Documenting history: Minutes of the New Piles Committee meetings

BY C. GEORGE LAWSON AND CAROLYN KRAUSE

In 1944, a committee of physicists, chemists, and engineers, including three Nobel Laureates, met at the Chicago Metallurgical Laboratory to explore new designs for power-producing nuclear reactors. The New Piles Committee's meeting minutes describe the proposed new reactor concepts, many of which evolved into today's nuclear technology.

Although this photo (date unknown) was not taken at one of the New Piles Committee meetings, it shows four of the committee members, together on a panel (from left): Walter Zinn, Leo Szilard, Eugene Wigner, and Alvin Weinberg. (Photo: ORNL)

BY APRIL 1944, the physicists, chemists, and engineers responsible for the design of the reactors at the Hanford Site, near Richland, Wash., were satisfied that those reactors would operate and produce sufficient plutonium for the atomic bomb that helped end World War II. They then formed a committee to explore a variety of reactor concepts, including breeder reactors that could produce both electricity and nuclear fuel. The committee recommended that reactors be used for the production of electricity for naval vessels and as sources of neutrons to breed nuclear fuels and test candidate structural materials for advanced high-temperature reactors, as well as for other purposes. In effect, the committee charted the future paths for the peacetime nuclear power industry, the nuclear navy, and nuclear energy research.

The committee members included three Nobel Prize winners in physics—Enrico Fermi, James Franck, and Eugene Wigner. The other members were Samuel Allison, Charles Cooper, Edward Creutz, Farrington Daniels, Thorfin Hogness, Miles Leverett, Phil Morrison, Lee Ohlinger, Frederick Seitz, Leo Szilard, "Ace" Vernon, William Watson, Alvin Weinberg, Gale Young, and Walter Zinn. The group called itself the "New Piles Committee." (The word "pile," as in a "pile of uranium fuel and graphite moderator," was replaced by "reactor" in 1947 when the Atomic Energy Commission [AEC] took charge of the nation's nuclear energy and nuclear defense programs.)

The committee members met at the University of Chicago Metallurgy Laboratory, where the water-cooled Hanford reactors were designed. They met for one-and-a-half hours almost every other week between April and July 1944.

Fortunately, some of the minutes taken at the meetings of the New Piles Committee have been located and are available.[1] Ohlinger prepared an excellent set of meeting notes.

Breeder reactors

Alvin Weinberg, former director of Oak Ridge National Laboratory (ORNL) and a protégé of Eugene Wigner, wrote about the meetings of the New Piles Committee in his book, *The First Nuclear Era: The Life and Times of a Technological Fixer* (American Institute of Physics, 1994, pp. 38–41). Weinberg noted that during these meetings, Fermi was concerned that the public might not accept an energy source such as a breeder reactor partly because of the possibility of the diversion of nuclear material to outlaw groups intent on making atomic bombs.

On April 26, 1944, according to the minutes, Fermi envisioned "one large mother plant" that would produce not only a million kilowatts of electricity but also plutonium "for consumption in a series of smaller plants." He saw the energy production by the mother plant as a way to reduce the cost of plutonium production. The minutes say Fermi "viewed the use of this power for the heating of cities." The minutes also record these words of Fermi: "There may be nontechnical objections to this arrangement, for example, the shipment of plutonium to the smaller consuming plants offers the serious hazard of it falling into the wrong hands."

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Why was the New Piles Committee so interested in the breeder? Weinberg explains it this way: "At the April 28, 1944, meeting of the New Piles Committee, Phil Morrison had reported the known reserves of uranium at workable concentration to amount to only about 20 000 tons. With so little fuel, nuclear energy based only on the 0.7 percent of uranium-235 in natural uranium could hardly amount to much. Morrison also pointed out at this meeting that the vastly larger amount of residual uranium in the granites could be burned with a positive energy balance—but only if used in a breeder."

Morrison suggested that "more work should be done on the nuclear development of thorium because of its greater availability and also suggested experiments," presumably to develop a reactor that would convert thorium by neutron bombardment to uranium-233 fuel. In subsequent years, it was determined that the supply of natural uranium was not nearly as limited as originally projected, so interest declined in breeders using thorium.

The New Piles Committee identified, evaluated, and compared possible reactor types. Its members evaluated peacetime uses for nuclear reactors, their thermodynamic potential, possible fuel arrangements, different types of neutron reflectors, and various coolant-and-moderator combinations. In the unclassified minutes, however, no mention was made of radioactive waste disposal and nuclear reactor safety. Some of the applications for nuclear energy suggested by committee members did not turn out to be practical: They range from polymerizing hydrocarbons to produce synthetic rubber to propelling vehicles for the exploration of the South Pole.

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Mobile piles and nuclear aircraft

Reviewers of the minutes might find it amusing that the committee briefly considered the use of "medium mobile piles" for use in boats and locomotives and "small mobile piles" for use in cars and airplanes. The committee concluded that research programs should focus on developing "large stationary piles"—large reactors—for central power stations that generate electricity for cities. In addition, the committee believed that mobile reactors should be developed for certain naval vessels but were "impractical" for cars and airplanes, mainly because they would require too much shielding.

Today pressurized water reactors and boiling water reactors are used throughout the world in central power stations. Smaller PWRs are employed to propel naval vessels, such as submarines and aircraft carriers.

Originally, Capt. Hyman Rickover wanted to power the U.S. Navy's submarines with liquid-metal–cooled reactors being developed by the General Electric Company. But when Rickover told Weinberg about the high thermal efficiency of such a reactor concept while he was at ORNL taking a reactor course, Weinberg persuaded him that in a submarine, reliability, simplicity, and small size are more important than thermal efficiency, and suggested to him that a PWR was the best match for a submarine. Since then, PWRs have been used widely in both submarines and central power stations.

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Unlike the New Piles Committee, the AEC during the Eisenhower administration was interested in pursuing the development of "small mobile piles" for airplanes. And so, the AEC directed ORNL to determine whether lightweight shielding and a small reactor could be developed to create a flyable nuclear airplane as part of the Aircraft Nuclear Propulsion (ANP) project. Although Weinberg and ORNL researchers agreed with the New Piles Committee that a nuclear aircraft was not feasible, the ANP project—later killed by the Kennedy administration—lifted materials development programs to a new level.

Reactor types and uses

The committee believed that the Hanford plutonium production reactors should be studied to improve their operation and productivity. In addition, the committee envisioned a future path for reactors in the United States. The members proposed that future reactors should be built to (1) produce power, (2) breed fissile materials (e.g., uranium-233 or plutonium-239 fuel from nonfissile thorium or uranium-238), and (3) produce high-neutron-flux sources for materials research and isotope production.

A summary of the reactor types considered by the committee is included in the accompanying table (see next page).

Nuclear energy research

Because the committee's evaluation of available information on known sources of natural uranium and thorium suggested that these materials were limited in supply, the committee recommended that the emphasis of the nation's nuclear research programs be placed on U-238-to-Pu-239 converters and thorium breeding reactors that produce U-233 nuclear fuel. The committee was also interested in learning about the mercury vapor cycle being explored at General Electric for use as a topping plant for the high-temperature reactor because liquid metal at high temperatures was seen as the key to highly efficient power production.

The New Piles Committee members understood that they must receive funds from the U.S. Congress to design "a power producing pile" using plutonium, which at the time was "being deflected into military channels." Although some basic experimental work was being performed during World War II, actual development work on some reactors under consideration by the committee did not begin until 1948.

Phil Morrison suggested to the committee members that the nation needed a "research reactor" that would operate at a high neutron flux. Such a neutron-generating reactor could be used to test samples of materials to determine which ones hold up best when exposed to neutron radiation. Such materials would likely be selected for construction of power-producing reactors designed to operate for decades.

This argument led to the design and construction of the Materials Test Reactor (MTR) in the late 1940s. The MTR and its successors were essentially low-pressure versions of the light-water reactors, which dominated nuclear power plants for civilian and naval power.

According to the minutes, in 1944, "it would appear desirable to press the development of better and more efficient designs for the production of isotopes and let the power production piles coast along. Even the high flux piles for radiation sources for experimental purposes will probably re-

REACTOR TYPES CONSIDERED BY THE NEW PILES COMMITTEE

Presenter	Power Level	Type of Reactor
Reactors for Power Production		
Fermi[2]	1000 kW electric	Small, homogeneous D_2O-moderated plutonium burner.
Wigner[6]	54 to 280 MW	"Pulsating" homogeneous reactor using slurry of enriched material in D_2O and energy from endothermic chemical reactions.
Vernon[4, 8]	Not specified	High-temperature, gas-cooled reactor for electrical energy production.
Reactors for Isotope Production		
Presenter	**Power Level**	**Type of Reactor**
Szilard[3]	250 MW thermal	Fast breeder reactor with enriched material using lead-bismuth (or sodium) as coolant.
Fermi[2]	1000 MW thermal	Mother plant to produce Pu-239 for use in smaller power plants; might be (1) Hanford type, or (2) D_2O-moderated heterogeneous or homogeneous, or (3) sodium-cooled converter or breeder.
Weinberg[6]	60 MW thermal	Water-moderated, enriched for U-238/Pu-239 conversion.
Weinberg[6]	100 MW thermal	D_2O-moderated homogeneous reactor to produce U-233.
Wigner[9]	2750 to 3300 MW	"Pulsating" homogeneous slurry reactor to convert U-238 to Pu-239.
Young[5]		Improvement to Hanford reactors by "flux flattening" and "canning" U in one long tube instead of in slugs. Leak detection during operation was also discussed.
Wigner, Weinberg, Allison, Fermi, Vernon, Szilard, Young[6]		Discussed using long vertical tubes about 1 cm in diameter, cooled by water in several of the reactor types, presented possibly using nucleate boiling for heat removal. Because of the high velocity of the coolant, some method for holding the rods firm would be required.[6] Several members discussed the desirability of a reactor core made of U dissolved in other (not specified) metals.[3, 7]
Reactors as a Radiation Source for Materials Research		
Presenter	**Power Level**	**Type of Reactor**
Morrison[10]	1000 kW	Beryllium (or its oxide) reflected to burn 1 g/day U-235 or Pu-239, moderated with water.

quire the use of enriched material and so this further justifies greater efforts on the piles for production of isotopes."

It is clear that the committee's considerations are the basis of U.S. government and industry reactor research and development programs of the 1950s, 1960s, and 1970s. These included cooperative efforts among the national laboratories, the Naval Reactors Branch, and three major companies—General Electric, Westinghouse, and General Atomics. Smaller companies were involved in minor roles. The AEC funded the Homogeneous Reactor Program, Molten Salt Reactor Program, and Gas Cooled Reactor Program; a project to develop a topping cycle using potassium for space reactors; and a series of research reactors for isotope production, materials testing, and neutron scattering research. The U.S. Naval Reactors Branch developed its Sodium-Cooled Fast-Breeder Reactor programs and its own, classified, PWR.

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Universities built or bought research reactors. Manufacturers of commercial power-generating equipment and metal alloys developed their own versions of PWRs and BWRs.

The New Piles Committee also identified the need for increased understanding of heat-transfer mechanisms, particularly in the boiling region, to ensure that heat is removed safely from fuel-containing tubes.

The New Piles Committee may have erred in its estimate of the cost of nuclear energy as compared with coal, oil, and gas in the production of electricity. The estimate for uranium was based on the energy costs of pulverizing the ore and separating fissile uranium-235 from the more abundant uranium-238. Calculating that burning uranium-235 to produce electricity cost only 2 cents per megawatt-hour, the committee underestimated the cost of nuclear energy.

The New Piles Committee believed that nuclear energy would eventually replace coal as a primary heat source for production of electricity and heat because of the air pollution caused by burning coal. Allison liked the idea of using nuclear power "for heating entire cities since it would also eliminate the usual smoke pall." Today, nuclear power provides about 20 percent of the electricity consumed in the United States.

The New Piles Committee showed great foresight in identifying both the research that would be required to develop a viable nuclear power industry and the variety of applications for nuclear energy. This foresight is further underscored by the Department of Energy's new interest in developing advanced reactors for the production of hydrogen as well as electrical power.

References

1. ORNL Central Files, 1-10 MUC-LAO Nos. 17, 18, 19, 20, 21, 22, 30, 40, 41, and 42, from April 26 to July 28, 1944
2. MUC-LAO No. 17, April 26, 1944
3. MUC-LAO No. 18, April 28, 1944
4. MUC-LAO No. 19, May 5, 1944
5. MUC-LAO No. 20, May 10, 1944
6. MUC-LAO No. 21, May 12, 1944
7. MUC-LAO No. 22, May 24, 1944
8. MUC-LAO No. 30, July 6, 1944
9. MUC-LAO No. 40, July 11, 1944
10. MUC-LAO No. 41, July 26, 1944

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