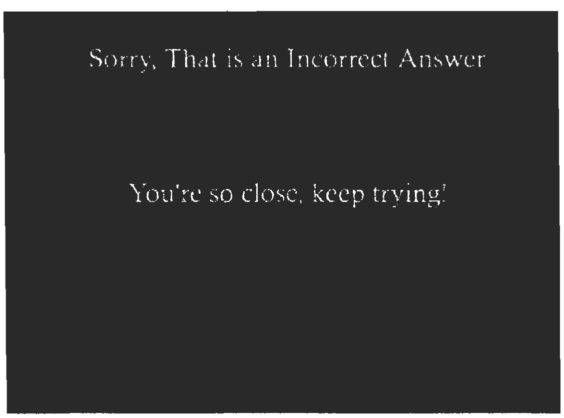
Appendix D.3 "Who Wants to be Top of the Class?"

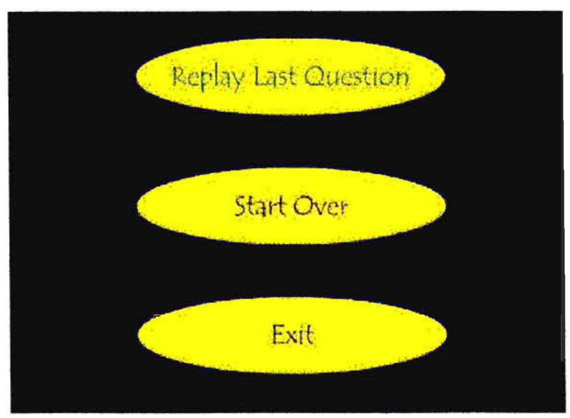
Primary Developer: Brian Pitreau





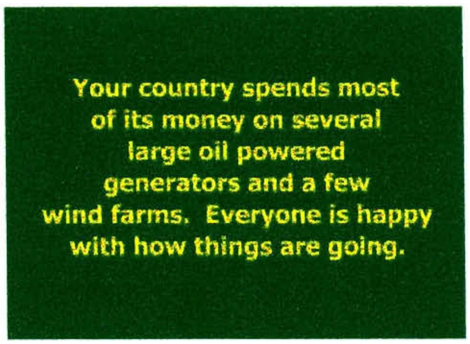


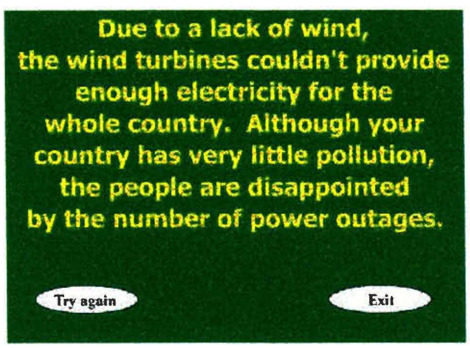


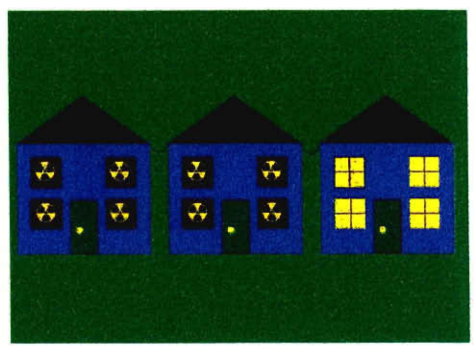


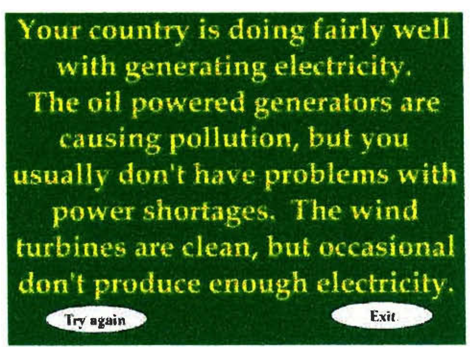
Appendix D.4 "Design Your Own Energy Efficient Country"

Primary Developer: Brian Pitreau



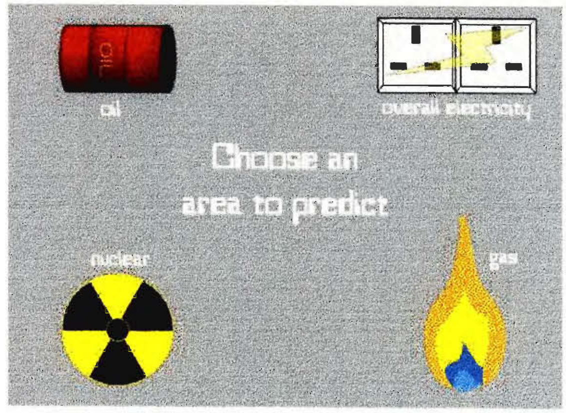


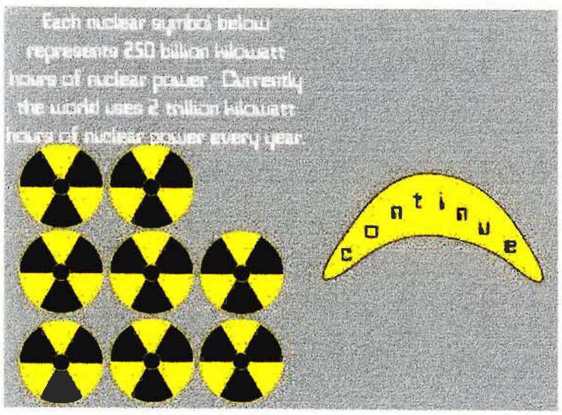


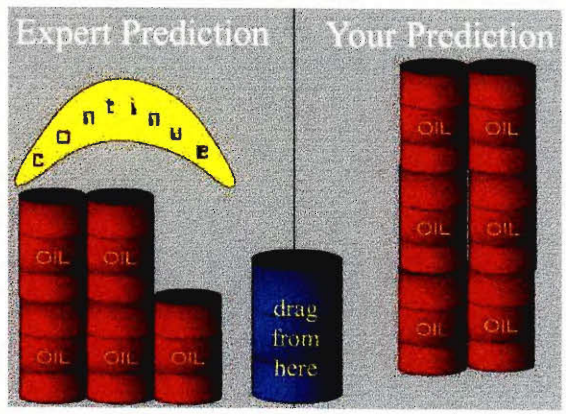


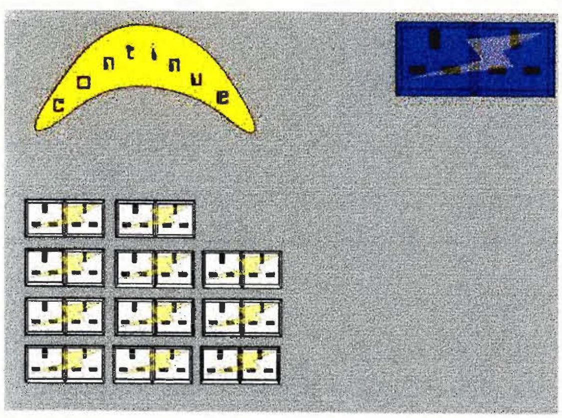
Appendix D.5 "An Energetic Future"

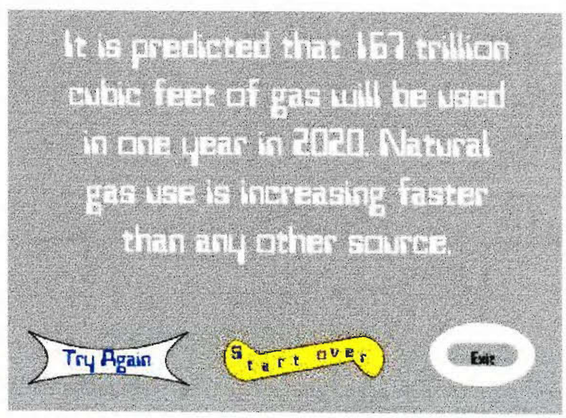
Primary Developer: Brian Pitreau





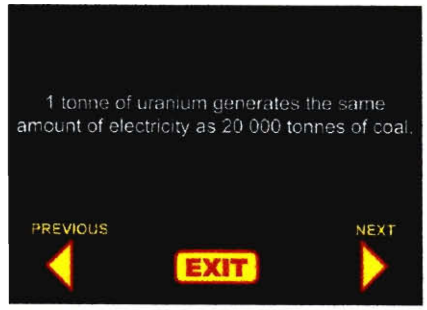


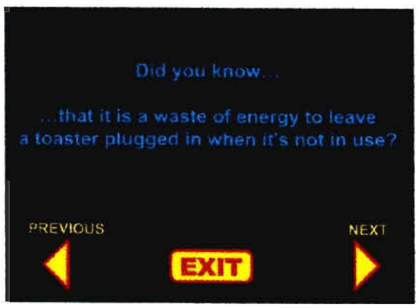


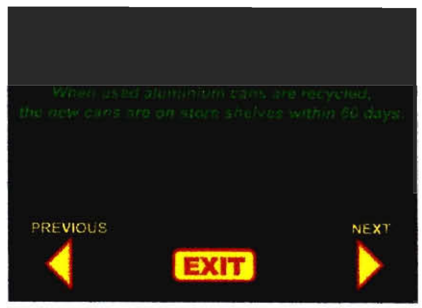


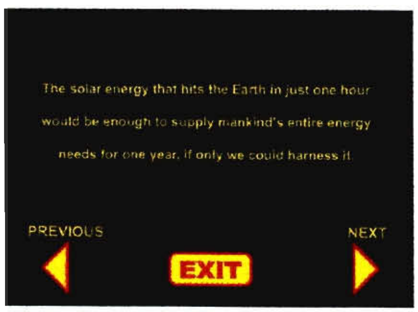
Appendix D.6 "Fun Facts"

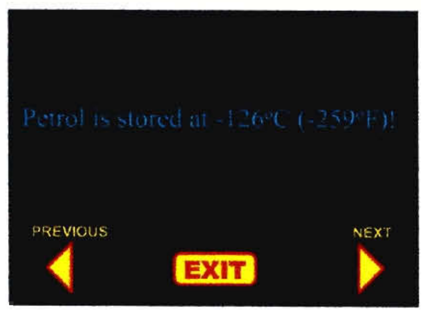
Primary Developer: James Partridge

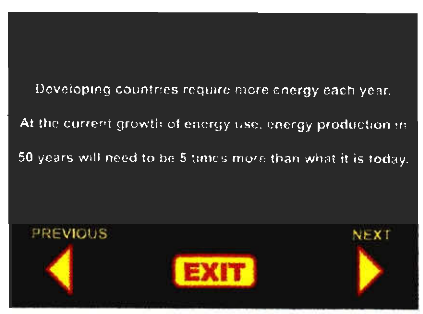






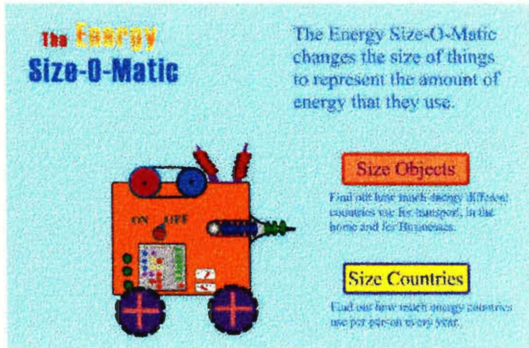


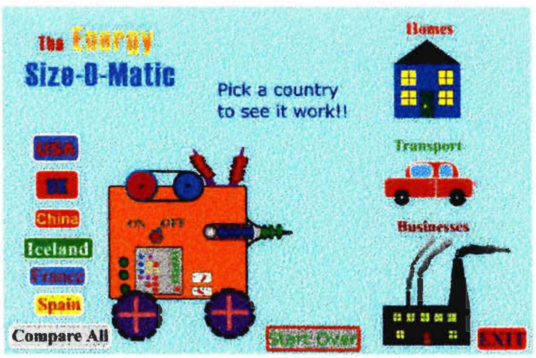


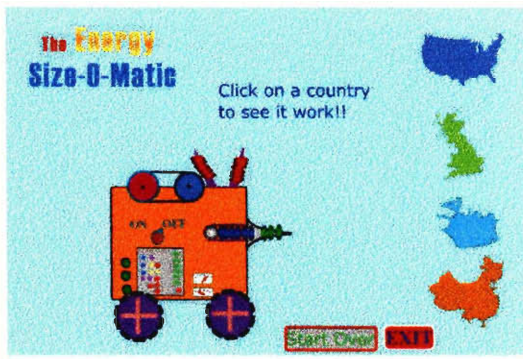


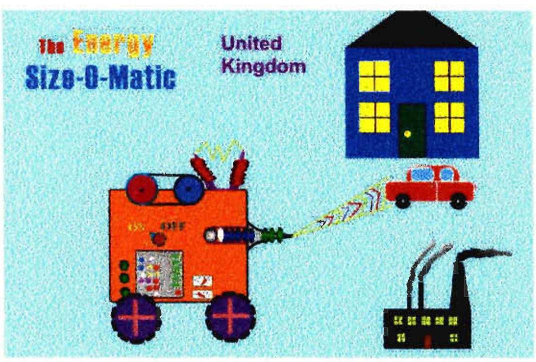
Appendix D.7 "Energy Size-O-Matic"

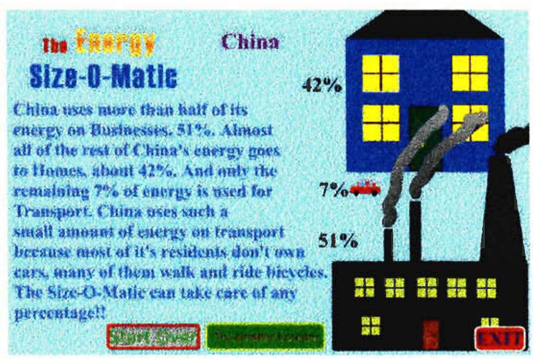
Primary Developer: Zachary Swick

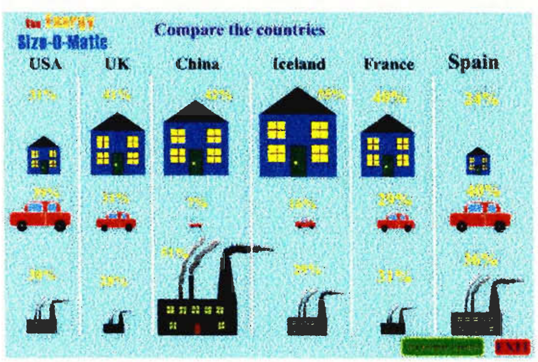


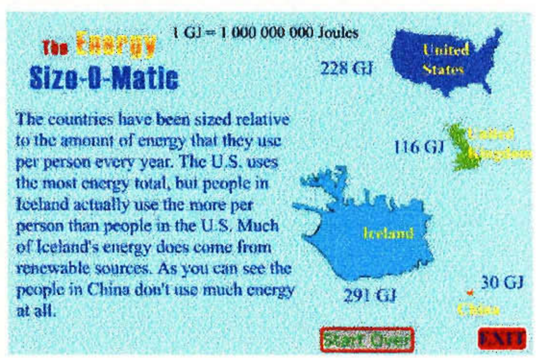






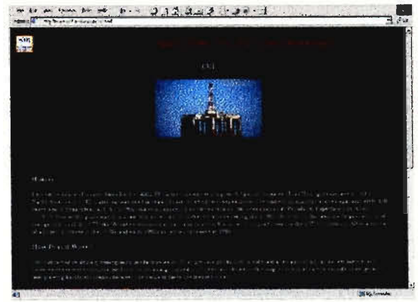


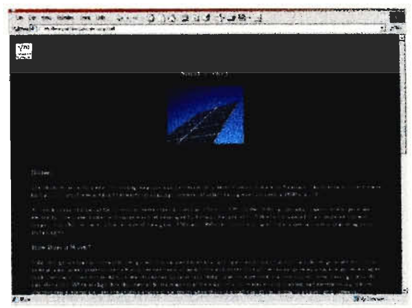


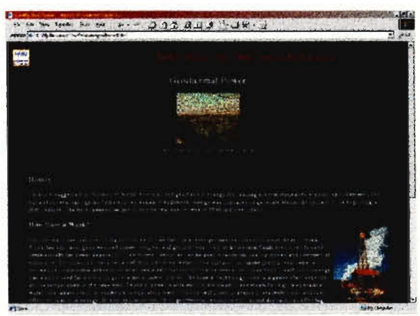


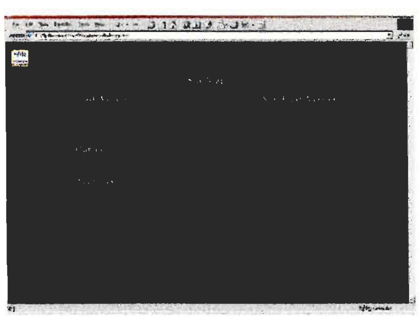
Appendix D.8 Non-Flash Version, Miscellaneous Components

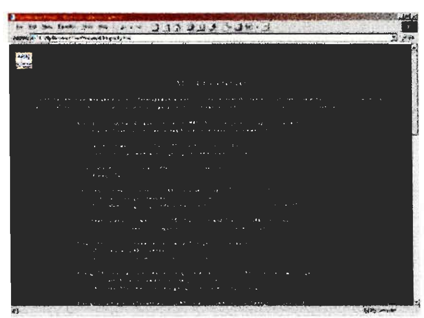
Primary Developer: Alex Proschitskiy











XIII. Bibliography

Ackermann, Thomas & Söder, Lennart. (2000). Wind energy technology and current status: A review. Renewable and Sustainable Energy Reviews, 4(4).

Alternative Energy Institute, Inc. (2000). Solar Energy [Online]. Available: http://www.altenergy.org/2/renewables/solar/solar.html [2001, February].

Belcher, Michael. (1991). Exhibitions in Museums. Washington, DC: Smithsonian Institution.

Berg, Bruce L. (1998). Qualitative Research Methods for the Social Sciences. Needham Heights, MA: A Viacom Company.

Birol, Fatih & Argiri, Maria. (1999, November). "World energy prospects to 2020." Energy, 24(11).

California Energy Commission. (2000, October). Chapter 7: The Energy Story. California Energy Commission [Online]. Available: http://www.energy.ca.gov/education/story-html/story.html [2000, November 5].

Chynoweth, David P., Owens, John M., & and Legrand, Robert. (2000). Renewable methane from anaerobic digestion of biomass. Renewable Energy, 22(1).

E-Sources, The Environmental Journal for Energy and Environment Professional (2000). [Online]. Available: http://www.e-sources.com/biomass.html [2001, February].

Energy Efficiency and Renewable Energy Network (EREN). (2000). Geothermal Energy Program: What is Geothermal Energy? [Online]. Available http://www.eren.doe.gov/geothermal/whatisgeoenergy.html [2000, Dec. 3].

Energy Information Administration. (2000, March). International Energy Outlook 2000.

U.S. Department of Energy, Office of Integrated Analysis and Forecasting [Online]. Available: http://www.eia.doe.gov/oiaf/ieo/index.html.

Funk & Wagnalls Knowledge Center (2000). Energy Supply, World [Online]. Available: http://www.fwkc.com/encyclopedia/low/articles/e/ [2001, February].

Goldemberg, Jose, Johansson, Thomas B., Reddy, Amulya K.N. & Williams, Robert H. (1988). Energy for a Sustainable World. Washington, DC: World Resources Institute.

Haggard, Mary. (1998). Survival Guide to Web Site Development. Washington: Microsoft Corporation.

Hanlan, James P., & Ljungquist, Kent P. (2000). "A Manual for Museums: A Guide for Projects in WPI's 'Living Museums' Program," Worcester, MA: Worcester Polytechnic Institute.

Hanns, Maul (1980). Europe and World Energy. London: Sussex European Research Centre, University of Sussex.

Howes, P. (2000). Caddet Renewable Energy Newsletter. Biomass in the U.K. [Online]. Available: http://www.caddet-re.org/html/496art4.htm [2001, February].

Hull, Thomas G., & Jones, Tom. (1962). Scientific Exhibits. Albany, NY: Bannerstone House.

Janesick, Valerie (1998). Stretching Exercises for Qualitative Researchers. Thousand Oaks, CA: Sage Publications.

Kadoshin, Shiro, Nishiyama, Takashi & Ito, Toshihide. (2000). The Trend in Current and

Near Future Energy Consumption From a Statistical Perspective. Applied Energy, vol 67, # 4: pp. 407-417. Science Direct. [Online] Available: www.sciencedirect.com.

Kleinpeter, Maxime. (1995). Energy Planning and Policy. Chicago, IL: John Wiley & Sons.

Ladd, Eric, & O'Donnell, Jim. (1998). Using HTML, Java, and JavaScript. Indianapolis: Que Corporation.

Lemay, Laura. (1996). Web Publishing with HTML 3.0. Indianapolis: Sams.net Publishing.

Mohler, James P. (2000). Graphics, Animation & Interactivity with FLASH 4.0. Albany: Thompson Learning.

National Renewable Energy Laboratory (1998, August). Solar Energy. Tapping into Earth's largest energy resource [Online]. Available: http://www.nrel.gov/lab/pao/solar_energy.html [2000, November 13].

O'Donnell, I.H.D.& Jognston, C. K. (1993). Hydro – U.K.'s Dependable Renewable International Conference on "Renewable Energy – Clean Power 2001." November 17-19. New York NY: Institution of Electrical Engineers.

The Online Fuel Cell Information Center (2000). Fuel Cells 2000 [Online]. Available: http://www.fuelcells.org/ [2001, February].

Riva, Joseph P. (1995, December). The National Council for Science and the Environment, Science Policy Research Division. The Distribution of the World's Natural Gas Reserves and Resources [Online]. Available: http://www.cnie.org/nle/eng-10.html [2001, February].

Rossman, Gretchen, & Rallis, Sharon. (1998). Learning in the Field: an Introduction to Qualitative Research. Thousand Oaks, CA: Sage Publications.

Schmitz, Joe (ed.). (1999). Macromedia FLASH 4: Using Flash. San Francisco: Macromedia, Inc.

Schneiderman, Ben. (1992). Designing the User Interface. Los Angeles: Addison Wesley Publishing Company, Inc.

Schneiderman, Ben. (1998). Designing the User Interface. Los Angeles: Addison Wesley Publishing Company, Inc.

Shefield, John. (1998). World Population Growth and the Role of Anual Energy Use per Capita; Technological Forecasting and Social Change; vol 59, #1: pp. 55-87. NY, NY: Elsevier Science Inc.

Sims, Ralph E. H. (2000). Bioenergy – a renewable carbon sink. Renewable Energy, 22(1).

Solstice-CREST (2000). On-Line Renewable Energy Education Module [Online]. Available: http://solstice.crest.org/renewables/re-kiosk/index.html [2001, February].

Thorstensen, Bernt. (1999). A parametric study of fuel cell system efficiency under full and part load operation; Journal of Power Sources; Vol 92, #1-2: Science Direct. [Online] Available: www.sciencedirect.com.

Ulrich, Katherine. (1999). FLASH 4 for Windows & Macintosh. Berkeley, CA: Peachpit Press.

U.S. Department of Energy. (1997, July). Hydropower Program & Hydropower facts Brochure, U.S. DOE Hydropower Program [Online]. Available:

http://www.inel.gov/national/hydropower/ [2000, November 14].

U.S. Department of Energy. (2000, November). Fossil Energy. Energy from the past to our future [Online]. Available: http://www.fe.doe.gov/education/index.html [2000, November 11].

U.S. Department of Energy. (2000). Office of Nuclear Energy, Science, and Technology. The History of Nuclear Energy [Online]. http://www.nuc.umr.edu/nuclear_facts/history/history.html [2001, February].

Weil, Stephen W. (1990). Rethinking the Museum. Washington, DC: Smithsonian Institution.