League of Women Voters of Minnesota Records

A Minnesota Citizen's Introduction to Nuclear Power

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BACKGROUND

About 30 percent of Minnesota's electricity is generated at its three nuclear reactors: one at Monticello and two at Prairie Island. These three reactors provide 40-50 percent of the total electricity produced by Northern States Power Company (NSP), a private utility which is the largest supplier of electrical power in the state.

Exploratory drilling for uranium to be used for nuclear fuel is already taking place in several counties. Full-scale uranium mining and milling may be in our state's future. Spent (used) nuclear fuel is now stored temporarily at our two reactor sites because there is no permanent waste disposal system. The complete nuclear fuel cycle from uranium exploration through the permanent disposal of reactor wastes involves risks unique to this source of electric power.

Public debate over the use of nuclear power continues. Most publications on nuclear power are written by special interest groups at opposite ends of the spectrum. Citizens are having difficulty making informed choices. They know that the nuclear power decision will greatly affect all of us as energy users, taxpayers, and people who care to live in a safe environment.

Continuing its tradition of educating citizens on important public issues, the League of Women Voters has produced this brochure. It is intended to partially fill the need for reliable, unbiased information on nuclear power technology and issues in a compact form. For more in-depth coverage, readers are referred to other LWV and non-League publications on nuclear technology, nuclear issues, and comparisons of nuclear with other energy sources (see Suggested Reading).

Issues for Decision

Our increasing reliance on foreign sources of oil, the high and rising cost of this dwindling resource, and the nuclear reactor accident at Three Mile Island (TMI) have heightened public concern over nuclear power. We will have to make some tough decisions within the next decade which will influence our lives and those of future generations. Our decisions could determine:

1) if, and to what extent, uranium mining and milling will occur in Minnesota;

2) if the United States will proceed with reprocessing and recycling of spent fuel;

3) how we will permanently manage existing or future radioactive nuclear wastes;

4) how many times and to what extent Northern States Power Company will be allowed to expand its on-site temporary storage capacity for spent fuel;

5) if we should call for a moratorium on nuclear power plant construction or operation until a permanent waste deposit site is available;

6) if we will expand commercial nuclear power to include breeder reactors;

7) to what extent the United States will export nuclear technology and materials;

8) to what extent we should fund fusion development.

If you had difficulty understanding the issues on this list, you are not alone. The subject is technical and complex. The purposes of this publication are to acquaint you with the language and technology of nuclear power, provide some energy statistics, summarize the generally-used pro- and con- nuclear power arguments, and interest you in reading more about nuclear energy and the alternatives to it.

Points to Consider

As we decide the future of nuclear power, several key points must be kept in mind:

1) **We will never achieve a risk-free society.** All risks must be weighed against presumed benefits.

2) **We should keep an on-going inventory of which risks we believe are acceptable and which are not.** What may be acceptable to us today may be unacceptable one year from now as our situation changes or new information comes to light.

3) **To make wise energy decisions we must compare nuclear power with other energy sources.** All of them have risks, costs, benefits, social implications, etc.

4) **We will need to make compromises which may not be entirely satisfactory.** For example, if we decide to reject nuclear power, we must face the considerable problems that exist in other current sources or in developing alternative sources.

5) **There may be a vast difference between an actual risk and the public's perceived risk.** Media coverage after the accident at Three Mile Island, for example, that stressed what **could** have happened may have led some people to overreact.

6) **Americans are already divided on nuclear power.** Some favor nuclear power because they believe it is technically feasible, safe, and economically desirable. Others oppose nuclear power because they think it poses too great a health risk and is unacceptable given their ethical and social values. Many Americans probably fall somewhere in the middle, waiting for further information about nuclear power and other energy sources before taking a position.

7) **The general public has the potential for breaking the nuclear stalemate. You can affect the outcome by becoming knowledgeable regarding energy issues, by making personal energy use choices, by voting, by taking every opportunity to speak up and inform others, by attending public hearings, and by writing letters to government officials.**

RADIATION

There are many radioactive chemical elements found in nature. They continuously decay and transform into new elements, giving off radiation, or energy in the form of rays, in the process. An element may have several different forms, or **isotopes**, all with the same number of protons but differing numbers of neutrons in the nuclei of their atoms. **Radioisotopes** are unstable forms that undergo radioactive decay, that is, give off radiation from the nuclei of their atoms.

The time it takes a radioactive element to decay is called its **half-life**. After one half-life, half the original radioactivity remains; after two half-lives, a fourth, and so on. Some radioactive elements have short half-lives (hours or days) while others have considerably longer half-lives (several years to 17,000,000 years). More radiation is given off in a specific time period if an element has a short half-life. Conversely, the longer the half-life, the less radiation given off in a specific time.

RADIOACTIVE elements give off three basic kinds of rays — alpha, beta, and gamma. Together they are called **ionizing radiation** because they tear electrons from the molecules and atoms they strike or pass in human tissue, leaving the molecules or atoms electrically charged, or "ionized." Each type has a different way of penetrating and damaging body cells. If radiation enters a body, it may damage the nucleus of a cell. Damaged cells may undergo repair, death or alteration that may result in subsequent cancer.

The amount of damage to human tissue from a radiation dose is usually expressed in **rems** (roentgen equivalent man) or millirems — **mrems** (thousandths of a rem). The rate is then usually expressed as mrems or rems per year. The term was devised to take into account the effect on the body of different types of radiation.

PEOPLE HAVE ALWAYS been subjected to natural background radiation emitted by cosmic rays from outer space and by radioactive materials present in the earth, in our building materials, and in our food and water. In addition to natural background radiation, people have created other low-level radiation sources: medical and dental X-rays, radiation used for other medical purposes, fall-out from nuclear bomb testing, and various wastes created in the complete nuclear fuel cycle and in operating nuclear and some coal-fired power plants.

It is generally agreed that, on the average, each person in the United States receives about 100 mrems per year of background radiation. The government has set 170 mrems per year as the acceptable dose for the general public over and above natural background radiation. (This is the equivalent of about four chest X-rays.) No more than 25 mrems may be received from nuclear facilities. At this level, the U.S. EPA (Environmental Protection Agency) believes the risks of health damage are balanced against the benefits of nuclear power. Most federal officials believe this risk is comparable to those accepted for other types of electrical generators.

RADIATION EFFECTS are not seen immediately except in massive single doses. (A dose of 600 full rems causes death within a month in most exposed people.) A few years after a smaller dose, leukemia may develop. Later, other cancers may appear. Fetuses or growing children are the most susceptible to damage from radiation because they are experiencing rapid growth through normal cell division. Genetic damage may cause offspring of those exposed to be born with defects.

Because the time between exposure to very low doses of radiation and the possible effects in cancers or mutations is long (25 years or more), and there are other possible causes in the environment of the affected individuals, scientists are still debating the risks of exposure to low-level radiation. They agree, however, that there is some risk.

RADIATION ILLNESS — sickness that results from exposure to massive radiation doses (100 rems or more) and is commonly marked by fatigue, nausea, vomiting, loss of teeth and hair, and, in more severe cases, by damage to blood-forming tissues with decrease in red and white blood cells and bleeding.

THE NUCLEAR FUEL CYCLE

Fission

Fission is the splitting or breaking apart of a heavy atom into two new atoms. When a heavy atom, such as uranium, is split, large amounts of energy and one or more neutrons are released.

In a typical nuclear power plant the heat energy created by uranium fission is used to create steam. The steam drives the turbine which turns the generator to produce electricity.

BOILING-WATER REACTOR — a nuclear reactor in which water used as a coolant and moderator is allowed to boil in the core. The resulting steam is used directly to drive a turbine; the reactor at Monticello is this less common type.

CHAIN REACTION (CONTROLLED) — a self-sustaining series of nuclear fissions taking place in a reactor core. Neutrons produced in one fission cause another.

CONTROL ROD — a tube that contains material that readily absorbs neutrons, thus preventing neutrons from causing further fission.

CORE — the central portion of a nuclear reactor containing the fuel elements, the control rods and the moderator.

CRITICAL MASS — the smallest amount of fissionable material that will support a self-sustaining chain reaction under certain conditions.

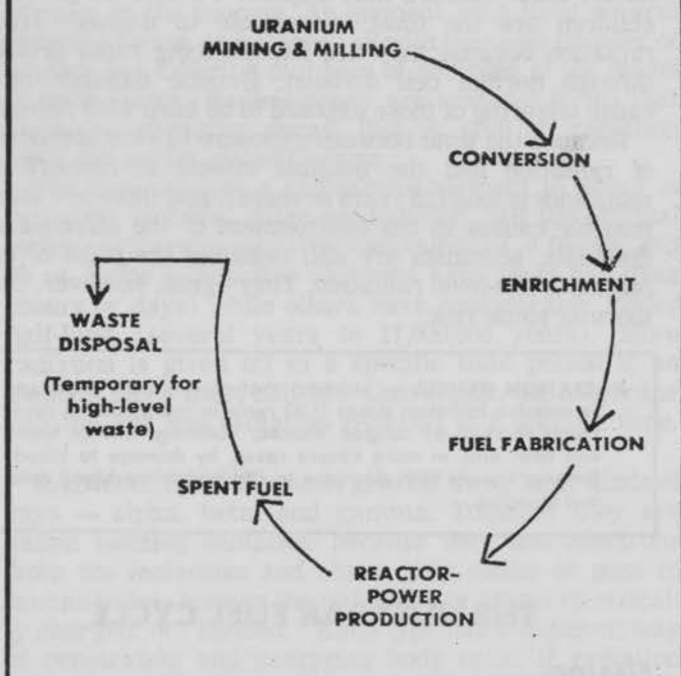
MODERATOR — a material used in a reactor to slow the neutrons and increase fission probability.

HEAVY WATER — D_2O; water enriched in deuterium, an isotope of hydrogen that has twice the mass of ordinary hydrogen. It is such a good moderator that unenriched (natural) uranium can be used as fuel in a heavy water reactor.

LIGHT WATER — H_2O; ordinary water (a common moderator).

PRESSURIZED-WATER REACTOR — a nuclear reactor in which heat is transferred from the core to a heat exchanger by water kept under high pressure to achieve high temperature without boiling. Steam is generated in a secondary circuit. The two reactors at Prairie Island are this most common type.

THE CURRENT NUCLEAR FUEL CYCLE



Uranium Mining and Milling

Most of the known recoverable supply of uranium in the non-Communist world is located in the United States, Australia, Canada, South Africa, and Niger. American uranium ore is mined mainly in the West and Southwest. Nearby mills crush and grind the ore and chemically concentrate it into "yellowcake."

Hazards associated with uranium mining and milling are:

1) ground and surface water contamination by radioactivity,

2) airborne emissions of radioactive materials,

3) exposure of workers to radiation, and

4) long-term effects of radioactive wastes resulting from uranium milling.

Uranium tailings are potentially the most hazardous nuclear waste to the health of the general public because they release radon gas for thousands of years. The danger is abated, however, if the tailings are sealed to keep the gas from escaping. Because the disposition of tailings was unregulated for many years, the waste piles were just abandoned when a mill closed. However, recent investigations have disclosed radiation seepage from exposed tailings.

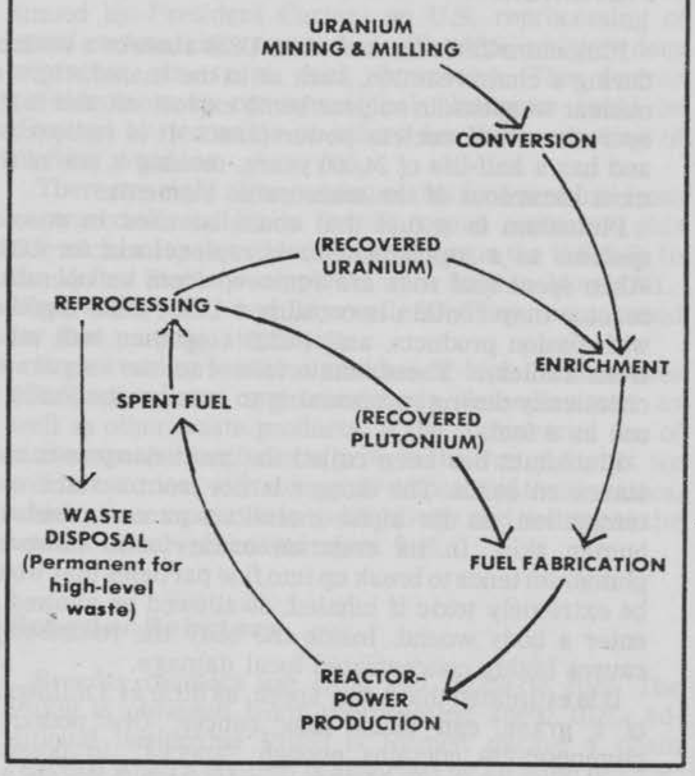
RADON — a radioactive gas resulting from the decay of uranium, thorium and radium.

The Uranium Mill Tailings Radiation Control Act of 1978 provides for government units to oversee the sealing of tailings piles at 22 inactive mill sites and the establishment of improved procedures for the management of tailings at operational mills.

In Minnesota, the 1980 Legislature amended existing laws on water-well drilling to encompass exploratory drilling for radioactive materials. Such drilling is currently taking place in Carlton, Pine and Aitkin counties and may begin in other counties as well. Full-scale uranium mining and milling is not being done in Minnesota.

Expert estimates of world uranium reserves differ. The United States is counting on the high estimates being correct so that we can continue fueling our reactors as we do now. The Department of Energy projects enough recoverable uranium in the United States to supply 400 reactors for their lives. This is twice the number of U.S. plants now planned. Otherwise, to continue with nuclear power, we will need to build more fuel-efficient reactors or reprocess spent fuel and accept the attendant risks.

PROPOSED FUEL CYCLE INCLUDING REPROCESSING



Uranium Enrichment and Fuel Fabrication

As found in nature, uranium is made up of less than 1 percent of the fissionable isotope, U235. Most of the uranium is U238, not easily split apart except in breeder reactors, which are designed to fission U238.

Nuclear power plants are sometimes fueled by natural uranium, but most often by uranium that has been "enriched" to contain 3.5 percent U235. (Nuclear weapons use uranium that has been enriched to more than 90 percent U235, or at least 20 percent for a crude bomb.)

"Yellowcake," the concentrated uranium ore, is shipped from the mills to factories that convert it into hexaflouride, UF_6. When heat is applied, UF_6 becomes a gas that permits the concentration, or enrichment, of U235. Uranium enrichment technology is complex and costly. There are three government-owned enrichment sites: Oak Ridge, TN; Paducah, KY; and Portsmouth, OH.

After enrichment, UF_6 is converted by cooling into uranium dioxide powder and formed into ceramic pellets. The pellets are stacked in slender tubes 12-14 feet long. Dozens of these tubes form bundles which can be inserted into a reactor vessel.

FUEL ROD — a tube that contains some 200 thimble-size pellets of enriched uranium-235. One-third of a reactor's fuel rods must be replaced annually. Each pellet, costing $5-$10, contains about the same power as one ton of coal or four barrels of crude oil.

Plutonium

Plutonium-239 is formed when U238 absorbs a neutron during a chain reaction, such as in the manufacture of nuclear weapons, in nuclear bomb explosions, and in the operation of all nuclear power plants. It is radioactive and has a half-life of 24,000 years, making it one of the most hazardous of the transuranic elements.

Plutonium is a fuel that could be used in reactor systems as a supplement to or replacement for U235. When spent fuel rods are removed from an operating reactor they contain unconsumed U235, U238 together with fission products, and Pu239 (together with other transuranics). These materials can be separated chemically during reprocessing to recover the Pu239 to use as a fuel.

Plutonium has been called the most dangerous substance on earth. The danger is not from surface contamination, as its alpha emissions cannot penetrate human skin. In its common oxide form, however, plutonium tends to break up into fine particles that would be extremely toxic if inhaled, swallowed or allowed to enter a body wound. Inside the body the radioisotope causes highly concentrated local damage.

It is estimated that a tiny speck, as little as 3 millionths of a gram, can cause lung cancer. One pound of plutonium-239 contains enough "specks" to possibly cause lung cancer in 9 billion people. Once in the air, the particles could remain suspended and continue to cause cancer for thousands of years.

Nuclear power advocates argue that the dangers of plutonium have been greatly exaggerated. They say it is extremely unlikely that the plutonium particles would get into the air or be inhaled by all those people. Extraordinary precautions taken during reprocessing, transportation, and operation of breeder reactors prevent the release of plutonium into the environment.

TRANSURANICS — some 200 radioactive elements with atomic numbers greater than uranium created when uranium atoms are split apart in the fission process. (Plutonium is a transuranic element.)

SPENT FUEL — nuclear reactor fuel (enriched uranium) that has been used to the extent that it can no longer effectively sustain a chain reaction.

RECYCLING — the reuse of fissionable material after it has been recovered by chemical processing of spent fuel, re-enriched, and then refabricated into new fuel elements.

Reprocessing

Spent, or used, reactor fuel contains uranium and plutonium that can be separated from the fission products and used again, "reprocessed." The nuclear industry has proposed that spent fuel from commercial reactors be taken to special plants around the country for reprocessing (see fuel cycle charts). Since there is no exact way to know how much plutonium will be recoverable from a set amount of spent fuel, strict monitoring against plutonium diversion is necessary.

The recovered U235, U238, and Pu239 can be used in our present type of nuclear reactors. U238 and Pu239 can be used as fuel for the proposed breeder reactors.

In 1976 President Ford placed a moratorium (continued by President Carter) on U.S. reprocessing of spent commercial reactor fuel. (The U.S. military does reprocess its spent fuel, however.) The former presidents were concerned that plutonium could be diverted by terrorists or others for the production of nuclear weapons.

There are eight reprocessing plants for spent fuel from commercial reactors in five European countries, plus one each in Japan and India and others in the U.S.S.R. In the United States, such plants were built in Morris, IL; West Valley, NY; and Barnwell, SC. They are not used for that purpose at present.

Reprocessing leaves a residue of high level wastes (fission products) and transuranic element waste, as well as other waste products. If the commercial use of nuclear power continues to grow in the United States, we will have to deal with storage or disposal of these wastes, which are comparable in radioactivity and volume to the wastes in unreprocessed spent fuel.

Breeder Reactors

Breeder reactors use U238 and Pu239 as fuel. The Pu239 is obtained from reprocessing spent fuel. Additional fissionable Pu239 is formed during a chain reaction when a neutron is absorbed by an atom of U238. In this manner, the reactor "breeds," or produces, more new fuel than it consumes.

The U.S. government is currently funding the construction of the Clinch River Breeder Reactor project in Oak Ridge, Tennessee. This Liquid Metal Fast Breeder Reactor (LMFBR) uses a liquid metal, sodium, as a coolant. There have been other small research and development breeders built in the United States. Two of these are currently operating.

Advantages of the breeder are that it:

1) multiplies the energy content of uranium at least 60 times.

2) uses fuel more efficiently than pressurized water reactors.

3) can operate at high temperature (1000 degrees F) without requiring the high pressures necessary in water-cooled reactors, virtually eliminating the chance of a loss-of-coolant accident.

Disadvantages of the breeder are that:

1) high capital costs are expected, and uranium would have to reach a very high price before breeders could be economically competitive with present uranium-fueled reactors.

2) the sodium coolant burns explosively on contact with air or water. Extraordinary care is necessary to prevent a meltdown or other accident.

3) a reactor explosion is also remotely possible. Such an explosion would hurl deadly plutonium particles, uranium, and radioactive molten sodium into the air.

Nuclear Power Plant Safety

The Nuclear Regulatory Commission supervises the process of technical review, approval and licensing of nuclear power plants. Strict design and construction standards must be met, including periodic testing for quality of materials and work. There are overlapping automatic and manual safety devices and barriers. A plant is expected to operate for 30-40 years. (Electrical rates during that time can be pro-rated to cover the cost of decommissioning a no-longer-operable plant.)

A uranium-fueled nuclear reactor can not explode like a bomb. The main concern is to guard against accidental release of radioactivity. The Emergency Core Cooling Systems (ECCS), for example, are designed to ensure that there is a back-up supply of water to prevent the reactor core from overheating if it accidentally loses its original coolant. The ECCS is designed to prevent a "meltdown" of the core, which could hypothetically melt through the plant's steel and concrete structure, releasing radiation into ground and water. In addition to the precautions to prevent escape of radioactivity, the reactor is protected from sabotage by an elaborate series of detection systems, fences, guards and security programs.

Proponents of nuclear power stress that there have been no deaths or serious injuries to the public as a result of commercial nuclear accidents. The accidents at Three Mile Island, Brown's Ferry and the Fermi Plant did not result in public health disasters. Valuable information was gained and modifications to equipment and operating procedures were made as a result.

Opponents view these same accidents in a different light. They point not only to the potential danger to human life and the environment but also to how such accidents are paid for. They are dissatisfied with the Price-Anderson Act of 1957. This law provides federal government funds in part to protect the nuclear industry from plant or transportation accident damage claims beyond $560 million.

AEC (Atomic Energy Commission) — former five-member agency established Jan. 1, 1947, and responsible for developing, promoting and regulating U.S. nuclear activities. The AEC was abolished in 1974 and its responsibilities were divided between the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA), itself later absorbed into the Department of Energy (DOE).

NRC (Nuclear Regulatory Commission) — a five-member U.S. agency established in 1975 to partially replace the AEC. The NRC regulates nuclear power plant design and operations.

DECOMMISSIONING — the act of closing down a nuclear power plant in a way that will prevent public access to or dispersion of radioactive materials. (NSP's Pathfinder Plant near Sioux Falls, SD, was decommissioned in 1967.)

DISMANTLING — the act of taking apart a reactor and disposing of the parts. (United Power Association's Elk River plant was disassembled in the early 1970's.)

Nuclear Power and Radioactive Wastes

Nuclear power produces two types of radioactive wastes: low-level and high-level. These wastes are identified as such because of the relative levels of radioactivity given off and the time it takes for the radioactivity to decay to acceptable levels.

A major source of low-level radiation is the uranium mining and milling process. Radiation exposure could occur through ground or surface water contamination or from radon gas and radon daughters carried on the wind. Uranium ore mill tailings retain 85 percent of their original radioactivity and thus require the special shielding currently being used.

Operating nuclear plants are also a source of low-level radiation. They routinely release small amounts of radioactive gases and liquid effluents into the environment and generate solid low-level waste, such as protective clothing and tools, which must be disposed of.

Sources of high-level radiation are the fuel and the material surrounding the fuel, which become highly radioactive as a direct result of nuclear fission. A commercial reactor produces 30-40 tons of this waste each year. Much of this total is reusable uranium and plutonium. If reprocessing becomes an option in the future, not all of this material will be considered waste.

Low-Level Radioactive Waste Disposal

Low-level wastes require only a limited isolation from the environment for a relatively short time. About 43 percent of the low-level waste comes from nuclear power plants. The other 57 percent comes from medical and research facilities, industries, and from government and military operations.

Liquid and dry wastes are reduced in volume by using one of several techniques. The Department of Transportation then regulates the packaging and shipping, carrying, stowing, storing and handling of all radioactive materials. The Nuclear Regulatory Commission is responsible for licensing and regulating all users and handlers of radioactive materials, including waste shippers and carriers.

Commercial low-level wastes are currently disposed of at three strictly regulated disposal sites; Barnwell, SC; Hanford, WA; and Beatty, NY. The military uses government-operated sites.

High-Level Radioactive Waste Disposal

A large quantity of commercial spent fuel has already accumulated, mainly at existing reactor sites. This does not include the tons of high-level radioactive waste (HLW) produced by the Defense Department. Most military HLW is stored in steel tanks at one of three government storage sites: Hanford, WA; Idaho Falls, ID; and Savannah River, SC.

Commercial reactor spent fuel is currently stored on-site in temporary storage pools of water since a permanent disposal site does not yet exist. Some people suggest that the government should establish interim away-from-reactor (AFR) storage pools as on-site pools fill to capacity.

Part of this waste will remain radioactive for thousands of years. The U.S. government's task is to develop a repository to isolate these wastes from geological, meteorological, or human interference. The government is investigating the possibilities of using salt beds, basalt, shale, and granite formations. Minnesota has deposits of the last three types mentioned.

Siting problems will naturally arise, especially since eight states have banned nuclear waste disposal within their borders. Although some states and communities have banned or severely limited the shipment of these wastes through their jurisdictions, new Department of Transportation regulations effective February 1982 supersede these state and local bans. (Three states have moratoriums on nuclear power plant construction until safe, permanent waste disposal is available.)

DIVERSION

Diversion refers to the illegal acquisition of nuclear materials for the purpose of making nuclear weapons. This might be carried out by a disgruntled employee, a terrorist group, or an irresponsible nation. They would need to divert either enriched uranium or plutonium after reprocessing, or they could acquire spent fuel and reprocess it themselves. Therefore, enrichment facilities, reprocessing plants, and transporters are especially vulnerable.

Diversion of plutonium might be difficult to detect (the amount obtained from reprocessing is not exact). No special precautions beyond wearing gloves would be necessary for an individual trying to steal a small amount of plutonium. A crude bomb requires only about 22 pounds.

Nations which adhere to the nuclear safeguards of the International Atomic Energy Agency are presumably less vulnerable to diversion of their nuclear materials. Those nations which have signed the Nuclear Non-Proliferation Treaty have agreed to abide by IAEA standards.

PROLIFERATION

Existing nuclear weapon states are the United States, the U.S.S.R., France, China, India, and the United Kingdom. The term proliferation refers to the acquisition by additional countries of the capability to produce nuclear weapons. Most countries agree that the spread of nuclear weapons capability would create a more dangerous and unstable world.

One hundred fourteen nations have signed the Nuclear Non-Proliferation Treaty (NPT). Under the treaty non-nuclear weapon states pledge not to manufacture nuclear explosive devices and agree to international verification. Nuclear weapon states pledge not to transfer nuclear devices to any non-nuclear state or assist it in the manufacture or acquisition of nuclear explosive devices, and to negotiate limitations and reductions of their own nuclear stockpiles. All parties agree to cooperate in the peaceful use of nuclear energy. NPT countries receive assistance (mainly from the United States) with uranium exploration, basic nuclear physics, and health and agricultural applications of nuclear science.

Some nations that have nuclear research programs have refused to sign the Non-Proliferation Treaty. They are India, Pakistan, Egypt, Israel, South Africa, Brazil, Spain and Argentina. In addition, Iraq and Libya have signed the treaty but say they want to acquire nuclear weapons anyway.

FUSION

When two small atoms combine, or fuse, they release energy. Researchers are presently trying to economically sustain a **controlled** fusion chain reaction. (Currently it takes more energy than is produced.) If this could be accomplished, we would have an energy source for which we would have an unlimited supply of fuel — hydrogen, more specifically heavy water, or deuterium (D_2O), from seawater. A fusion reaction will occur only under extreme heat and pressure, such as occurs on the sun. The sun is fired by fusion.

There are serious problems, however. Controlled nuclear fusion may not be possible. Then again, scientists may achieve a breakthrough any day. The Tokamak device, using electromagnetic coils, will be experimentally in operation in 1981 at Princeton University.

Due to the high temperatures required, special engineering designs will be needed to prevent thermal pollution or adverse reactions of materials to extreme temperature changes. However, a fusion reactor could not experience a meltdown due to malfunction. Because of the requirement to heavily shield the fusion reactor, it would be economical to construct large reactors only.

SUMMARY OF COMMON PRO-NUCLEAR ARGUMENTS

Proponents assert that nuclear power is a safe, clean, economical, indispensible source of energy. Without a commitment to production of nuclear energy, the United States demand for electricity cannot be met. Increased energy use is necessary for continued economic growth. They argue that nuclear power costs less and is less dangerous to the environment and to our health than fast-diminishing fossil fuel alternatives.

1. **CONSTRUCTION COSTS.** Current construction costs are abnormally high because public interference and changing government regulations push completion times to 12 years rather than the 5-6 years that other nations experience. They could be cut considerably if we committed ourselves to speeding up the process.

2. **SAFETY.** Admittedly, technical elements may have been imperfect, but they have not been unsafe. Even though a possibility of a serious accident exists, the statistical probability is small and getting smaller.

Technological advances, particularly since the accidental release of radioactive gases from the nuclear generator at Three Mile Island (TMI) led to a close look at equipment and procedures, have greatly improved existing reactor equipment, operations, and safety systems. Additional developments will soon minimize the potential hazards of reprocessing spent fuel and operating breeder reactors. The safe storage of nuclear wastes is technologically possible but there are social and political hurdles to cross. Although in the past the hazards of uranium mill tailings were underestimated, current mill tailing operations are safely regulated by industry and government.

3. **INDEPENDENCE.** Proponents argue that nuclear power is necessary if we are to meet our goal of energy independence from unstable, possibly enemy nations.

4. **WORLD DEVELOPMENT.** The United States is perhaps even obliged to spread the benefits of its nuclear technology throughout the world. If we do not, the world will not be able to grow the food, provide the fuels, extend the benefits of medicine, or develop the natural resources required if its millions are to have a decent life.

5. **PROLIFERATION.** Our involvement in sales of nuclear materials and technology to other nations is vital if we are to stay in a position to influence nuclear developments abroad. Halting nuclear power in the United States would not end the threat of nuclear weapons proliferation as long as other countries continue their nuclear development. The United States should maintain the lead and control proliferation.

6. **SABOTAGE.** The problem of sabotage by terrorists or antinuclear groups is not beyond technical solutions. Current reactors would be difficult to sabotage and their sabotage so unlikely to result in public harm that the threat's credibility and its effectiveness as a blackmail tool would likely be very small. Furthermore, it would be more logical for terrorists to steal an existing weapon, thus avoiding the risks of creating their own.

7. **NEED FOR OTHER ENERGY SOURCES.** Proponents are neither anti-conservation nor anti-alternative energy. Both are necessary in our energy future. Since nuclear power can only fill our electrical needs, we should convert wherever possible to electric heating, electric cars and the like. We will still need to conserve fossil fuel consumption and develop the appropriate alternatives.

SUMMARY OF COMMON ANTI-NUCLEAR ARGUMENTS

Opponents attack nuclear power as being a dangerous source of energy that has been forced upon us by considerable government support, financial and otherwise, over the last 30 years.

1. **COSTS.** The critics question the assertion that nuclear power is economically a good deal for Americans. Costs are skyrocketing for nuclear construction, fuel processing, decommissioning, and hidden government subsidies.

2. **SAFETY.** The critics' main objections, however, emphasize the gravity of the potential health hazards due to radiation in the entire cycle, from uranium exploration, mining, milling, and transportation through the eventual disposal of nuclear wastes and dismantling of old reactors. They point to potentially catastrophic accidents. They fear that we can never eliminate the possibility that human error will cause such an accident or interrupt the operation of automatic safety systems.

They doubt the possibility of guaranteeing the technologicial, geological, and political safekeeping of radioactive nuclear wastes for thousands of years. Critics quote scientists like Dr. Karl Z. Morgan, former director of health physics for 30 years at Oak Ridge National Laboratory, who says that there is no safe level of radiation exposure.

3. **INSTITUTIONAL STRUCTURES.** The channels of control are already difficult for the average citizen to use because of lack of time and resources to attend licensing hearings and a lack of education in nuclear power. Opponents also lack confidence in a government agency's ability to regulate the industry.

4. **SOCIAL VALUES.** Some critics resent the inevitability of a "technological elite" controlling the industry. Furthermore, the nuclear trend seems to point to more centralization of facilities and an increased demand for energy. Opponents criticize the underlying philosophy that "bigger is better" and would prefer a return to the days of "waste not, want not" to avoid potential social and environmental disasters.

5. **TEMPORARY USE ONLY.** Some opponents see nuclear power as a necessary transition stage for the next 20-30 years. They recognize the need for current

production rates of electricity to avoid brownouts and the resulting inconvenience and social chaos. When viewed in this light, the benefits of the short-term use of nuclear power outweigh the risks, they say.

6. ALTERNATIVES. Opponents of nuclear power stress that geographically appropriate alternative energy sources, safe and readily available, should be developed with government support. Electricity from these sources could be sold or traded to the utility companies' grid system.

In addition, the greater use of home insulation, more fuel-efficient transportation and manufacturing processes, the purchase of fewer single-purpose appliances and goods in throw-away packaging, and many other conservation measures would reduce energy demand considerably. Conservation could reduce the need for new power plants.

7. PROLIFERATION. Most critics assert that nuclear power in the United States contributes greatly to the proliferation of nuclear weapons in the world.

8. SABOTAGE. In addition, every reactor and fuel cycle facility is a potential target for terrorists interested in materials for bombs or sabotage. Any benefits of nuclear power, to this way of thinking, do not justify the risks involved.

SOME ENERGY STATISTICS

1. The United States is the world's largest producer, consumer and importer of energy.
2. Oil supplies about ½ of the U.S. energy consumed. Half of this oil is imported. Until 1970, domestic oil production filled most of the demand.
3. Natural gas supplies about ¼ of the U.S. energy consumed. Only 5% of this is imported.
4. Both oil and natural gas production in the United States have been declining since 1970. We currently import almost ¼ of all our energy.
5. In the years 1974-80, the United States average energy growth rate was 3.1%. Previously the growth rate had averaged about 7% each year.
6. Department of Energy statistics on U.S. electrical energy sources (1979):
   - 47.8% — coal
   - 14.7% — natural gas
   - 13.5% — oil
   - 11.4% — nuclear
   - 12.5% — hydro-power (dams)
   - 0.2% — other (geothermal, wood and waste)
7. The first U.S. commercial nuclear power plant went into operation in 1957 at Shippingport, PA.
8. As of 1979, the following states depended greatly upon nuclear power to produce electricity:

Vermont	78%
Maine	60%
Connecticut	53%
Nebraska	50%
S. Carolina	44%

9. Minnesota generates about 30% of its electricity by nuclear power. (Most of the rest is generated by coal.)
10. Northern States Power Company operates three nuclear reactors in Minnesota: two pressurized-water reactors, built by Westinghouse, at Prairie Island (operating since 1973 and 1974) and one boiling-water reactor, built by General Electric, at Monticello (operating since 1971).
11. As of Sept. 15, 1980, this was the status of U.S. nuclear power plants:

74	reactors with operating licenses (includes 2 indefinitely shut down — Humboldt Bay and Three Mile Island)
87	reactors with construction permits
2	reactors with limited work authorizations
19	reactors on order
182	total commitments

12. As of Dec. 31, 1979, this was the status of foreign nuclear power plants:

166	reactors operable
156	reactors under construction
33	reactors on order
233	reactors firmly planned
588	total commitments

13. Types of operating reactors in the United States:

PWR	— Pressurized-water reactor	45 units
BWR	— boiling-water reactor	26 units
HTGR	— high temperature gas-cooled reactor	1 unit
LWBR	— light water breeder reactor	2 units
GR	— graphite reactor	1 unit
		75 units

14. Manufacturers of operating reactors in the United States:

W	— Westinghouse Electric Corp.	29 units
GE	— General Electric Company	26 units
B & W	— Babcock & Wilson Company	9 units
CE	— Combustion Engineering, Inc.	8 units
GA	— General Atomic Company	1 unit
AC	— Allis-Chalmers	1 unit
		74 units

15. 1977 DOE statistics showed that 226,954 people were employed in U.S. nuclear energy activities.
16. North America has 41% of the known uranium reserves in the non-Communist countries: United States — 29%; Canada — 12%; Mexico — 3%.
17. 1979 DOE statistics on U.S. uranium production:

State	% of total Uranium Oxide
New Mexico	40
Wyoming	27
Others: Arizona, California, Colorado, Florida, Texas, Utah, Washington	33
	100

Forecasts about uranium reserves differ greatly, but one estimate is that there are about 5 million metric tons of relatively high-confidence, low-cost uranium in the world outside the Communist countries.

18. 1979 DOE nuclear power forecasts:

Number of commercial reactors with operating licenses (range):

1985	1990	1995	2000
101-122	134-149	149-167	167-200

Nuclear as percent of *total electrical* generation:

1985	1990	1995	2000
18	22	22	26

Nuclear as percent of *total energy* consumption:

1985	1990	1995	2000
6.9	9.2	9.9	10.1

Projections of energy demand and use differ greatly among forecasters.

19. As recently as 1978, Minnesota electric utilities were forecasting a deficit in their summer peak output capacity of 2959 megawatts by 1989. The most recent estimate (April 1981) forecasts a surplus of 548 megawats of capacity in 1989, not including a required 15% reserve. Recent forecasts have persistently overestimated growth rates in electricity demand. This demonstrates the inherent uncertainty of forecasting during a time of change.

SUGGESTED READING

Abrahamson, Dean and Edward Zabinski. ***Uranium in Minnesota: An Introduction to Exploration, Mining and Milling.*** Minneapolis, MN: Center for Urban and Regional Affairs, University of Minnesota, 1980, 67 pp., Pub. No. CURA 80-2, single copies free. Order from CURA, 311 Walter Library, 117 Pleasant St. SE, Minneapolis, MN 55455, (612) 373-7833. Stresses in nontechnical language the radiological hazards associated with uranium mining and milling. Discusses the history of exploration for uranium in Minnesota and the development of the uranium industry elsewhere.

"Can the Spread of Nuclear Weapons Be Controlled?" ***Senior Scholastic,*** October 17, 1980. Contains an easy-to-read map of existing nuclear weapon states as well as those that have the capability.

Garrett, Wilbur E., ed. ***Special Report on Energy.*** Washington, D.C.: National Geographic Society, February 1981, 115 pp., 10-99 copies, $1.15 each; 100 or more, $1.00 each. Order from National Geographic Society, Dept. 5000, Washington, D.C. 20036. Summarizes the worldwide energy situation. Investigates the range of energy sources, including nuclear and conservation measures. Contains the author's recommendations for America's near-term energy future.

Keeney, Spurgeon M. Jr., et.al. ***Nuclear Power: Issues and Choices.*** Ford Foundation Nuclear Energy Policy Study Group. Cambridge, MA: Ballinger Publishing Co., 1977, 412 pp. Look for this in libraries. An excellent overview summarizes the nuclear power issues and the common pro- and anti-nuclear arguments. The complete report discusses in depth the full range of nuclear issues and makes recommendations on U.S. nuclear policies.

Nuclear Plant Next Door: The Prairie Island Nuclear Plant and Its Influence Upon Our Community. LWV of Red Wing, May 1981, 24 pp., $1.00. Order from Marge Henke, Route 4, Red Wing, MN 55066. Based on a study of the relationship of the nuclear plant to the city and surrounding area, this booklet looks at economic benefits and liabilities; and responsibilities to the community of the plant, government agencies, and the private sector.

Nuclear Power: An Annotated Bibliography. Washington, D.C.: League of Women Voters Education Fund, March, 1981, 2 pp., Pub. No. 466, 20 cents each, 10 for $1.00. Order this and other national LWV publications from LWVUS, 1730 M Street NW, Washington, D.C. 20036. Add a 50-cent handling charge per order (not per publication) from LWVUS. This up-to-date list features resources that deal with nuclear energy in general, reactor safety, radiation, the nuclear fuel cycle, proliferation, terrorism, and economic and environmental concerns.

A Nuclear Waste Primer. Washington, D.C.: League of Women Voters Education Fund, 1980, 64 pp., Pub. No. 391, $1.25. See ordering information above. This comprehensive, well-organized booklet provides citizens and public officials with the background information they need to participate in nuclear waste management decisions. It defines technical terms; reviews the sources, types and hazards of radioactive waste; outlines past and present government waste management programs; and describes future policy options as well as opportunities for citizen involvement at all levels of government.

An Overview of Nuclear Issues. Washington, D.C.: League of Women Voters Education Fund, available in Summer 1981. See ordering address above. Presents fair representations of pro and con arguments on controversial nuclear issues and a framework for citizens to think through their own answers. Encourages Americans to be part of the decision making process. Includes an excellent bibliography.

Pringle, Laurence. ***Nuclear Power from Physics to Politics.*** New York: Macmillan Publishing Co., Inc., 1979. Specially designed for young people, this book traces the development of nuclear power, explains the physics of fission, describes the nuclear fuel cycle, and explores the controversial issues.

Taking Nuclear Issues to the Village Square: A Guide for Community Leaders. Washington, D.C.: League of Women Voters Education Fund, 1981, 8 large pages, Pub. No. 155, 75 cents. See ordering information above. This new community guide from the LWVEF Nuclear Energy Education Project describes how to design an effective nuclear education campaign. Tips for handling especially "hot" topics and for establishing a middle ground for discussion are included, as well as background information.

Weaver, Kenneth, F. "The Promise and Peril of Nuclear Energy," ***National Geographic Magazine,*** April 1979. Pictures, maps and diagrams make this a valuable resource for anyone unfamiliar with the technology of nuclear power.

RESOURCE GROUPS

Atomic Industrial Forum, Inc., Public Affairs and Information Program, 7101 Wisconsin Ave., Washington, D.C. 20014. This organization provides excellent brief brochures on a variety of nuclear power generation aspects. They also provide sheets of energy statistics.

Critical Mass Energy Project, P.O. Box 1538, Washington, D.C. 20013.

Edison Electric Institute, 1111 19th St. NW, Washington, D.C. 20036.

Minnesota Energy Agency, 150 E. Kellogg Blvd., St. Paul, MN 55101, Information Center telephone number (612) 296-5175.

Northern States Power Company, 825 Rice St., St. Paul, MN 55117, Energy Information number ("Ask NSP") is (612) 330-6000.

Sierra Club, 330 Pennsylvania Ave. SE, Washington, D.C. 20006.

Union of Concerned Scientists, 1725 Eye St. NW, Suite 601, Washington, D.C. 20006.

U.S. Department of Energy, Office of Public Affairs, Room 1E 218, Forrestal, 1000 Independence Ave. SW, Washington, D.C. 20585.

CREDITS

This publication was researched and written for the League of Women Voters of Minnesota by Karen Kooda under the direction of Natural Resources Director Jeanne Crampton. Editorial assistance was provided by LWVMN editor Judith Rosenblatt, LWVMN Development specialist Karen Anderson, and technical consultants from Northern States Power Company, the League of Women Voters Education Fund, and the Committee of Minnesota Certified Radiation Protection Professionals.

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League of Women Voters of Minnesota, 555 Wabasha, St. Paul, MN 55102 - May, 1978

(Sent on Letterhead)

To: The Energy Agency Hearings on the Biennial Energy Policy and Conservation Report
From: Mary Poppleton, Director of Natural Resources for the League of Women Voters of Minnesota
Date: May 11, 1978

I am Mary Poppleton, Director of Natural Resources for the League of Women Voters of Minnesota.

The League of Women Voters at the local, state and national levels has been studying energy since 1974. We reached a national consensus on Energy in March of 1978. A copy of our consensus is on file at the Energy Agency.

During the past year we have cooperated with the Energy Agency in training 95 League members to be Energy Resource Persons in their communities. Training emphasized the reality of the Minnesota energy situation. Energy Agency personnel taught the date on supply, demand and transportation alternatives that is included in this EPCR. They provided ideas for energy education projects in local communities. The Local Services Division under Dixie Diehl continues to provide information and support to Leaguers promoting energy education in their communities.

The League of Women Voters believes that democratic government depends upon the informed and active participation of its citizens. Leaguers from all over the state report that their fellow citizens are not informed about the reality of our energy situation. There is strong evidence that Minnesotans do not believe there is an energy problem.

The League has responded to this with an effort at teaching the basics of the energy situation through a film/discussion program aimed at adult community groups.

The report indicates that efforts are being made to provide energy data curriculum at adult levels. The League strongly recommends that the Agency direct education efforts at the general adult public who will not be affected by formalized instruction. These efforts should start with the realities of supply, demand and alternatives available to Minnesotans that form the basis of this report. Conservation efforts and techniques will be a national outgrowth of the energy information provided.

An informed public will actively participate in the wide areas of choice available to them. The League strongly recommends that the Agency find all possible way to involve informed citizens in energy decision-making. We support the Agency's recommendation for a Citizen Advisory Committee to the Agency. We urge the consideration of an ombudsman so that the public might meaningfully participate in the certificate of need process for power plants and transmission lines.

We thank you for allowing us to speak today and look forward to continued cooperation with the Agency in the future.

League of Women Voters of Minnesota, 555 Wabasha, St. Paul, Minnesota 55102
September 1975

Testimony submitted to the House Committee on Environment and Natural Resources by Mary M. Poppleton, Chair, Environmental Quality Committee on September 20, 1975.

The League of Women Voters of Minnesota enthusiastically supports the energy conservation measures proposed in H.F. 1437. We have followed the bill's progress through the Legislative Commission on Energy, and believe the interests of a wide variety of constituents have been encompassed in the present form of the bill.

The first proposal - prohibiting the use of decorative gas lamps - although not a significant energy saver, would be a highly visible sign of the state's effort. And of course, the many small efforts we make together effect significant savings. We are not sure how it would be possible for the utility or gas distributors to insure that gas provided is not used for this purpose. Perhaps simply a penalty provision for illegal use would provide incentive for compliance.

Sections of the bill providing for energy conservation in state buildings and in schools are particularly important, given the horribly inefficient state of most of these buildings. The additional levy allowed the schools for this purpose is essential.

League members strongly support section 6, requiring disclosure of energy efficiency on appliances. There is currently no way, short of a considerable research effort, for consumers to make wise choices in terms of energy.

In addition to energy ratings, information about estimated cost of operation per unit of time (assuming a given rate per kilowatt hour) would be helpful to consumers, since most are unfamiliar with energy rating terminology. NSP already provides this information, in a general way, for its customers.

Section 6 does not specify who will do the testing. Does subdivision 4 suggest that the Energy Agency Director be responsible for testing? We believe the Agency, as presently structured, does not have the facilities or funding for this. But the choice of testing standards should be left to the discretion of the Agency director.

Automobile labeling is another very visible sign of conservation effort, and one with considerable potential impact.

League members believe the proposed research and development program is one of the most important provisions of this legislation. Although much research is now being done on the National level, Minnesota's situation is unique, since we have none of the traditional sources of energy. Our position could be enhanced by diversifying supply as a result of research in solar energy, and development of small-site hydroelectric plants, among other efforts. Development of intermediate technology (rather than energy intensive technology) for use in Minnesota's industries and agriculture could be another important product of a research and development program.

The League supports the creation of an Energy Research Council to administer the grant program. Since the Energy Agency is now without any formal mechanism for "outside" citizen input, why not expand the responsibilities of the Council to include some participation in formulation of energy policy, or other areas? Such an advisory group would perhaps be free to explore a wider range of policy choices than Agency staff could initiate. It could also help to mobilize support for new policies.

Section 9, providing for low interest loans for improving the energy efficiency of residences, could be very helpful in reducing energy requirements in Minnesota, particularly if the program is promoted extensively. We wonder why houses constructed after 1965 would be ineligible for the loans, since many recently built houses are at least as inefficient as older homes. Also, our understanding is that funds from the Minnesota Housing Authority would be used for this program, thus automatically eliminating households with incomes over $16,000. Given the rationale in subdivision 9 (i.e. improving all dwellings contributes to the general welfare) is this restriction the intent of the proposal?

Energy conservation legislation has been slow in coming on the National level. We urge your swift approval of these much needed programs.

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