UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
DUKE POWER COMPANY	)	
	)	Docket No. 70-2623
(Amendment to Material License SNM-1773 for Oconee Nuclear Station Spent Fuel Transportation and Storage at McGuire Nuclear Station)	)	

TESTIMONY OF DR. LEONARD D. HAMILTON

My name is Leonard D. Hamilton. My address is 6 Childs Lane, Setauket, New York 11733.

I am, among other responsibilities, Head of the Biomedical and Environmental Assessment Division in the National Center for Analysis of Energy Systems; the Division is jointly sponsored by the Department of Energy and Environment and Medical Department, Brookhaven National Laboratory, Associated Universities, Inc.

The Biomedical and Environmental Assessment Division aims at developing a realistic assessment of biomedical and environmental effects of energy production and use. All forms of energy, including electric power generation using fossil fuels, hydro, nuclear, and new technologies, are assessed.

I have been involved in assessing the risks of radiation for man for 30 years, specifically the health effects of nuclear energy for electric power generation for nearly 20 years, and the assessment of the comparative health effects from various energy sources for the past 6 years. The

Biomedical and Environmental Assessment activity formally began in July, 1973; for the past and present year, our level of effort is 120 man-months annually.

I received my Bachelor of Arts in 1943 and qualified in Medicine from Oxford University in 1945. I am a registered medical practitioner in the United Kingdom and a licensed physician in New York State. After several positions in University hospitals, I proceeded to research at Cambridge University on histological studies of the mechanism of the action of therapeutic doses of ionizing radiation for which I received my Ph.D. in experimental pathology in 1952. In the meanwhile in 1951 I had received my Doctor of Medicine degree from Oxford; this is a senior medical qualification in the U.K., roughly equivalent to Diplomate in Internal Medicine in the U.S. I am also a Diplomate of the American Board of Pathology (Hematology).

From 1950-1964 I spent 14 years on the research staff of the Sloan-Kettering Institute for Cancer Research and on the clinical staff of Memorial Hospital in New York being Associate Member and Head, Isotope Studies Section at the Institute and Assistant Attending Physician, Department of Medicine at Memorial. During this time I was also a member of the faculty of Cornell University Medical College and a Visiting Physician, Cornell Division, Bellevue Hospital. Since then I have maintained a continuing association with the Sloan-Kettering Institute as Associate Scientist.

~~349 125~~

514 142

At the Institute my laboratory research was on the molecular structure of the genetic material (DNA) and the cells in man concerned with the immune mechanism. I provided the DNA on which the proof of the double-helical structure of DNA is based, and was one of the first to establish the long life of cells in immunity. My clinical work in the hospital involved research on treatment of patients affected with cancer and leukemia with new chemical agents and new applications of radiation therapy.

In 1964 I joined the scientific staff of Brookhaven National Laboratory as Senior Scientist and Head, Division of Microbiology, and Attending Physician, Hospital of the Medical Research Center. Since 1973 I have been Head of the Biomedical and Environmental Assessment Group which in 1976 became a Division of the National Center for Analysis of Energy Systems.

At Brookhaven I continued my laboratory research begun at Sloan-Kettering. In addition, since my Visiting Fellowship at St. Catherine's College, Oxford 1972-73, I have been concerned with placing all risks in life in perspective; and, since becoming Head of the Biomedical and Environmental Assessment activity in 1973, particularly with the assessment of the hazards associated with alternative energy sources and their use. Our group has the lead responsibility to the Department of Energy (DOE) for the assessment of health effects from energy systems and for coordinating such assessments nationally.

~~369~~ 126

514 143

My interest in the risks of radiation for man began with my Ph.D. work in Cambridge in 1944 and, since DNA and the immune system are prime targets of radiation damage, has continued throughout my laboratory research. I have been associated informally with the United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR) almost since its inception in 1957, served as Consultant, Office of the Under-Secretaries for Special Political Affairs, UNSCEAR, 1960-62, and reviewed most of its working papers since then. I was a member of the National Academy of Sciences Committee on Biological Effects of Atomic Radiation, Subcommittee on Hematologic Effects, 1958-64, the NRC-NAS Solar Energy Research Institute Workshop, 1975, and the NRC-NAS Committee on Environmental Decision Making, Steering Subcommittee on Environmental Monitoring, Panel on Effects Monitoring 1975-76, was a member of the Mayor's Technical Advisory Committee on Radiation, New York City, from 1963 to its end in December 1977, and of its successor, the Technical Advisory Committee on Radiation to the Commissioner of Health in the City of New York since then. Since 1972 I have been Consultant to the Environment Directorate, Organization of Economic Co-operation and Development, since 1976 served as DOE (formerly ERDA) represenative in the U.S. Delegation to the Environment Committee, and U.S. delegate to the Joint Environment-Energy Steering Group. I am currently a member of three NRC-NAS groups concerned with the health effects of energy: the Health Effects Resource Group, Risk/Impact Panel of the Committee on Nuclear and Alternative

Energy Systems (CONAES); and the Committee on Research Needs on the Health Effects of Fossil Fuel Combustion Products (HEFF), and the Panel on Trace Element Geochemistry of Coal Resource Development Related to Health (PECH).

In the past year I was a member of United Nations Environmental Programm (UNEP) International Panel of Experts, reviewing the health and environmental damage from the fossil fuel cycle, and of a similar panel reviewing the nuclear fuel cycle. I chaired a Workshop on the Costs of Damage from SO_x for the Organization for Economic Co-operative and Development (OECD), and have been a member of an Advisory Group on the Health Effects of Alternative Energy Sources for the International Atomic Energy Agency (IAEA). Since last year, I have been one of the Consultants to HEW NIOSH, overseeing the Portsmouth Naval Shipyard Study.

I have been Professor of Medicine, Health Sciences Center, State University of New York at Stony Brook, New York since 1968 and I am currently member of the American Association for Cancer Research, American Society for Clinical Investigation (emeritus), American Association of Pathologists, Inc., and the British Medical Association.

Duke Power Company has asked me to assess the various health effects associated with their proposed activity of transporting spent fuel from its Oconee Nuclear Station to its McGuire Nuclear Station. I have focused on the following:

a. Modification of existing Oconee spent fuel pools.

The total doses calculated by Mr. Lionel Lewis (See Testimony of Lionel Lewis) for modification of existing racks (reracking, installation of poison racks, Units 1, 2 and 3, and transportation and storage at McGuire, based on the shipment of 400 spent fuel assembiles, are 84, 107, and 56 person-rem respectively. Using the cancer risk estimates for the general population for exposures to low dose, low-LET radiation, single exposure, both sexes combined, absolute risk model from the Report of the Committee on the Biological Effects of Ionizing Radiation (BEIR-III), the incidence of cancer for the reracking option would be $(2.2\text{-}3.4)\ 10^{-2}$ with mortality $(0.6\text{-}1.1)\ 10^{-2}$, and for the poison rack option $(2.8\text{-}4.2)\ 10^{-2}$ with mortality $(0.6\text{-}1.4)\ 10^{-2}$. The incidence of cancer for transportation and storage at McGuire would be $(1.5\text{-}2.3)\ 10^{-2}$ and mortality $(0.3\text{-}0.7)\ 10^{-2}$.

Using the genetic effects information given in the 1972 Report of the Committee on Biological Effects of Ionizing Radiation, (BEIR I), from which the recently published update of the BEIR Committee, BEIR III does not differ significantly, the genetic effects for the three options were estimated. Reracking would give rise to 0.0006-0.009 genetic effects first-generation, and 0.003-0.08 total genetic effects at equilibrium. Poison racks would give rise to 0.0007-0.009 genetic effects first generation, and 0.004-0.09 total genetic effects at

equilibrium. Transportation and storage at McGuire would give rise to 0.0003-0.007 genetic effects first-generation, and 0.002-0.05 total genetic effects at equilibrium.

b. Construction of separate storage facility at Oconee.

The total doses calculated for AFR on Oconee site and for transportation and storage at McGuire are 48 and 56 person-rem respectively. Using the cancer risk estimates as above (a), the occurrence of cancer from AFR on site would be $(1.3\text{-}1.9)\ 10^{-2}$ with mortality $(0.4\text{-}0.6)\ 10^{-2}$. The occurrence of cancer from transportation and storage at McGuire would be $(1.5\text{-}2.3)\ 10^{-2}$ and mortality $(0.3\text{-}0.7)\ 10^{-2}$. Using the genetic risk estimates as above (a), the AFR on site would give rise to 0.0003-0.006 genetic effects first generation and 0.002-0.04 total genetic effects at equilibrium. Transportation and storage at McGuire would give rise to 0.0003-0.007 genetic effects first generation, and 0.002-0.05 total genetic effects at equilibrium.

c. Construction of separate storage facility away from Oconee but not at McGuire.

The total doses calculated for AFR off Oconee site and for transportation and shipment at McGuire are 72 and 56 person-rem, respectively.

Using the cancer risk estimates as above (a), the incidence of cancer for AFR off-site would be $(1.9\text{-}2.9)\ 10^{-2}$ with mortality $(0.5\text{-}0.9)\ 10^{-2}$. The incidence of cancer for trans-

portation and storage at McGuire would be $(1.5\text{-}2.3)\ 10^{-2}$ with mortality $(0.3\text{-}0.7)\ 10^{-2}$. Using the genetic risk estimates as above (a), the AFR off-site would give rise to 0.0005-0.009 genetic effects first-generation, and 0.003-0.07 total genetic effects at equilibrium. Transportation and storage at McGuire would give rise to 0.0003-0.007 genetic effects first-generation, and 0.002-0.05 total genetic effects at equilibrium.

d. Radiation dose to persons living in the vicinity of the transportation routes.

The annual population dose that would be received by approximately 42,000 persons who live within 0.5 miles of the route over which 400 spent fuel assemblies will be transported would be 0.14 person-rem. The corresponding annual population doses that would be received by the same 42,000 persons from background radiation would be 5880 person-rem; i.e., 42 thousand times greater.

Using the cancer risks estimates as above (a), the occurrence of cancer from routine releases in persons living along transportation routes, i.e., the 42,000 persons who live within 0.5 miles of the route, would be $(3.7\text{-}5.6)\ 10^{-5}$, with mortality $(1\text{-}1.7)\ 10^{-5}$. The corresponding annual incidence of cancer from natural background radiation would be 1.58-2.35 with mortality $(4.12\text{-}7.39)\ 10^{-1}$.

For perspective, the annual death rate from all causes in South Carolina is 8794 per 100,000 persons and in North

Carolina 8803 per 100,000 persons. The annual mortality from cancer in South Carolina is 1209 per 100,000 persons, and in North Carolina 1286 per 100,000 persons. One thus expects roughly 370 of the 42,000 to die each year from all causes, and, 52 deaths from cancer per year.

Using the genetic effects risk estimates as above (a), the genetic effects from routine releases in persons living along transportation routes would be 1×10^{-6} -1.7×10^{-5} genetic effects first generation, and 5×10^{-6} -1.3×10^{-4} total genetic effects at equilibrium. The corresponding genetic effects from natural background radiation would be 0.0412-0.706 genetic effects first generation, and 0.212-5.47 total genetic effects at equilibrium.

The current incidence (resulting from causes other than the added radiation) of human genetic effects is ~107,000 per million liveborn.

e. Radiation dose to persons traveling over the transportation routes concurrently with spent fuel shipment.

The dose that would be received by people traveling over the transportation routes concurrently with spent fuel on the conservative assumption that such a person would be following the truck for 10 hours for 400 shipments at a distance of 100 feet from the truck for approximately 300 miles is 0.16 rem per person, or for 4 hours for 400 shipments at a distance of 100 feet from the truck for approximately 170 miles is 0.064 rem per person.

369 132

514 149

Using the cancer risk estimates as above (a), the risk of the occurrence of cancer in a person who had followed the truck for 10 hours for 400 shipments at a distance of 100 feet from the truck for approximately 300 miles would be $(4.29\text{-}6.38)\ 10^{-5}$ with mortality $(1.12\text{-}1.98)\ 10^{-5}$, and for 170 miles would be $(1.71\text{-}2.55)\ 10^{-5}$ with mortality $(4.5\text{-}7.9)\ 10^{-6}$.

Using the genetic risk estimates as above (a), the genetic effects in persons who had followed the truck for 10 hours for 400 shipments for approximately 300 miles would be 1.12×10^{-6} -1.92×10^{-4} genetic effects first generation, and 5.76×10^{-6} -1.49×10^{-4} total genetic effects at equilibrium. For persons who had followed the shipments for 4 hours for approximately 170 miles, the corresponding figures would be 4.48×10^{-7} -7.68×10^{-6} genetic effects first generation, and 2.3×10^{-6} -5.95×10^{-5} total genetic effects at equilibrium.

f. Radiation dose to persons in the vicinity of an accident or exposed to a delay in transit.

On the assumptions used in the U.S. NRC Environmental Impact Appraisal related to Spent Fuel Storage, December 1978 (p.31), the population dose for a traffic jam would be less than 0.2 man-rem and the maximum dose to an individual would be 15 mrem (note Mr. Lionel Lewis in his testimony is more conservative and uses a 10-hour rather than a 3-hour traffic jam with a maximum dose to an individual due to delay of 30 mrem) and using the cancer risk estimates as above (a), the total risk of cancer

~~369 133~~

514 150

from such a delay would be less than $(5.36\text{-}7.97)\ 10^{-5}$ with mortality $(1.4\text{-}2.47)\ 10^{-5}$. The risk of an individual developing cancer as a result of such a delay would be $(4.02\text{-}5.98)\ 10^{-6}$ with mortality $(1.0\text{-}1.8)\ 10^{-6}$.

Using the genetic effects risk estimate as above (a), the genetic effects of delay would be less than 1.4×10^{-6} - 2.4×10^{-5} genetic effects first generation, and 7×10^{-6} - 1.9×10^{-4} total genetic effects at equilibrium.

From the risk analysis made by Dr. B. John Garrick of the transport of spent fuel (See Testimony of Dr. B. John Garrick), from 400 shipments of spent fuel assemblies, using the cancer risk estimates as above (a) the total risk of cancer from all accidents in such shipments would be $(7.2\text{-}10.8)\ 10^{-4}$ with mortality $(1.9\text{-}3.4)\ 10^{-4}$. Using the genetic effects risk estimates as above (a), the genetic effects of all accidents in such shipments would be 1.9×10^{-5} - 3.3×10^{-4} genetic effects first generation, and 9.6×10^{-5} - 2.5×10^{-3} total genetic effects at equilibrium.

Conclusion

The total somatic (risk of cancer) and genetic effects from propinquity, delay, and accidents in the transport of 400 spent fuel assemblies are extremely small and the total hazard to health is thus correspondingly extremely small.

g. Residual health risks to workers even if NRC regulations are complied with.

~~369 134~~

514 151

The occupational dose to workers involved in the transportation and storage at McGuire option is 56 person-rem. The corresponding occupational doses to workers for modification of existing racks (reracking) is 84 person-rem, for installation of poison racks, Units 1, 2, and 3, 107 person-rem, for AFR on-site 48 person-rem, and for AFR off-site, 72 person-rem.

Using the cancer risks estimates as above (a), the incidence of cancer for transportation and storage at McGuire would be $(1.5\text{-}2.3)\ 10^{-2}$ and mortality $(0.3\text{-}0.7)\ 10^{-2}$, the incidence of cancer for the reracking option would be $(2.2\text{-}3.4)\ 10^{-2}$ with mortality $(0.6\text{-}1.1)\ 10^{-2}$, the incidence of cancer for the poison rack option would be $(2.8\text{-}4.2)\ 10^{-2}$ with mortality $(0.6\text{-}1.4)\ 10^{-2}$, the incidence of cancer for the AFR on-site option would be $(1.3\text{-}1.9)\ 10^{-2}$ with mortality $(0.4\text{-}0.6)\ 10^{-2}$, the incidence of cancer for the AFR off-site option $(1.2\text{-}1.8)\ 10^{-2}$ with mortality $(0.3\text{-}0.6)\ 10^{-2}$.

Using the genetic effects risk information as above (a), transportation and storage at McGuire would give rise to 3×10^{-4} - 7×10^{-3} genetic effects, first generation, and 2×10^{-3} - 5×10^{-2} total genetic effects at equilibrium. The corresponding genetic effects from reracking would be 6×10^{-4} - 9×10^{-3} first generation, and 3×10^{-3} - 8×10^{-2} total genetic effects at equilibrium. The corresponding genetic effects from poison racks would be 7×10^{-4} x 9×10^{-3} genetic effects first generation, and 4×10^{-3} - 9×10^{-2} total genetic

~~369 135~~

514 132

effects at equilibrium. From AFR on-site, there would be 3×10^{-4} - 6×10^{-3} genetic effects, first generation, and 2×10^{-3} - 4×10^{-2} total genetic effects at equilibrium. From AFR off-site there would be 5×10^{-4} - 9×10^{-3} genetic effects first generation with 3×10^{-3} - 7×10^{-2} total genetic effects at equilibrium.

Overall Conclusion

The overall health effects, i.e., the total expected risks of cancer and of genetic effects in the general population and in workers, occupationally exposed from any of the options - reracking, poison racks, AFR on-site, AFR off-site, and transportation and storage at McGuire - are very small, both in terms of total risk and of risk to any individual.

The transportation option involves a risk of less than one hundred thousandths of a percent increase in the mortality rate of the exposed population. Among workers the risk calculated from the maximum radiation exposure would be one-tenth of one percent probability of developing cancer.

~~367 136~~

514 153