UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

DOCKET 50-323

TESTIMONY OF WILLIAM J. LINDBLAD
ON BEHALF OF
PACIFIC GAS AND ELECTRIC COMPANY
SEPTEMBER __, 1973

My name is William J. Lindblad. I am the Project Engineer for the Diablo Canyon Units 1 and 2, with responsibility for directing the engineering activities of the project.

My business address is 77 Beale Street, San Francisco, California 94106.

In general, my testimony covers a brief discussion of the cooling water system of the Units and of various alternatives thereto and why they were not adopted. In addition, I have included a brief description of why two of the alternative energy sources discussed in the consolidated petition to intervene are not viable alternatives to the Diablo Units.

I am a graduate of the University of California College of Engineering. I received the Bachelor of Science degree in Electrical Engineering in 1951. I was then called to active duty in the U. S. Navy, serving until 1954. In 1954, I joined PGandE working in the technical operations groups of various steam-electric generating stations. In 1956, I was transferred to the Company's Department of Engineering where I have worked continuously since, with increasing levels of responsibility for design

of fossil and nuclear fueled power plants.

My experience in nuclear power began in 1956 as the Company's representative on the Nuclear Power Group study team, which was related to the Company's participation in Commonwealth Edison's Dresden Nuclear Power Station. I have been involved in much of the Company's nuclear engineering activities since. Beginning in 1966, I have devoted essentially full time to the Diablo Canyon project. I was appointed to my present position in January of 1972.

I am a member of the American Society of Mechanical Engineers and of the Institute of Electrical and Electronic Engineers.

I am a Professional Engineer, registered with the State of California in the field of mechanical engineering.

Nuclear plants such as Diablo Units 1 and 2 will operate with a thermal efficiency of about 32 percent, meaning that about one-third of the heat released by the fission process in the reactor core is converted to electricity. The rest of the energy is at too low a temperature to be efficiently converted to power and must be rejected. Several methods of dissipating this heat are available. After considering these methods, a once-through ocean cooling system was selected. This means that ocean water for cooling will be pumped through the plant from the cove located to the south of Diablo Cove. Each unit has two circulating water pumps capable of pumping 867,000 gallons per minute of seawater

from the intake structure through the two intake conduits to the condensers. Facilities are installed in the intake for the protection of fish. As the water passes through the condenser, steam from the turbine is condensed, and the waste heat transferred to the circulating water.

After leaving the condensers, the cooling water flows by gravity through two discharge conduits to the discharge structure located on the shoreline of Diablo Cove. Total travel time for the circulating water from the intake to the discharge is approximately 4-1/2 minutes. The heated water returning to the ocean is quickly mixed with the turbulent waters of the cove resulting in limited exposures of the benthic and pelagic communities to elevated temperatures.

It is PGandE's belief that the optimum medium, from an environmental standpoint, for receiving waste heat from Diablo Units 1 and 2 is the Pacific Ocean. Once-through cooling, using the ocean water, is the least expensive alternative, will result in the highest power plant efficiency, and requires the least amount of land space. It does not create any obtrusive visual impact on the landscape, and the thermal discharge causes no significant adverse environmental effects. Possible alternatives to the once-through cooling design include off-shore discharge, several kinds of cooling towers, spray canals, and cooling ponds. For the reasons outlined below each of these alternatives was rejected.

An offshore discharge would carry the heated water outside Diablo Cove and dissipate the heat in deeper offshore waters. This would be accomplished by extending the cooling water discharge conduit from the shoreline to an area where the water depth would permit a mixing of the heated water and the ambient ocean in the vertical water column. The water depth required is dependent upon the desired maximum water surface temperature rise, the number and size of conduit discharge openings, and the velocity of water at the discharge openings. For example, for two units the size of the Diablo Units, to achieve a maximum surface temperature rise of 4°F which is the temperature set by the State of California thermal water standards, an offshore discharge could consist of two 11-foot-diameter ports, with a 100-foot separation, discharging water horizontally at 20 feet per second at a depth of 45 feet. Water at this depth is available approximately 1,700 feet offshore from the present discharge structure.

A practical design of a discharge conduit to a point 1,700 feet offshore along the turbulent rocky coast probably would require a submarine tunnel mined in the rock under Diablo Cove. A buoyant flexible conduit would not be expected to survive the wave action during the stormy weather and is not considered a feasible alternative. A conduit laid in a trench along the bottom of the cove would require a construction tramway over the water, and could require a breakwater or a cofferdam. The extensive construction and blasting required for a conduit-in-trench design

would involve a significant environmental impact in itself.

An approximate estimate of the cost of the tunneling required is $21,000,000. If tunneling under pressure were required, the cost would increase by as much as $7,000,000. The two exit ports must be drilled and set with the use of an offshore drilling platform, and this is estimated to cost an additional $7,000,000. If detailed examination of the local area and heat dispersion characteristics show a need for additional ports, the cost for constructing these ports would be as much as $14,000,000. Thus, the total capital costs for an offshore discharge could range from $28,000,000 (without pressure, without additional ports) to $42,000,000 (with pressure, with additional ports).

Alternatives to the once-through cooling system include cooling towers, cooling ponds, and spray canals, all of which dissipate heat to the atmosphere by evaporation. Cooling ponds also dissipate a part of the heat through radiation and conduction. In an evaporative cooling process, a closed cycle system (cooling water recirculating between tower and condenser) would consume in evaporation about 50,000 acre feet of water a year for the two units at Diablo Canyon. These systems require an additional water exchange to maintain the dissolved solids concentration below a maximum limit. To maintain normal environmental quality within

the system, fresh water is preferred. Fresh water in this quantity is not available in the plant site region as indicated by State of California, Department of Water Resources Bulletin No. 160-70. No reclaimable water sources are present in the necessary quantity. Therefore, only closed water systems using salt water have been considered.

It is possible to use a cooling tower in conjunction with a once-through cooling system to reduce the water temperature before discharging the water back into the natural body of water. At the Diablo Canyon Site, as opposed to inaldn sites, use of open system towers of a reasonable size would not be of any significant temperature-reducing benefit because the air wet bulb temperature is usually about the same as or a little higher than the ocean ambient temperature. In addition, the "helper" tower would give rise to several adverse environmental effects associated with saltwater cooling towers. These include principally damage to structures and vegetation resulting from saltwater drift.

A closed cycle (recirculating) cooling tower system using mechanical draft towers would require approximately 48 "cells" per unit, each cell typically 36 feet long, 51 feet wide, and 49 feet high, with a 19-foot high stack over the fan. Twelve of these cells would be in a row 432 feet long, with four such rows required for each unit. The capital cost of a closed cycle mechanical draft cooling tower system for Units 1 and 2 is estimated at $38,000,000. Maintenance of the system is estimated to

be $350,000 annually. Reduction in turbine cycle efficiency results in a loss of capability of up to 85 megawatts during warm periods with an additional penalty of 15 megawatts for cooling tower fan requirements. The plant site would be limited to a total of three units unless additional land could be obtained.

Natural draft towers dissipate heat in the same way as the mechanical draft type but rely on the natural circulation of the heated air through the tower rather than on fans. A natural draft cooling tower arrangement is possible that would allow six units. The tower for each unit would be at least 400 feet high and more than 400 feet across the base. The capital cost of the natural draft cooling tower system for Units 1 and 2 is estimated at $37,000,000. Maintenance of the system is estimated to be $300,000 annually. Reduction in turbine cycle efficiency results in a loss of capability of up to 160 megawatts during warm periods.

A dry cooling tower removes heat from the condenser in a manner similar to an automobile radiator. Heat transfer occurs by conduction and radiation to the air. Because the heat transfer capacity of air is much less than that for water, large fin tube areas are needed to remove the heat. In addition, the air dry bulb temperature is the theoretical limit to which the condenser water can be cooled, whereas the wet bulb temperature is the theoretical limit for wet towers. In a practical size the approach to dry bulb in a dry tower may be 37-42°F. The condenser inlet water temperature for a dry tower at the Diablo Canyon Site

during warm periods would be 108-113°F (71°F dry bulb plus the 37-42°F approach). This compares to the condenser inlet water temperature of 78°F (63°F wet bulb plus 15°F approach) for the evaporative cooling towers, and to 60°F for one-through ocean cooling. The turbine back-pressure for condenser inlet temperatures of 108-113°F would be about 5.5 inches of mercury absolute, causing more than a 12 percent reduction of the plant's full load power output and exhaust pressures and temperatures exceeding the design of the turbines for the plant. Turbines of this size compatible with dry cooling towers have not yet been developed. The additional cost for dry towers is roughly 3-1/2 times the additional cost of providing the same cooling using evaporative natural draft cooling towers (Hauser 1971).

In short, we have rejected all cooling towers on the grounds that they have a much greater adverse effect on the environment than the cooling system proposed and that they cost so much more than the proposed system. In addition, there are technological objections to certain types of towers.

Topography will not permit the use of spray canals or cooling ponds. The only land area that can accommodate a spray canal is the coastal terrace south of the plant. Such an alignment parallels prevailing summer winds and, therefore, would not work effectively as a heat transfer mechanism. Even if winds were favorable, a canal for one unit would require 2.8 miles of terrace. No space appears available for a spray canal for Unit 2 or

subsequent units.

Recirculating cooling ponds were investigated for the Diablo Canyon Site. In cooling ponds the warm water from the condensers is cooled by evaporation, conduction, and radiation to the atmosphere. It was estimated that a pond size of 1,950 acres would be required for cooling the thermal discharge of Units 1 and 2. The land required is not available at the site.

Turning now to some alternative energy sources fusion energy is still in the early stages of development. The technical questions involved in this process are highly complex and solutions are not expected to be forthcoming for some time. A recent optimistic announcement from the AEC indicated that a power plant developing energy from the fusion process might be available during the 1990's. This would be far too late to replace the Diablo Canyon Units, which are required in 1975 and 1976.

Similarly, solar energy remains a potential source of generation but not as an alternative to the Diablo Canyon Units. The technology of using solar energy to generate electricity on a scale the size of the Diablo Units simply has not yet been developed. Furthermore, the environmental impact of at least some of the schemes which have been proposed would greatly exceed the impact of the Diablo Units, most of which has already occurred.

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