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Nuclear Energy

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Introduction

During the 1970's, interest in different energy alternatives surfaced in this country. Obviously, this increase in public awareness was mainly due to our problems with foreign oil. Energy alternatives, like gas, coal, solar, wind, and nuclear, have been researched and each of their advantages and disadvantages have been examined and scrutinized.

The energy alternative that is the subject of this unit is probably the most controversial, nuclear energy. One reason I chose this topic is because of the ignorances and fears of many people regarding nuclear energy. My students are the adults of tomorrow and should be given the facts on this energy source, its past record and what the possibilities and changes are for the future.

The unit covers 4 to 6 weeks and is planned for use in a 9th grade Physical Science course. The unit is divided into the following sections:

I. What is nuclear energy and what makes up a nuclear power plant.
II. Advantages and disadvantages of nuclear energy.
 (a) safety
 (b) radiation
 (c) the environment
 (d) waste disposal
 (e) economics
III. The Three Mile Island incident—research and discussion.
IV. Connecticut Nuclear Power Plants

The unit will consist not only of the relaying of facts to the students, but will also involve the reading and research by the students with follow-up discussions.

I. Nuclear Energy and nuclear power plants.

A. Nuclear Energy

Nuclear energy or atomic energy is the type of energy that comes from the nuclei of atoms. Both protons (positive electric charge) and neutrons(neutral) are found in the nucleus of an atom. The nucleus contains most of the mass of an atom. Energy is released any time there is a change in an atom's nucleus.

There are two types of nuclear change, nuclear fission and nuclear fusion.

In nuclear fission, atoms having a large mass, like uranium, are split into two and energy is released. New elements are formed as a result of nuclear fission.

As a reminder, mass refers to the amount of matter found within an object.

During nuclear fission, the splitting of the nucleus results in a loss of mass. The two new nuclei, that have formed as a result of the division, together have less mass than the original nucleus. The missing matter has been converted into energy.

Uranium 235 is an isotope that is used in starting nuclear fission chain reactions. An isotope is a form of an element with a different number of neutrons in its nucleus.: Uranium 235 is split in two by a neutron. At releases energy and neutrons. These neutrons that are released will then split other atoms. enough uranium, a chain reaction will begin. Each uranium 235 atom will be split and send off neutrons that will split other uranium 235 atoms If this chain reaction is controlled, like in a reactor, nuclear energy can be produced. This is also the type of chain reaction that resulted in the atomic bomb.

Uranium 235 is not the only isotope used in starting nuclear fission chain reactions, but is a widely used form. Plutonium-239 is also used but many opponents of nuclear energy fear that plutonium is too dangerous. Plutonium is poisonous but remains in fuel pellets until it's carefully removed from the plant. There has been no reported public damage from plutonium.

Other materials are found in a reactor, like uranium-238. U-238 can change into a fuel that can start a fission reaction by absorbing neutrons from a U-235 fission reaction.

Atoms having a small mass, like hydrogen, are involved in nuclear fusion. Nuclear fusion occurs when and new elements are formed. Nuclear fusion has the capability of releasing greater amounts of energy than nuclear fission. These fusion reactions are also referred to as thermonuclear reactions. An example of thermonuclear reactions is found on the sun where hydrogen atoms unite and form a new element, helium. This type of reaction releases heat, radiation, and light. Another example of a thermonuclear reaction is the hydrogen bomb.

The atomic bomb (fission chain reaction) although very destructive is yield of energy released by a hydrogen bomb (fusion reaction).

Nuclear fusion appears to be a better energy source and consumer-wise. The main problem is the control of a nuclear fusion reaction. Once that is achieved, there then would be the time needed to set up an energy plant to supply a large number of the population. The research behind nuclear fusion power and the possible fusion plant construction would take many years.

> “It may well be 2020, then, before we arc a fusion society. It would be wise to conserve oil supplies and to substitute other energy sources hot springs, and so on: to keep us going until fusion can take over.”1

This last statement reflects some of the present problems with nuclear energy production. Also this statement presents the various energy alternatives that are offered to us. It is important to stress here, that nuclear energy is part of our future, along with the other energy alternatives and collectively we can combat and possibly deplete our emphasis on foreign oil.

B. Nuclear Power Plants

Electricity in power plants i~ produced when a turbine is forced to turn. The turbine then spins a generator which produces the electricity. Water, gas, or steam can cause the blades of the turbine to spin. Steam can be produced in oil, coal, and nuclear power plants.

The main difference between coal or oil power plants and nuclear plants is that coal and oil are burned in a furnace producing enough heat to change water into steam. A reactor replaces a furnace in a nuclear power plant. The reactor contains the ‘fuel’, usually uranium. The splitting (fission) of uranium produces the heat needed to change the water to steam.

There are different types of nuclear power plants, but the major parts of a plant are generally the same. within the *reactor* , fission occurs and energy, in the form of heat is released. This heat boils the water and steam is produced. The steam moves to the *turbine* that spins the *generator* which produces electricity. The ‘used’ steam then moves to the *condenser* where it changes back to water and returns through a pump to the reactor.

In Connecticut, we have two types of nuclear power plants: pressurized water reactor and boiling water reactor. The chief difference is that the pressurized water reactor has a separate steam generator and pressurizer. The pressurizer keeps heated water then moves it to the steam generator where the water is converted to steam. Also in a pressurized water reactor, the pump returns the water to the steam generator for reuse.

The main parts of a nuclear reactor where the chain reactions are controlled are:

(a) the *fuel* , like uranium 235, that undergoes fission
(b) Neutrons produced by the nuclear fission reaction are slowed down by a *moderator* .
(c) *Control rods*— have the ability to absorb neutrons that are released by nuclear fission. The control rods are placed in the reactor to stop nuclear fission and are removed when the fission chain reaction is needed.
(d) A *coolant* is used to move the heat away from the fission reaction.
(e) the *inner containment structure* or *shielding* to help prevent any radiation leakage. This is reinforced by a concrete building that houses the reactor.

There are different types of reactors. Two, the pressurized water reactor and boiling water reactor, have been described briefly above. Another type of reactor that is in use in parts of Europe and in Russia is the breeder reactor. A breeder reactor was used in this country in 1951 to produce electricity from the first nuclear reactor plant. But, America has no breeder reactors in operation today. One is presently under development: the Clinch River Breeder Reactor Plant in Oak Ridge, Tennessee.

A breeder reactor produces both electric power and fuel. Every reaction releases two or three neutrons, and only one is needed to continue the fission chain reaction. The other neutron(s) strike other atoms that are converted to fuel. Breeders are necessary for a nuclear future because the fuel supply for nonbreeders is limited, but the breeder produces more fuel than it needs. A breeder reactor plant has an estimated fuel supply of thousands of years.

The opponents of breeder reactors argue many of the same ideals of the following statement: “But breeders convert uranium to plutonium reactor fuel, only a few pounds of which are needed to make a powerful bomb. Many fear nuclear weapons proliferation, and breeder development is stalled in the U.S..”2

II. Advantages and Disadvantages of Nuclear Energy

A. Safety

Within the past few years, concern of nuclear power plants has become a public issue and, also, a political one.

In Connecticut, an inspector from the Nuclear Regulatory Commission (NRC) has been assigned to the Connecticut Yankee plant and another to the Millstone plants. These inspectors are responsible for looking over the operations at the plant and that all federal regulations are being followed. There are also frequent spot checks to make sure that all regulations are being upheld.

As a result, or consequence of the Three Mile Island incident, Northeast Utilities set up a task force in 1979 to work with the NRC to insure that safety regulations are being upheld on a continual basis.

Along with the NRC and NE task force was the results of the Kemeny Commission. This commission was set up by former President James Carter to investigate and report back on the situation at Three Mile Island.

The main features of a safety inspection include the design, construction, and operation of a reactor; accident prevention features, and containment shells to confine or minimize the release of the product of fission reactions.

B. Radiation

The term ‘radiation’ refers to the transfer of heat by waves. Everyday exposure includes radiation from the sun, gases in the air we breathe, and in our food and water.

Different types of radiation include alpha, beta, gamma, X-rays, and neutrons. Neutron radiation is the type involved with nuclear energy. This type of radiation occurs in nuclear reactors.

Radiation doses are measured in 'rems'. A comparison of X-rays' radiation and that of a nearby resident of a nuclear power plant, is that a dose of radiation from a X-ray averages 20 millirems(thousandths of a rem) while living close to a nuclear plant averages l millirem per year. This estimate of radiation dose are tested by taking environmental samples. In CT, even before our nuclear plants were built, samples wore taken to measure radioactivity in the area. This gave the researchers an estimate of the area's radioactivity before the initial construction of the nuclear power plants. Now, the Nuclear Regulatory Commission requires periodic readings of the radioactive dose to the environment. "The highest dose an individual living at the site boundary could have received in 1980 was 6.4 millirem from Millstone releases and 1.2 millirem from Connecticut Yankee releases. Doses to the average individual around the sites are much smaller than those presented as the highest possible."3

Background radiation is one of two forms: natural and synthetic. Natural background radiation includes sun, air, food, and the ground. Synthetic (manmade) background radiation includes color T.V., X-rays, jets, and living within approximately 50 miles of a nuclear power plant. The amount of exposure to background radiation varies across the U.S. chiefly from the amount or influence of each of the above natural and artificial types of radiation upon a particular section of the country. Nuclear plants give off the smallest doses of radiation than all of the others listed above.

C. Environment

The individual power plants are required to reports of data they have collected on environmental studies. In CT, Millstone gives the NRC their reports every year and CT Yankee files reports when required.

The type of testing surrounding water and land mass, all life forms, and the air.

The initial sitting important to the environment. The most important concern involved with a sitting is the radiological hazard to the surrounding population. There are now federal laws and regulations for the recording of data near a possible plant site. One law that helps to ensure the safety of the public and surrounding environment is that there must be an area around a plant site that is restricted. There also has to be some structures and dispose of all wastes that occur during normal operations.

The obvious advantage to all these regulations is that it ensures the safety of the public and environment. The major disadvantage is the expense,(this will be discussed later under economics).

D. Waste Disposal

The issue of nuclear disposal has probably been of the utmost concern of many people. Besides being a social problem, this issue has become political in nature. There are methods available for the disposal of the wastes but the currently, best method of encapsulation is still being researched. There are many different roadblocks ahead on this issue; many in the form of political lobbies from various groups and organizations.

The radioactive waste from a nuclear plant is usually put into one of two categories: high-level waste and low-level waste.

When an uranium atom is split to start the fission reaction, there are radioactive atoms produced. These radioactive atoms make up the high-level waste. These wastes can remain radioactive for long periods of time and require around 10 feet of water to absorb the energy. Theoretically, the same amount of soil can also give the same protection.

Most products of the fission reaction have short half-lives. A half-life is the amount of time needed for one half the atoms of a radioactive isotope to decay. Almost all radioactivity disappears after four months. The radioactivity that is still present has a longer half-life (about 30 years) and thus the necessity for proper disposal.

Low-level wastes are of solid, liquid, and gaseous forms and make up the majority of wastes removed from nuclear plants. These are materials that become contaminated during normal plant operations. This includes tools, wastes are disposed of at the site. Liquid wastes are usually mixed with concrete or urea formaldehyde (a plastic) to form a solid. Waste in gas form is usually contained until it decays. It then is released by the plant, under environmental regulations. Solid wastes are shipped, under strict regulations, to burial facilities, that dispose of this low-level waste.

The possibilities for disposal of high-level waste include burial far beneath the surface of the earth. The waste could be imbedded in rock or salt formations. Some researchers prefer salt formations because most of these formations have not changed over millions of years. Some researchers prefer the granite (rock) over the salt. Testing is continuing on this issue, with other options, like ocean burial, being discussed.

Testing is underway to determine the best and safest method for nuclear waste disposal. ~ problem is public concern over the testing, especially if it is done in their area (state, city). Politicians also tend to fight the testing in their districts. If nuclear power is to be a part of our future, the public, politicians, and the members of the nuclear power plants, must work together to lower the risks of nuclear power as an energy alternative.

E. Economics

One advantage of nuclear energy that has always keen discussed is its economic value. Uranium is cheaper than oil and coal, and shipments of the fuel for a nuclear plant can be done annually instead of on a constant basis for coal and oil. But uranium is also a non-reusable source and is not immune to inflation, it has risen in cost.

The space needed to accommodate a nuclear plant is considerably smaller than other electrical plants with the same output of energy. However, since 1975 there have been no new orders for nuclear plants. The main reasons for this are the uncertainty of governmental involvement, rising construction cost, rising uranium cost, and delays in licenses and permits. Strict regulations have delayed construction of other plants and new safety measures (since Three Mile Island) are more expensive. In comparison, the construction of a coal plant is much cheaper than that of a nuclear plant. However, nuclear is still cheaper than oil and is more environmentally accepted than coal.

One important issue here is that nuclear energy is in competition with the other energy sources. Usually when there is competition, costs and price usually drop or at least the rates are kept down. With oil skyrocketing, coal, nuclear, wood, hydro, solar, etc., are all in competition, trying to bring the consumer a safe, less expensive, energy source.

III. The Three Mile Island Incident

The incident at Three Mile Island on March 28, 1979 was more of an operator problem There was a routine shutdown of the system that returns water to the steam generator. The instruments at first, and then, after realizing their error, they preceded in cooling the plant until it was 'shutdown'

The Kemeny Commission was set up by President Jimmy Carter to establish what occurred at Three Mile Island. Of the utmost concern to most people was how much radiation was released. There was significant damage at TMI but the safety devices held up well and very little radiation escaped. There are approximately two million people living in a 50 mile radius of TMI. The individual exposure of radiation to these citizens has been averaged out to 0.001 rems.

The Kemeny Commission criticized the media and opponents of nuclear energy for instilling fear into the media tended to compare the TMI incident with the atomic bombings of World War II, Nuclear radiation is destructive to cells upon contact with human tissue; in high dosages it can cause cancer. But the amount of radiation released during the TMI incident was so insignificant in comparison to that of the A-bomb. In essence, there should have been no comparison between the two, but rather a better explanation to the public about the extent and possible risk of the release of radiation from TMI. Also, the media should have spent time on informing and educating the public about nuclear power plants, its safety features, possible risks, and economic feasibility for our future.

Kemeny Commission reported that human error was a major, contributing factor to the Three Mile Island incident. Many nuclear facilities, since then, have extended and/or expanded their training sessions for all nuclear technicians and other plant workers.

One helpful side effect of the incident is the development of more safety regulations. These rules are necessary for the neighbors of nuclear plants; however, it has increased the cost of this type of energy to the consumer.

Finally, this whole incident made us aware of the necessity for an effective evacuation program that would coincide with an equally effective communication system. Confusion, in March of 1979, resulted from confusion within. The media, government, public, and plant officials must work together in each state, to set up state emergency plans, and more importantly, to educate and inform citizens about the advantages and risks of nuclear energy.

IV. Connecticut Nuclear Power Plants

The three nuclear power plants of CT include Connecticut Yankee, Haddam Neck; and Millstone I and II, Waterford. Millstone III is under construction and is approximately 35% complete. These plants have saved many CT bills, up with problems of temporary shutdowns.

CT Yankee, Millstone II, and Millstone III contain a pressurized water reactor, while Millstone I has a boiling water reactor.

Because of the availability of information and educational assistance from the plants, there is no need to go indepth about our nuclear plants. The people involved with each individual nuclear plant, are happy to accommodate any inquiry of information and provide help in the education of youngsters.

One thought to keep in mind, is that our first state nuclear plant was under way in 1968, Although there have been ‘shutdowns’, there have been no incidents or accidents to force people away from CT or New England.

Conclusion

Nuclear energy is only one of many energy alternatives. What gives nuclear an advantage is its past record, safety features, and economical promise for the future. Although I believe that nuclear energy is not the answer-all, I do believe that it is and will continue to be part of our energy future. Energy should be taken seriously and education of our energy sources should not be limited to the school system but be shared with the city or state, and the energy facility.

CLASSROOM ACTIVITIES

I. Safety and Evacuation Program

Place the students in groups consisting of 4-5 people. Each group must set up their own safety and evacuation program.

The specific initial instructions for the groups are:

1. select a specific area (state, city, neighborhood, or school)
2. find out the population of that specific area
3. what type of communication set-up would you use to warn of a possible nuclear problem and how to keep the people aware of what’s going on
4. where would the people go for shelter or how will the people evacuate an area without chaos and panic

This project will make use of the library, the city (census bureau and fall-out shelter locations), and a person involved in public communications.

It also gives the students the chance to experience working within a group.

II. Debates

Some possible issues and topics for debates are:

1. Nuclear proliferation and the third world countries

2. Nuclear energy vs. other energy alternatives

3. How safe is nuclear energy?

4. Fission vs. Fusion

5. American feelings towards nuclear energy

The debates can be set up in various ways:

(a) split the class into two, assigning one group one view point with the rest of the class taking the opposing view point.
(b) assign only a few students to prepare a debate while the rest of the class prepare questions and act as judges of the debate.
(c) set up a debate with another Science class whom are also working on an energy unit.

Again the library would be used for research of the issues.

III. Library—Research

Teaching the students on how to go about doing a research paper. (The English cluster teacher would be a helpful aid).

Using the library for research allows the students to learn how to look up books, magazines, periodicals, and other available equipment.

Possible Research Topics:

1. Three Mile Island

2. “The China Syndrome”

3. The attack on Iraq’s nuclear reactor

4. International feelings towards nuclear energy

5. The Trident submarines

Audio Visual Aids

Radiation: It’s Part of Our World . Northeast Utilities, P.O. Box 270 Hartford, CT 06101. (A slide show, demonstrations and discussion.)

Exploring Electric Energy .United Illuminating, 80 Temple St. New Haven, CT 06506.(A film of the electrical station in New Haven Harbor)

35 Energy Films. DOE Film Library, P.O. Box 62, Oak Ridge, TN 37830.(a catalog that contains a listing of 35 films on energy).

Energy Curriculum Materials . DOE Technical Information Center, P.O. Box 62 Oak Ridge, TN 37830. (Materials available for primary, junior high, senior high, and post-secondary students.)

Northeast Utilities, P.O. Box 270, Hartford, CT 06101. (Can write to for information on obtaining a speaker on nuclear power.)

Notes

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1. Oatman, Eric F. editor, *Prospects for Energy in America* , Asimov, Issac, *Nuclear Fusion—The Perfect Solution* (the Il.W. Wilson Company, New York) 1980 Volume 52 No. 2 pg. 96.
2. *National Geographic Special Report Energy* (National Geographic Society, Washington, D.C.) Feb. 1981 p. 67.
3. Nuclear Power at Northeast Utilities, Fact Book 1980 (System Communications Department, Northeast Utilities, Hartford, CT) 1980.

Teacher’s Bibliography

Commoner, Barry *The Politics of Energy* (Alfred A. Knopf Inc., New York) 1979.

Pro-solar energy, anti-nuclear. A book that looks at these two energy alternatives. Examines former President Carter’s energy plan and how it related to these two topics.

Conner, David A., Winter, John V., *Power Plant Siting* (Van Nostrand Reinhold Company, New York) 1978.

Environment is the key issue in this book. The siting of power plants is a highly researched and technical business that follows state and federal regulations.

Foreman M.D., Harry, editor, *Nuclear Power and the Public* (University of Minnesota Press, Minneapolis) 1971.

Contributors to the book include medical doctors, members of various energy commissions, nuclear researchers, environmentalists.

Shows both sides of the issue.

Glasstone, Samuel Sourcebook on Atomic Energy (D. Van Nostrand Company, Inc., Princeton, N.J.) 1958.

Can be used as a handbook by teachers—complex ideas and theories can be easily followed.

National Geographic Special Report *Energy* (National Geographic Society, 1981 p. 67

The article, *URANIUM Too Hot To Handle* ?, talks about uranium as fuel for energy. Also mentions breeder reactors and its stalled development in the U.S.

Oatman, Eric F. editor, *Prospects for Energy in America* (The H.W. Wilson Company, New York) 1980. Volume 52 No.3

A look at the energy problem, different alternatives and their pros and cons.

Robertson, J. Craig, *A Guide to Radiation Protection* (John Wiley & Sons, New York) 1976.

Explains what radioactivity is and its biological effects.

Wallace, Bruce and Dobshanskt, TH, *Radiation, Genes* , *and Man* (Holt, Rinehart and Winston Inc., New York) 1959.

Explains nuclear energy and the effects of nuclear fallout and possible genetic damages to life.

Student's Bibliography

Halacy, D.S. Jr., *Energy and Engines* (The World Publishing Company, Cleveland and New York) 1967

A look at many energy alternatives of today and tomorrow and the need for these energy sources and their development. It is simply written and can be used resourcefully by high school students.

Mann, Martin *Peacetime Uses Of Atomic Energy* (Thomas Y. . Crowell Company, New York) 1957.

As the title suggests, this book, through explanations and illustrations, looks at the use of the atom and atomic energy for peaceful means.

Splaver, Sarah *Careers* , *New and Unique* (Julian Messner, Simon & Schuster Division of Gulf & Western Corp., New York) 1979.

This book lists different careers in atomic (nuclear) energy, like researchers, engineers, and operators. Also introduces the careers in atomic medicine. Lists schools of higher education that offer degrees in these fields

Steele, George P. Commander, and Gimpel, Herbert J. Commander, *Nuclear Submarine Skippers* (Franklin Watts, Inc., New York) 1962.

Two commanders tell their stories about commanding a nuclear submarine. It explains what it is like to be aboard a nuclear submarine and how the nuclear plant operates.

Newspaper Articles

Hershey, Robert D. Jr., *Can Rea* g *an Lift the Cloud Over Nuclear Power?* (The New York Times, New York) March 8, 1981 Section 3.

The New Haven Register, *Man* y *rebellin* g *at electric rates* (A. Jackson Newspaper, New Haven CT) May 13, 1981 p. 1.

Pamphlets

Nuclear Power and the Environment U.S. Atomic Energy Commission, U.S. Government Print Off., Washington 1969.

Nuclear Power Answers to your questions. Edison Electric institute, EE1 Pub. No. 78-24.

Nuclear Power at Northeast Utilities Fact Book 1979 Systems Communications Dept. Northeast Utilities, Hartford, CT.

Q & A Nuclear Power & the Environment American Nuclear Society 1976 Edition, Second Printing June 1976.