CHAPTER 5

NUCLEAR POWER

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Introduction

Nuclear power has been used as an energy source in California since 1963. It now can supply California with 1412 MWe (Megawatts of electricity) from three plants: Humboldt Bay in Eureka, San Onofre in San Clemente, and Rancho Seco I, southeast of Sacramento.

Nuclear power was once looked upon by environmentalists as a potential ally. It was believed that nuclear power would reduce both air pollution and other adverse consequences of using coal, oil, or natural gas for producing electricity. Unfortunately, nuclear power may be neither as safe nor as economical as was once believed, due to the unsolved problem of disposal of the radioactive waste, the possibility of sabotage by terrorists, the possibility of accident, the risk to public health due to added radiation into the environment, as well as the scarcity and high cost of uranium for fuel. Nuclear power is now undergoing sever questioning because it was a technology developed without sufficient foresight.

EXISTING NUCLEAR PLANTS -- Marian Chapla

California has three active nuclear power plants that primarily serve their surrounding regions. These are the Humboldt Bay, San Onofre I and Rancho Seco I plants (Figure 1). The oldest plant, the Humboldt plant, is owned by the Pacific Gas and Electric Company (PG&E) and was licensed to operate in 1963. It has a boiling water reactor with a generating capacity of 69MWe. The San Onofre I plant in San Clemente is owned by the Southern California Edison Company (SCE) and was licensed in 1968. It has a pressurized water reactor with a capacity of 430 MWe. More recently, in 1975, Rancho Seco I in Sacramento County was licensed. It is owned by the Sacramento Municipal Utility District (SMUD) and has a pressurized water reactor with a capacity of 913MWe. The total capacity of these plants is 1,412MWe, which is about 4% of the total energy supply in California.

California's actual gain from nuclear power is still not very significant. The nuclear power input to California has never been 4%. In 1976, only 0.5% of the energy consumed in California was from nuclear power.[30] The plants have not run at 100% capacity simultaneously and, at times, some have not run at all. This has been due to breakdowns, regulation changes, modifications, additions refueling and holds due to questionable safety.[7] For example, the Humboldt plant has been down since July 1976. After Nuclear Regulatory Commission (NRC) regulations were changed, the plant needed modifications and seismic investigation. During the 6 months prior to July 1976, it ran at 71.5% capacity.[67]

The San Onofre I plant has run near 100% capacity for the past 4 years with the exception of the period between November 1976 to April 1977. The plant needed refueling, construction of a metal shield around the reactor (for protection against aircraft collision) and the addition of a new diesel generator.[5] About the same time that San Onofre I was shut down in November 1976, Rancho Seco I began running at 100% capacity. Before that, Rancho Seco I was shut down from April 1976 to October 1976 for repairs.[56] Consequently, only two plants have run at 100% capacity at the same time, and this has just been since April 1977.

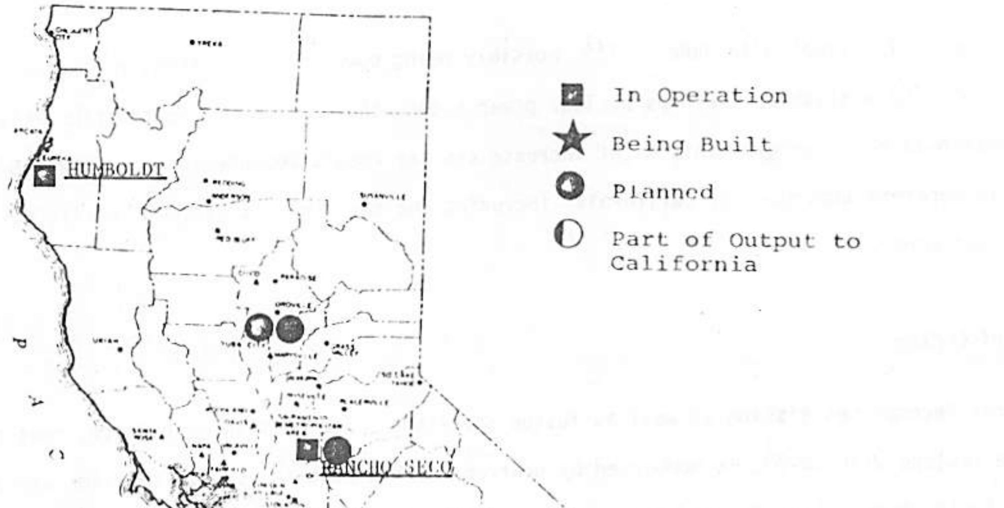

Figure 1. California Nuclear Power Plants, 1975-1995.[65]

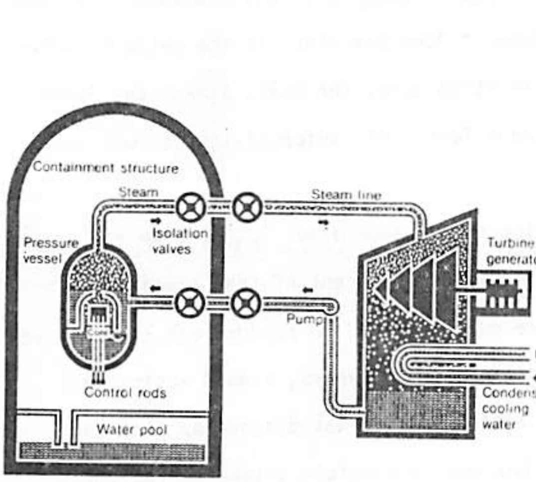

Figure 2. Boiling Water Reactor (BWR).[7]

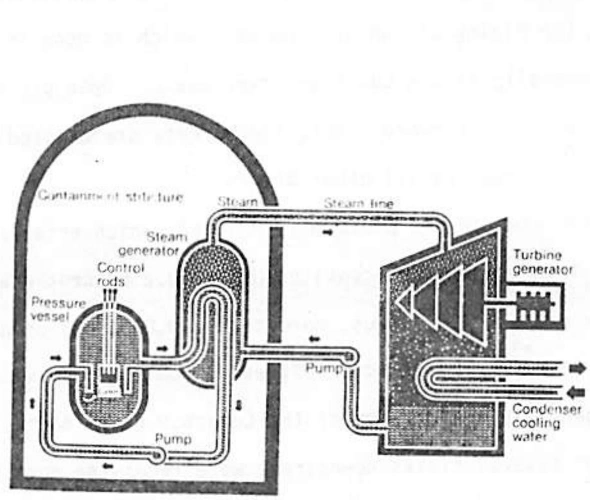

Figure 3. Pressure Water Reactor (PWR).[7]

When Rancho Seco I is refueled in June 1977,[11] possibly being down for two months, a maximum of 430MWe from San Onofre I will be available. Perhaps nuclear power plants that are under construction will come on-line soon and contribute more energy. This might increase the Bay Area's dependence on nuclear power. Until that happens it is apparent that much of California--including the Bay Area--is neither benefiting from nor dependent on nuclear power.

TECHNOLOGY -- Lori Erdley

Nuclear energy encompasses fission as well as fusion processes. In the fission process, heat energy is released when the isotope uranium-235 is bombarded by neutrons. This heat is used in the same way as heat is used in a fossil fueled power plant to produce steam which turns a turbine to run an electric generator. Fusion, on the other hand, uses the energy released when two light elements are fused into heavier ones. Thus far, it has not been technologically feasible to extract more energy than the process consumes; this "break even point" may not occur for many years. Because this is so, only the fission type reactor is important to the energy needs of the Bay Area and is the type that will be discussed.

The predominant type of fission reactor in the United States is the light water reactor (LWR) which is cooled and moderated by ordinary (light) water. Light water reactors can be divided into boiling water reactors (BWRs) and pressurized water reactors (PWRs). There exist three other types of fission reactors, 1) reactors moderated by graphite and cooled by gas (GCRs), 2) reactors moderated by heavy water and cooled by either heavy water, light water or gas (HWRs), and 3) unmoderated, liquid metal cooled breeder reactors (LMFBRs).[32]

Uranium, a naturally occurring element, can be used to fuel a nuclear reactor because its isotope, uranium-235, has the unique property of fissioning (splitting) spontaneously into fragments if it captures a slowly moving free neutron. The splitting is accompanied by the conversion of about a tenth of a percent of the original mass of the uranium nucleus into energy, according to Einstein's $E=MC^2$.[30]

The nuclear fuel cycle which will be described below entails many steps, from exploration for uranium ore to final waste disposal. Exploration involves drilling for core samples and some invasion of wilderness areas by men and equipment.[30] This step is relatively harmless to the environment, especially when compared with the next step, the mining of the uranium ore, which is done in underground or open pit mines in the western United States, especially in the Colorado River Basin. Open pit mines, like strip mines for coal, damage the landscape; while in underground mines, the workers are exposed to dangerous levels of radioactivity, as well as other hazards common to all other miners.

The next step in the process is milling, which entails extracting the uranium oxide (U_3O_8) from raw ore. Presently mined uranium ore contains 0.1 to 0.2 percent uranium, and only 0.71 percent of that uranium is fissionable uranium-235. Thus, more than 100,000 tons of uranium ore must be mined to produce one gigawatt-year of electricity.*[15] The residue left over from the ore is called "tailings". For years, liquid wastes were simply dumped into the streams of the Colorado River Basin. In the late 1950's it was discovered that the residents of several cities downstream were receiving more than the maximum permissible intake of radium--a dangerous radioactive isotope.[30]

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* One gigawatt-year of electricity is the amount of electricity generated in one year by a 1000 megawatt power plant.

Solid tailings are usually discarded on a tailings pile. At present, nearly 100 million tons of tailings have been deposited in these piles.[7] As the pile dries out, radioactive radon-222 gas routinely escapes into the atmosphere where it travels long distances. Two radioactive isotopes, polonium-218 and polonium-214, are formed by the decay of radon-222. These isotopes have chemical and physical properties that cause them to be deposited in the tissue of the human lung, leading to high radiation dose rates in the bronchus, where lung cancers are most likely to arise.[15] The tailings have also been used as a substitute for sand in concrete to make homes and landfill before it was realized how harmful they were.

The enrichment process is the next step. Here the concentration of fissionable uranium-235 is increased several times above its natural concentration of only 0.71 percent. Several methods are possible for this, gaseous diffusion, centrifuges, or lasers. Gaseous diffusion requires 5 percent of the energy the uranium would produce compared to the 0.1 percent that centrifuges need.[31] Possible hazards at this point include transportation accidents and the threat of sabotage (to be discussed later).

In fabrication solid uranium dioxide (UO_2) is compressed into fuel pellets, which are then stacked into fuel rods ½" wide by 12' long.[31] Fifty or sixty fuel rods constitute the fuel element, used in the reactor itself. Gradual internal losses of bomb grade material at the fuel fabrication plant may be extremely difficult to control, while transportation and sabotage are also problems at this stage.

The main components for the reactor itself are the fuel, the moderator, the control rods and the coolant. The moderator serves to slow down the energetic neutrons produced by fission so that they will be captured by uranium-235 to sustain the chain reaction. Only slow neutrons cause the U-235 to fission.[30] The control rods absorb neutrons and can be either withdrawn from or pushed all the way into the reactor core to control the rate of the reaction. The coolant carries away the heat of fission and radioactive decay.

In the boiling water reactor (BWR) this coolant water boils at 645°F and the highly radioactive steam is used directly in the turbine (Figure 2). Since there is no secondary water line, this used steam is then cooled by a condenser and reused. In the pressurized water reactor, on the other hand, the coolant water remains liquid although heated to 600°F (Figure 3). In the steam generator it is allowed to become steam which heats up a completely separate stream of water used to spin the turbine. This working steam is cooled by condenser cooling water and reused. The primary water is also reused in the reactor vessel. Humboldt Bay uses a BWR while both San Onofre and Rancho Seco have PWRs.

Since some fission products remain radioactive for millions of years, spent fuel must either be reprocessed or stored. The fuel becomes "spent" when it has been in the reactor for a year or two and has become so contaminated with neutrons that the chain reaction cannot be sustained. Of particular concern are strontium-90, cesium-137, and plutonium-239. Strontium-90 and cesium-137 both emit extremely intense penetrating radiation and large amounts of heat as they decay. Both require guardianship and isolation from the environment for about a thousand years.[7] They are both potent carcinogens. Plutonium is a synthetic element which was first produced by a group headed by Dr. Glenn Seaborg at the University of California at Berkeley.[43] It is the most lethal carcinogen known and single particles of it in the form of PuO_2 can cause lung cancer when inhaled.[7]

Reprocessing is currently not in practice in the United States. In theory, reprocessing plants extract recyclable fuel components and store the remaining wastes permanently. Recovery and refabrication of this fissionable material into fresh fuel could reduce the need for newly mined uranium by 25-40 percent.[20] Reprocessing is dangerous in that plutonium would be vulnerable to sabotage and accidents because of the vast amounts which would have to be transported. President Carter, in his recent energy proposal, has recommended that the United States defer indefinitely commercial reprocessing and recycling of spent fuels produced in U.S. civilian nuclear power plants.[46]

Presently, hazardous wastes are accumulating at nuclear plants in temporary storage pools awaiting safe means of disposal. In the case of the Humboldt plant, wastes are being stored at the plant, while at Rancho Seco, the first refuelling has not yet taken place.

The Energy Research and Development Administration (ERDA) is the agency responsible for the deposition of nuclear waste products. Thus far, ERDA has used tank storage "farms" and trench waste storage, simply putting highly radioactive wastes directly into the ground.[7] Future ideas for waste disposal include burying nuclear wastes far underground in salt beds or domes, or in solid rock, though these plans present many unresolved problems. The problem of nuclear waste disposal stems mainly from the fact that the nuclear industry as well as government have been irresponsible in creating vast amounts of waste without having the capacity to handle it.

<u>NUCLEAR SAFETY</u> -- Lori Erdley

The safety of nuclear plants is a central issue in the debate on the future of nuclear energy. A sequence of mechanical or human failures, a major earthquake, or an act of war or sabotage might threaten the lives of thousands of people, cause billions of dollars of property damage, and contaminate large areas for many years.

A serious accident could be initiated by a loss of coolant due to a ruptured pipe, a break in a weak weld, a control system failure, or human error. The cooling water must be kept circulating even after shutdown to stop the chain reaction. Even after fission has stopped, accumulated fission products continue their radioactive decay, which can generate enough heat to melt the core ("core meltdown") anytime the cooling water stops. If there did exist a loss of coolant, a backup cooling system would then cool the core. If this backup also fails, then the Emergency Core Cooling System (ECCS) would flood the reactor with more water. If this failed, the reacotr would heat up to more than 5000°F, at a rate of 400°F every ten seconds.[7] Within a minute, fuel rods and surrounding metals would have melted and collected at the bottom of the reactor vessel. It is believed that within a few hours this super-hot radioactive mass of molten metal would melt through both the pressure vessel and its supporting concrete structure.[52] The exact consequences of such an accident cannot be accurately predicted, but it is certain to be disasterous considering that an average reactor contains long-lived radioactivity roughly equal to the fall-out produced by 1000 Hiroshima-sized atomic bombs.[52]

The most controversial of the required safety features is the ECCS. If it works, a meltdown could be prevented, but many nuclear experts have doubted its adequacy. The ECCS has never been tested in a full scale reactor accident and even realistic experimentation is difficult. The prediction of this performance rests solely on computer data. In 1970 the Aerojet Nuclear Company ran six tests for the Atomic Energy Commission (AEC). The ECCS failed to operate as expected each time.[7,52] In 1971, an Aerojet Nuclear report on the tests said that it was "beyond the scope of currently used techniques and...some areas of present engineering knowledge" to predict what might happen in a loss of coolant accident.[7] These results were not released to the public until critics learned of them. The AEC was accused of trying to cover up hazards of nuclear power. Debates ensued between the AEC and its various critics. The reliability of the ECCS has not been settled.

An accident which occurred at the San Onofre plant illustrates the unreliability of the ECCS. A turbine blade broke, causing the alarmed operators to turn off the reactor too quickly. This activated a back-up cooling system which should have been turned off. A drop in pressure, which to the plant's computer simulated a break in pipe, thus caused the ECCS to turn on. Because there really had been no loss in coolant, there was no place for the water to go. This caused both the plant and its ECCS to be damaged by the resulting vibrations and the plant was shut down for months.

Another potential safety problem of nuclear power plants is the threat to nuclear installations from malicious groups and individuals. Certain stages of the nuclear fuel cycle are particularly vulnerable (Figure 4). In order to steal radioactive material for making bombs, terrorist groups could sabotage the enrichment plant, the fabrication plant, the power plant, the reprocessing plant, or they could sabotage during transport. Terrorists could also purposely cause a meltdown after taking over a power plant.

The nuclear industry and their government regulators work on the assumption that there is a threshold or safe level of radiation exposure below which there would be no danger to public health. What counts, for any particular organ, is the total absorption of radiation energy, which is measured in rads.[25] The only possible way to set a safe standard would be to know for certain that no biological effect will occur. Drs. Gofman and Tamplin, in their book, Poisoned Power, state "unequivocally, and without fear of contradiciton that no one has ever produced evidence that any specific amount of radiation will ever be without harm. Indeed, quite the opposite appears to be the case " (p.92).[25] In their research, a clear linear correlation emerged between cancer and radiation, extending even to the smallest doses. The researchers also concluded that if the U.S. public were actually exposed to the allowable radiation limits set by the AEC, 32,000 additional cancer and leukemia deaths, and a large number of genetically-induced deaths, would result.[7]

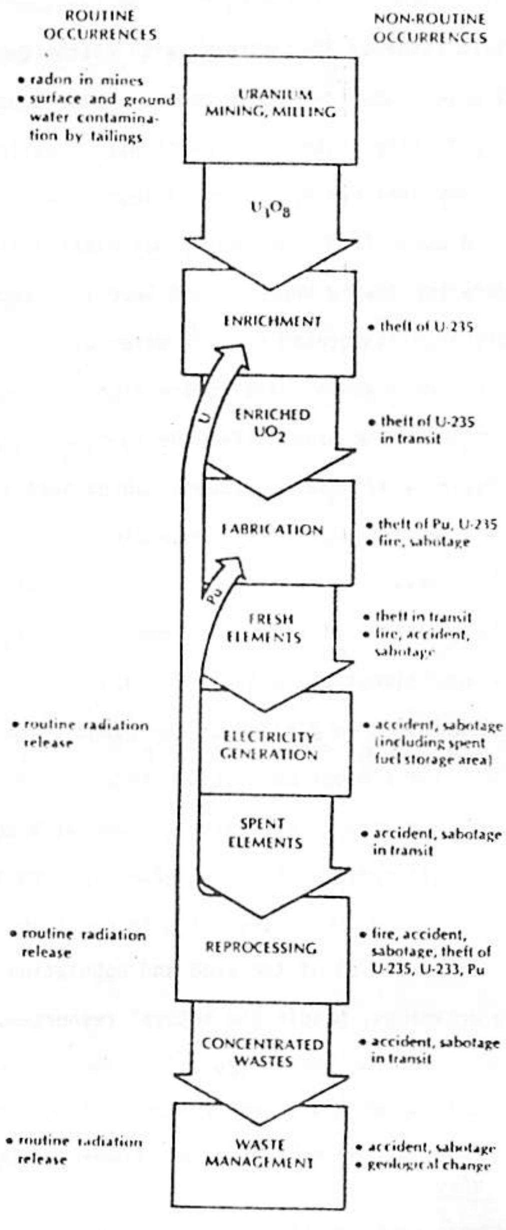

Figure 4. Vulnerable Points of Nuclear Fuel Cycle.[29]

One final problem with nuclear power plants and radioactivity is that of what to do with the plant after it is no longer in operation. Each power plant may have a useful life of up to 40 years. After that time the plant itself may remain hazardous for 1.5 million years.[28] During that time the steel and concrete structures of the reactors will be too hazardous to approach and must be protected. The three possible alternatives are 1) mothballing--in which all parts of the facility must be made inoperable and then guarded, 2) entombment--or burial, with the drawback that the burial may not be long-lasting enough and 3) dismantling--which shifts the problem of disposal to another site. Here we see another example of the lack of long term planning.

ENVIRONMENTAL EFFECTS -- Marian Chapla

Introduction

There are many possible environmental effects that could result from an active nuclear power plant. Radioactivity could be emitted in solid, liquid or gaseous form resulting in air, water or ground pollution as well as solid waste disposal problems. Heat from the cooling waters may thermally pollute the atmosphere or streams, depending on whether cooling is done in towers as at Rancho Seco I or by circulation waters as at Humboldt. Also, chemicals used in the treatment of cooling water may be released into the atmosphere with the evaporated water or into streams with discharged wastewaters before the water is at a chemically safe level. Other problems that can occur concern water supply and earthquake hazard. All of these issues will be explained more specifically in terms of particular locations.

The Bay Area has no active nuclear plants. This means it would not suffer directly from most problems that could occur from a nuclear power plant's discharge. It could, however, suffer indirect effects because it borders the county where Rancho Seco I is located. The Bay Area could: 1) receive air-borne radiation or chemicals from evaporated cooling water or 2) receive contaminated water or agricultural products from the Sacramento-San Joaquin delta region since Rancho Seco I drains into the delta's water sources. Depending on what happens at the plant site, the surrounding region and/or any of the Bay Area counties could be physically or biologically affected. Because Rancho Seco I is the closest to the Bay Area, the potential environmental effects of nuclear plants will be explored with regard to Rancho Seco I.

Rancho Seco I is located on 2,480 acres of grassland which, along with annual and perennial grasses, supports 136 varieties of birds, 5 types of rodents and a few carnivores.[54] Land within a 5-mile radius of the plant is used almost exclusively for grazing. The nearby population totals around 170 people living to the southwest within 1 to 4 miles of the plant. The population is expected to grow between 48% and 113% by the year 2000. The closest population center of 25,000 or more is Lodi, 17 miles to the southwest. Within a 50-mile radius, grazing is extensive throughout 6 counties and there are about 51,000 head of dairy cattle. According to the California Dept. of Agriculture, about 1000 square miles within the Rancho Seco I area are devoted to field crops and 200 square miles to fruit and nuts.[54]

This description of the area and population around Ranch Seco I shows that the plant is close to many interrelating organisms, people and natural resources. The area supports crops, livestock, wild land and aquatic organisms as well as local populations and outside consumers. It follows, then, that the potential problems that could affect one of these members could affect any of the others. Depending on water consumption and on emissions of heat, chemicals or radiation, any number of things could happen.

Radioactivity

The most controversial issue about nuclear power plants deals with radiation emission. It is more dangerous to life than any other type of pollution and its effects are more long-lasting. In the case of an accident, the local environment could be contaminated with dangerous radioisotopes of plutonium, strontium, iodine and other elements. Some of these isotopes remain toxic for hundreds of thousands of years and all of them tend to concentrate in our food chains. Iodine, in particular, can be very harmful. All of the Federal agencies admit that the most immediate danger to the public after any nuclear reactor accident would be the clouds of iodine gases which could be carried by the winds to areas 20 to 50 miles away. This could create contamination of water and milk supplies that could contribute to radioactive iodine concentration in the thyroid glands and cause malignant thyroid cancers.[6]

If an accident occurred at Rancho Seco I, the water used by the Bay Area could become contaminated. Its source could receive contaminated drainage from the site or air-borne radiation. Also, radioactive water could be irrigated into crops or grazing land that provides food for the Bay Area.

Water Pollution

The water cycled through Rancho Seco I comes from and is returned to the Northern California water ways. Water enters the pumping plant from two sources: direct diversion from the American River, and the Folsom South Canal (a canal which was also built to supply water to the East Bay Utility District and Sacramento and San Joaquin county agencies for municipal, industrial and agricultural uses). The water is then run through one of three cycles where chemicals and heat are added and the pH is changed. After this, it is discharged, along with the water from the cooling tower, into a retainment pond called the effluent discharge structure. The discharged water stays there until resident scientists determine that it is safe for release. For example, chlorine, which is conentrated to 3.0 parts per million (ppm) must be reduced to 0.1 ppm before release. The amount of sulfuric acid (added at 3,000 lb./day), chlorine and other elements in the discharge water must not exceed 800mg/l in total dissolved solids.[54] The water is then returned to the Folsom South Canal or to Hadselville Creek. The creek bed, dry during most of the summer, intercepts all site drainage to the north and empties about 2½ miles to the west into Laguna Creek. This water flows into the Cosumnes River, then into the Mokelumne River and Finally into the Sacramento River, about 20 miles south of Sacramento.

The most immediate risk in using a natural water way for nuclear plant discharge is the addition of chemical pollutants to irrigation water used on the agricultural Sacramento-San Joaquin River Delta region and to municipal water used for East Bay Consumption. If management were careless or a disruptive accident occurred at the plant, chemicals at "unsafe" levels could be released into the water ways. If chemicals flowed down the water way, they might be detrimental to soil, crops, livestock and people. Chlorine and sulfuric acid in high concentrations can alter soil and cause varying degrees of poisoning. If crops absorbed these chemicals they might grow poorly and perhaps supply consumers with doses of concentrated amounts. If the East Bay population received chemicals in their water, toxin build-up and/or sickness could result.

The aquatic life in the canal water could be harmed during cycling and discharge. The canal supports a limited number of fish, mostly trout.[54] Where the water is diverted to the plant, there is an entrainment entrance that has a trash rack of 1/8th-inch mesh to keep the large fish out. This unfortunately, allows eggs, fry, plankton and other minute organisms to be whipped through the mesh, mechanically beaten through the plant's systems and exposed to toxic elements and high temperatures.[1] The numbers of the different aquatic species could be reduced drastically. Also, because of this upstream reduction in aquatic fauna and flora, populations of aquatic life downstream could be altered due to food source destruction or contamination.

If the water of the upper Sacramento River watershed became contaminated by heat, chemicals or radiation, the salmon spawning could be affected. Though the Rancho Seco I Environmental Statement reports that there should be not thermal effects, many researchers have shown that small heat or chemical changes can alter much of the aquatic ecosystem.[1,10,37] Heat might raise the temperature to an intolerable or damaging level for spawning or egg growth, cause mutation of embryos by lowering the dissoved oxygen concentration, promote the growth of competitors, predators or parasites or promote the growth of fish that pollute water by their feeding habits (ie: carp).[60,61]

Chemicals and radioactivity can also be threats as groundwater contaminants. There is a very minimal, yet existing risk to the groundwater supplies near Rancho Seco I. Water draining through the site can percolate to an unconfined Sacrmento Valley groundwater basin which supplies the wells of Gault. Although the present level of the basin is about 160 feet below ground surface and the approximate travel time for groundwater through this distance is 1800 to 6000 years,[54] the possibility still exists for contamination. The life of radioactive fission products is much longer than this travel time. This means that there would be a long-run chance for radiation to seep through the soil to the water supply wells. If the level of the groundwater were to rise enough, the wells could become accessible to chemical seepage as well as to radiation.

Environmental concerns have also been expressed with regard to the extra moisture added to the air by the cooling towers. Two points in particular have been raised: 1) whether the evaporated cooling water increases the winter tule fog in Sacramento (and possibly results in higher auto accidents due to thicker fog) and 2) whether the condensation could create harmful precipitation. The Sacramento Weather Bureau reports that there has been no fog increase in Sacr mento due to Rancho Seco I's cooling water and that any talk about it is pure speculation.[69] The question about contaminated precipitation was raised in a report by the Federal Energy Commission Administration which pointed out that an increase in precipitation could result in the removal of toxic materials from the atmosphere -- such as sodium chloride, sodium chloride, sodium sulfate, boron and tritium -- with a possible adverse impact on agriculture in the valley.[20]

Water Supply

Rancho Seco I's water consumption practices presently affect efficient water use in Northern California. The plant uses 25,000 to 27,000 acre-feet of water per year,[11,65] 1.67 gallons for every kilowatt-hour produced.[11] About half of this, 12,000 acre-ft./yr., is lost by evaporation. This is enough to irrigate 4,000 to 5,000 acres of crops.[65] Such consumption could be reduced if a different cooling method were used and/or municipal or agricultural wastewaters were used rather than the fresh water.

Rancho Seco I uses wet cooling towers which require the circulation and discharge of water after a very short use. If it were to use dry towers (which operate similarly to a car's radiator and require small volumes of flushing water) the evaporation loss would be eliminated and intake would be cut to almost 1% of that used for wet towers.[65] Much water could be saved for other needs by using dry towers rather than wet towers. The presently available irrigation wastewater in the San Joaquin Valley could also contribute to more efficient water use by Rancho Seco I. It could provide nearly 425,000 acre-ft/yr., enough to cool nearly 28,000MWe while requiring no diversion of fresh water. The Bay Area could help even more by adding 500,000 to 750,000 acre-ft/yr. to both the Sacramento-San Joaquin Delta region and the cooling towers.[20] This input could be enough to support up to 33,000MWe.

Unfortunately, economic and health reasons have deterred the application of these methods. The dry cooling towers are more expensive to construct, and they reduce the maximum output of the plant by lowering its thermodynamic efficiency. The cost to the consumer of the power produced would increase by 5 to 10%.[65] The use of wastewater would also add to the expense of nuclear power production. Water that goes through the power plant must be purified to the extent that there are no particles in the water near the reactor. This is to eliminate the possibility of radioactive particle discharge. The needed purification would cost a great deal of money. In addition, these might be a chance of adding micro-organisms harmful to human health from municipal wastewater to water supplies used for crop irrigation[20] (though this is unlikely since wastewater is treated).

The very large amount of fresh water used by Rancho Seco I adds expense to people and agriculture in California. In particular, it taps a source used by the East Bay Utility District which is presently under water restriction due to drought. This fresh water could be better utilized and the power plants would be sustained if a dry tower system or recycling were employed.

Conclusion

These factors of environmental concern indicate the relationship that the Bay Area counties and the counties surrounding the plant have with Rancho Seco I nuclear power plant. People homes, land, livestock, crops, products of the area's resources, water quality and quantity and wildlife are vulnerable for miles.

NUCLEAR POWER AND THE BAY AREA - FUTURE -- Laurence Starnes

It seems likely that all the nuclear generated electricity used by the nine counties comprising the Bay Area in the next 20 years will be supplied by plants of similar design to the fission reactors which presently supply this region with energy. This projection assumes that the two alternate forms of nuclear generation, breeder and fusion reactors, will not be sources of commercially produced energy in the near future.

Although commercial production of energy by breeder reactors is at present technologically feasible, because of economic and political complications such commercial production would not be likely until the 1990's.[49]

The U.S. Breeder program is currently the subject of debate in Congress and in the White House. President Carter recently outlined an energy program which could greatly deemphasize the Liquid metal fast breeder reactor and which would terminate the funding of a prototype reactor being constructed at Clinch River, Tennessee. However, the House Science and Technology Committee has voted to continue work on the breeder project as it was originally conceived and to hold further hearings on the issue. An amendment which would cut ERDA spending on breeder research was defeated.[59] It appears at present that even if the Clinch River project is continued, that it will proceed at a slower pace because of pressure by the White House.

ERDA's time table for commercial energy production by breeder reactors is very much contingent on the Clinch River project schedule. A slowdown on this project will result in a slowdown in the overall program.[36] If the Clinch River plant is built it will be followed by a period of evaluation by ERDA scientists. The data compiled from various tests would then be used to influence design of future plants. It would then take an average of ten years for any additional plants to come on line, following this testing period of several years.[36]

The primary supplier of energy to the Bay Area, PG&E, has no plans at present to build any breeder reactors.[62]

Commercial production of energy by fusion power plants is not technologically possible at present and is not likely to be so until after the year 2000.[17] The parmount technical barrier to large scale energy production by fusion is the problem of containment of plasma for a long enough time at a high enough temperature. New methods of plasma containment must be developed so that the plasma is held long enough for economical net energy production.[17]

With breeder and fusion reactors unlikely in the next twenty years it can be seen that nuclear generated electricity will come from fission reactors. But the amount of electricity coming from this source is not likely to increase greatly, for the Bay Area. This is partly due to increasing public concern and protest over the perils associated with nuclear power generation.

In June 1976 a grass roots initiative, Proposition 15, was placed on the ballot. This initiative would have placed much stricter controls on nuclear power plants and placed a possible moratorium on building or operating nuclear plants in California. This is an indication of growing public opposition to nuclear power as it is today. This opposition has also taken the form of appeals and objections at the public hearings held by the nuclear licensing committees and has resulted in delaying the power plants from coming on line. Because of such delays in the long licensing process, utilities such as SMUD are becoming less enthusiastic about nuclear power as the energy panacea of the future. SMUD spokesman Ronald Mattson says: "Ranco Seco II was cancelled primarily because of rising costs. The long licensing process often involving 62 different agencies sulted in much greater costs than were originally expected when the plant was designed. Emphasis is now on conservation and hiking prices to discourage consumption".[39] Discussions with representatives from other utilities reflected similar moods.[62]

High population densities and seismological problems throughout the Bay Area, are factors which will bar the construction of any nuclear plants within this nine county region. In a study done by the California Assembly Committee on Resources Land Use and Energy, most of the Bay Area was described as an unfavorable area for nuclear reactor siting.[65] Given these conditions it appears that future plants serving the Bay Area will be located outside this region.

Although all of the proposed nuclear plants which may serve the Bay Area are surrounded by controversy of one form or another, it is possible that some of these will come on line. The two plants most likely to come on line are Diablo Canyon I and II, located near San Luis Obispo, California. These plants have not yet been granted permits to operate and are presently involved in hearing procedures in conjunction with a review by the Advisory Committee on Reactor Safeguards (ACRS), and the Atomic Safety and Licensing Appeal Board(ASLAB). At present unit I is 99.4% completed and has a designed capacity of 1084 MWe (as of March 1977).[55] Unit II has a designed capacity of 1106 MWe and is 86.1% completed as of March 1977.[55] PG&E's overall system capacity to deliver electrical power is 13,000 MWe could be added to the energy pool, or 18% of the present system capacity.[57]

The major point of controversy involving the Diablo Canyon units is whether or not these plants will be able to withstand an earthquake of maximum magnitude on the Hosgri Fault, which is 120 miles long and 3 miles offshore from the plant. The United States Geological Survey has identified the Hosgri Fault as active and and responsible for a 1927 earthquake of 7.23 magnitude. PG&E originally designed the Diablo Canyon plants to withstand a quake of 6.75, but was told last year to increase that to 7.5. The difference between 6.75 and 7.5 is significant. The larger quake would actually be six times the size of the smaller one, and would release nearly 16 times more energy, according to U.S. Geological Survey scientists.[57] The main concern is the possibility of failure in all backup systems.

at once, something that might result in the melting down of the core of the reactor and the subsequent release of large amounts of radiation into the atmosphere. The Center for Law in the Public Interest, an anti-nuclear group, estimates that corrective steps may cost 200 million dollars. The plant is currently being reviewed by boards of the Nuclear Regulatory Committee. The licensing board will not get the case until September at the at the earliest. It will take at least three months for the board to arrive at a decision in the matter. Appeals by the public will lengthen this time table further. James Geocaris, a lawyer for the Center for Law in the Public Interest says it may take two years for the license to be granted if modifications have to be made.[57]

The construction of these plants has also been hindered by circumstances outside the realm of licensing, such as strikes by electricians, pipe fitters, general strikes and various reconstruction projects involving retubing of main condensors and reblading of low pressure turbines. As a plant ages repairs become a more frequent neccesity and the plant will thus not be functioning for longer periods of time. David Comey has fond that nuclear plants will average only about 43% of designed capacity during a thirty year plant life.[1]

In a recent move, PG&E applied for an interim operating license for the Diablo plants in an attempt to alleviate energy shortages connected with the hydroelectric power shortage caused by the drought. This permit, if granted, would allow the plant to operate for a two year period and would not depend on the current studies of safety.[66]

Rancho Seco unit I currently provides the Bay Area with nuclear energy when extra is produced which cannot be used by SMUD. PG&E helped finance the Rancho Seco plant construction in exchange for surplus energy. "PG&E obligated itself to puchase any of the capacity and energy from Rancho Seco unit one which was temporarily surplus to Sacramento's needs, thus assurring a market for the plant full capacity." [64] Furthermore in this agreement, PG&E also agreed to serve SMUD with energy in the event of a breakdown or emergency of a component of SMUD's system. So far, contributions by Rancho Seco unit I to the Bay Area energy supply have not been high. With its designed rating of 918 MWe the plant could potentially provide 3% of the overall PG&E energy system capacity (If all the energy generated by the plant was in excess of Sacramento's needs). However actual delivery of energy has been so low that PG&E is suing SMUD for loss of revenue.[68,64] The unit has been beset by numerous problems of mechanical origin. Since the plant came on line it has realized only a rating of 32%. (A rating of 100 is given when a plant operates at designed capacity during the period under consideration, ie. 918 MWe.) Therefore cumulative forced outages equal 64%. Nuclear power plants frequently encounter many problems during their first five years of operation, and are gradually debugged during this period. They reach their peak output during the following six years, after which they decline in effectiveness and decrease to an output similar to that, or lower than, the first five year period.[14] Assuming that figures for typical plant capacity factors, will fit the performance of Rancho Seco (C.F.=45%), one would expect very little increase of energy to be available to the Bay Area from this source. Any increases will be muted, in terms of supply to the Bay Area, as the region receives only <u>surplus</u> power above that which SMUD needs for its district. SMUD is not presently investing capital into a major power plant of any type, but rather is stressing conservation among its customers as a means of reducing the rate of energy demand increases. This position, coupled with the growing population of the Sacramento area, implies that in the future an increasingly smaller percentage of excess energy will be available for Bay Area consumption.

A Rancho Seco unit II which would supply a minimum of 1100MWe has been postponed for an indefinite period.

Other nuclear power plants which may yield energy to the Bay Area are the four plants collectively called the San Joaquin Project, which are proposed for the Central Valley, ten miles outside of Wasco. In this project, PG&E would be entering into contracts with Southern California Edison, San Diego Gas and Electric, and L.A. Water and Power. It is still uncertain how much energy each district would receive. If constructed, this 5 billion dollar facility would consist of four units of 1200 MWe each. Assuming that PG&E would receive at maximum one fourth of the total output because there are four utilities involved, this could add 4.5% to present PG&E capacity. This addition is however not at all certain as these plants have not even been granted a construction permit and are involved in litigation. Sponsors acknowledge that construction schedule has slipped by ten years.

PG&E has applied for permits to construct a two unit nuclear power plant in Stanislaus County. This area is currently under early site review by the Nuclear Regulatory Commission. The environmental impact reports have not yet been completed and are not yet available for public scrutiny. PG&E expects a construction permit by July 1, 1978[9]. If current timetables for construction and complete licensing of nuclear power plants persist and are applicable to the Stanislaus project, energy from this plant would probably not be available to Bay Area customers until the late 1980's of early 1990's (it generally takes ten years for a plant to come on line from the time the application process is first initiated.)[7]

San Onofre uits I and II are the source of energy for which PG&E may in the future contract with Southern California Edison. These plants are both 30% completed as of March 1977. Both units have a designed capacity of 1140 MWe and are scheduled for operation in 1980 and 1981.

Other nuclear power plants are proposed to be built in California by Southern California utilities but seem unlikely to contribute any significant amounts of energy to the Bay Area as PG&E has not entered into contractual agreements for surplus energy from these plants. San Diego Gas and Electric has proposed a Sun Desert unit I facility with a designed capacity of 950 MWe to be located in the desert region of Southern California. This plant is targeted for completion by 1984. A second unit is also proposed with the same designed capactiy, and is expected to come on line in 1986.

Southern California Edison plans to build two nuclear generating units in the southern part of the state, to be termed Eastern Desert units I and I . There have thus far not been any contracts between PG&E regarding this facility. These units will have a designed capacity of 1000 MWe each, but have not yet been granted construction permits. Even if a contract were negotiated between PG&E and SCE, it is probable that this would only involve temporary surplus , and in light of the large population and growing energy demands which SCE must serve, such an excess is not likely to occur often for any appreciable lengths of time.

Currently, PG&E has a contractual agreement called the "Seven Party Agreement" which makes it possbile for four northwest utilities (Pacific Power and Light Co., Portland General Electric Co., Puget Sound Light Co., and Washington WaterCo.) to sell a certain form of surplus energy to and purchase excess energy from PG&E, SCE, and SDC&E. This agreement presently is only applicable to power generated from hydroelectric sources, however it is a possibility that the contract will be expanded to include nuclear energy supplies as well, although the amounts of energy involved are presently unknown.

The overall nuclear picture suggests that in the forseeable future, the primary addition to current Bay Area energy supplies from this sector, will be from the Diablo Canyon units if they are allowed to come on line, with the San Joaquin Project being the second most likely source of a significant addition to the Bay Area's supply of nuclear generated electricity.

THE ECONOMICS OF NUCLEAR POWER -- Laurence Starnes

One of the most important factors to shape the future of nuclear energy supplies to the Bay Area is the fact that costs for nuclear power generation are increasing at very rapid rates, and it may soon be economically sound as an investment. Lewis Perl, vice president of National Economic Research Associates, (a firm of consultants on energy and resource problems), estimates that plant construction costs, allowing for regular cost increases plus inflation, will rise 9 to 10 percent a year during the period studied (1980-1990). He further projects that 1990 fuel costs for nuclear power plants will be two times that of present costs.[41]

Although nuclear power plants are by far the most expensive type of fuel plant to build, nuclear energy has been until recently, cheaper for utilities to produce because of the very low cost of the uranium fuel supplies which nuclear power plants use to generate electricity. However, this one-time cost advantage is changing rapidly. In the late 1960's General Electric (a major supplier of uranium fuel along with Westinghouse), projected future uranium prices (final selling price), to be $4 per pound.[19] However, a short time later in 1972 the price for immediate delivery of uranium fuel was reevaluated and has continued rapid rates of increase to the current value of $41.60 per pound.[38] The uranium price escalation has come as quite a surprise to the nuclear industry. Westinghouse misread prices so badly that in 1975, the company announced it would have to default on its uranium supply agreements with twenty utilities which had contracted with Westinghouse for uranium ore deliveries in the 1980's and in some cases into the 1990's. The Westinghouse incident and accounts in newspapers have signaled the existence of a uranium shortage in the U.S. and world markets.[7,23] Morgan Huntington, an engineer with Enforcement and Safety Administration, U.S. Department of the Interior, calculated that the amount of uranium reserves in the U.S. are only sufficient to fuel sixty-two nuclear reactors of the 1000 MWe size for the projected lifespan of these plants.[34] In 1976 James Harding of the Friends of the Earth, analysed Rancho Seco I and found the actual cost of power delivered by the plant would be 3 times the amount projected by the SMUD's consultants. This increase was the result of fuel cycle costs, which were found to be five times higher than the estimates at the time of the original planning.

Nuclear power will most likely be an uneconomical source of energy by the next decade. As uranium supplies continue to dwindle, cost advantages of nuclear over other forms of energy will continue to decrease. Help cannot be expected from abroad. The U.S. has the bulk of the world's uranium supply within its borders. Other countries will need foreign supplies to operate their own light water nuclear reactors. ERDA states that, "Over the long term, prospects for significantly augmenting U.S. uranium resources, with imported uranium are not good, unless new discoveries add appreciably to currently estimated foreign reserves.'

Such high costs of nuclear power make this source of energy quite undesirable for the residents of the Bay Area in view of the great environmental risks this energy source poses for the Bay Area and California.

CONCLUSION

The Bay Area is not dependent on nuclear power which only supplies a small percentage of our total energy needs. Because of this, wesstill have time to evaluate our energy priorities and weigh them against the environmental risks and social costs of this form of power. The hazards of nuclear power, including the increase in radiation, the threat of sabotage, the accident risk, and the danger to people, land, and livestock have not proven to be worth the benefits derived from it. We feel that for the small amount of energy provided, nuclear power is an unacceptable risk to California and the Bay Area. It now appears that within a decade nuclear power will not be economically feasible nor will it be a competitive source of energy.

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