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on

THE PAEC AND NATIONAL DEVELOPMENT

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A PRIMER ON THE BATAAN NUCLEAR POWER PLANT

BY

PROF. SALVADOR RAXAS GONZALEZ, M. A., M. Sc. (Cantab.)

Professor of Theoretical Physics and
History of Science of De La Salle University, and Consultant to the Ministry of Public Information
FOREWORD

With this issue, the Technical Service inaugurates an occasional publication which hopes to be able to disseminate position essays on various national issues affecting the country and our people.

The Technical Service believes that declassified position papers of the Ministry's consultants may be too precious to simply keep on file without their being shared by our decision-makers.

As part of the service rendered to our clientele, this publication -- tentatively called MPI Position Papers -- welcomes contributions from the MPI personnel. As it becomes more regular, we hope to be able to include feedback articles discussing the published issues. We hope to encourage a healthy exchange of ideas in order to ensure a cogent multi-disciplinary approach to the viewing of contemporary national issues.

From those position papers could arise concepts which would be utilized for information planning. From these may arise communication strategies which will be utilized by the Ministry in the pursuit of its function of husbanding communication for national development.

We encourage our colleagues in the regions to send in position papers on such issues as:
- The national and local elections.
- The agenda of normalization.
- The extension of martial law and its lifting.
- The energy crisis and conservation efforts.
- The rising of prices and government responsibility.
- The imperatives of self-reliance and economic
prosperity through increased production.
- The human settlements projects and the urban land reform.
- The internationalization of New Society values through formal and non-formal education.
- Military abuses and the judicial system as avenues of redress.
- International relations and stability of the Republic.

ALBERT B. CASUGA

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What is nuclear energy? What is a nuclear reactor? Will the Bataan nuclear power reactor be safe? These questions are being asked by experts and laymen alike. The Filipino people, indeed, have the right to know the story behind the Westinghouse pressurized water reactor or PWR. The people are the ones who will ultimately say the $1.1 billion loan of the government for the purchase of this modern device to boost the electric power supply of Luzon.

Laymen's questions regarding the safety of the nuclear reactor are important to the extent that they can elicit contradictory answers from the Westinghouse panel, for this would reveal any internal flaw in whatever arguments they present to support their claim that the reactor is safe, but up to the present it appears that no inconsistencies have been discovered. In fact, the executive branch of the United States government in Washington recommended to the U.S. Nuclear Regulatory Commission the exportation of the reactor in September 1979, although, of course, it is up to the USNRC to issue the necessary export licence.

It must be understood that the Philippine government, through the National Power Corporation, has already bought the reactor, by signing the contract with Westinghouse in 1976 and the reactor, should the construction be realized, is scheduled to be finished by 1983. It must also be understood that the question is if this were so it would be hard to explain why most nations of the world use nuclear reactor moreover, such a statement, that all nuclear reactors are unsafe, is too sweeping.
The Philippine Atomic Energy Commission is the Philippine nuclear regulatory commission for the government, and as such it has the full authority, subject only to the final authority of the President of the Philippines, on nuclear matters in the country, including the approval of the site. In fact, the PAEC has endorsed the Bataan site at Napot Point after reviewing the EBASCO report on site evaluation which was a result of two years of study.
A PRIMER ON THE BATAAN NUCLEAR POWER PLANT

1. What is nuclear energy?

-energy is the capacity to do work. Nuclear energy is the energy confined in the nucleus of the atom. In 1905, Albert Einstein, the German-Swiss-American theoretical physicist, deduced from his theory of special relativity that any mass of matter can be transformed into energy by his famous equation \( E=MC^2 \), where \( E \) is energy, \( M \) is mass, and \( C^2 \) is the square of the speed of light in empty space. In 1935, Hideki Yukawa, the Japanese physicist, theorized that nuclear energy is stored in the nucleus of the atom as its binding mass, and this is released as energy when the nucleus is split. The splitting apart of the nucleus of an atom when a neutron is absorbed by a nucleus is called nuclear fission.

2. When was nuclear fission discovered?

In 1938, three German scientists, Otto Hahn, Fritz Strassman and Lise Meitner, stumbled accidentally on nuclear fission while reproducing the experiments of Enrico Fermi, the Italian physicist, on transuranic elements, i.e. the production of substances beyond the size of uranium, e.g. plutonium. One type, or isotope, of uranium, the now famous uranium-235, split into two instead of becoming bigger by the bombardment of neutrons, releasing a tremendous amount of energy never before
known. Meitner was a Jew and hunted by Hitler; she had to flee Germany with nothing but her notes and her clothes on, and she went to Sweden where she met her nephew, Otto Frisch, the Austrian physicist who later became the head of nuclear physics in Cambridge University, and together they analyzed the fission experiment. (Read Brancazio, P., *The Nature of Physics*, published by Macmillan Co., N. Y., 1975, p. 649). They sent the results to Einstein and Fermi who were then in America. The first nuclear reactor was produced by Fermi under the football stand of Chicago University.

3. What is a nuclear reactor?

A nuclear reactor is a device for controlled nuclear fission, i.e., either the splitting of uranium-235 or plutonium-239. If uranium-235 is used to produce nuclear energy, then the reactor is known as a uranium-235 fission reactor. Since only 0.7 percent of uranium in natural uranium is uranium-235, this may be augmented or enriched, i.e., more uranium-235 may be added as fuel of the reactor. Such a reactor may be used simply for research into the structure of matter and the production of radioactive isotopes for medicine, agriculture, and industry, and is thereby known as research reactor. Heat is produced in such a reactor, but a coolant is utilized to remove the heat. In such a reactor also, a moderator is used to slow down the fast neutrons produced in fission in order that they can bombard other uranium-235 nuclei and cause fission by chain reaction, i.e., a slowed-down (thermalized neutron is absorbed by a ura-
nium-235 nucleus and the uranium splits into two daughter nuclei with the production of one to three fast neutrons and radiation, and the fast neutrons are slowed down by the moderator to cause further fissions with, of course, some neutrons lost due to leakage or non-fission absorption by other nuclei. If the heat produced is transformed by a steam generator into steam to run a turbine that would in turn work an electric generator to produce electric power or to run a motor, the reactor is called a nuclear power reactor.

4. Is a nuclear reactor the same as a nuclear bomb?

No. A nuclear fission bomb is a device that uses the uncontrolled fission of uranium-235 or plutonium-239 such that an explosion is possible. A nuclear reactor is not a nuclear bomb and will not explode like one. It must be noted that there is also a nuclear fusion bomb, which is better known as a thermonuclear bomb, since it explodes only when great heat is introduced; basically it is due to the combining of hydrogen to form helium by merging or fusion as what happens in the sun. There is as yet no fusion reactor, for fusion has not as yet been controlled. A fusion bomb is much more destructive than a fission bomb, and it in fact requires the detonation of a fission bomb to explode it.
5. Does the Philippines have a nuclear research reactor?

In the early 1950's the US government gave the Philippines a small (1 megawatt or 1 million watts) nuclear uranium-235 fission reactor (fuel enriched by 20 percent) to be used in research and the production of radioisotopes for medicine, agriculture, industry, and other peaceful uses. It has ordinary water as coolant and moderator. (See The Philippine Research Reactor, published by the Philippine Atomic Energy Commission). It was constructed in Diliman, near the University of the Philosophers, amidst prior protests of the neighbours and Quezon City folk who were afraid of radiation leakage or who thought it might explode like a bomb, despite scientists telling them it wouldn't. Ever since 1962 when it was put into operation by Dr. Zoilo Bartolome, the only leak came from the cement dome when it rained for the dome was built by the lowest bidder, and the raindrops were a nuisance for they mingled with the reactor water. Now, few pay attention to the Diliman reactor, which is run by the Philippine Atomic Energy Commission, apart from the scientists who are doing work there, and even they are often forgotten. The PAEC is the Philippine nuclear regulatory commission and has the final say on the construction of nuclear reactors in the Philippines and their safety.
6. What is the story behind the proposed Bataan nuclear power plant?

In 1963, 1966, and 1972, the Philippines invited consultants from the International Atomic Energy Agency, or IAEA (Vienna), to help in studying the feasibility of constructing a nuclear power plant somewhere in Bataan to boost the electric power supply of Manila and neighbouring places. After studying possible candidates for the site, the IAEA consultants selected Bagac, Bataan and proposed that to offset any danger, if there were, due to the existence of some earthquake faults in Mariveles, China Sea, and Manila Bay, the reactor should be able to withstand a maximum earthquake magnitude of 7.2 on the Richter scale, or a horizontal earth acceleration of about 35 percent of the acceleration of gravity (equal to 35 percent of 32 feet per second each second).

The National Power Corporation, which is the government agency to install the nuclear plant, for further surety contracted the ECASCO Corporation of experts in seismology and volcanology, among other things, to examine the possible site and other possibilities. The ECASCO experts made a in-depth study for two years, from 1972 to 1974, at the cost of US$15 million resulting in more than fifteen volumes of detailed reports. They chose Napot Point instead, which is only a few kilometers from Bagac. The reason was that Bagac is near two rivers, and the occurrence of
floods will make the site unsafe and unsuitable. (See, for instance, Margulova, T., *Nuclear Power Stations*, published by NIR Publishers, Moscow, 1978). Moreover, Napot Point is about 18 meters above sea level and Bagac is only 3 meters above sea level, making the former a better choice against possible tidal waves (the huge ones that visited Mindanao were only 12 meters high), and the foundation was firmer than that of Bagac.

In 1976, the contract between the National Power Corporation and the Westinghouse Corporation was signed and approved by the President of the Philippines. Westinghouse was to export the reactor parts, facilitate the construction of the plant, and train the operators, subject to the issuance of the export licence by the US Nuclear Regulatory Commission. An application to the USNRC was formally submitted in the same year as the ones submitted by Taiwan and Korea. Westinghouse designed the plant to withstand an earthquake magnitude of 7.9 on the Richter scale or about 40 percent of the acceleration of gravity, just to make it safer in the estimation of the public. At 7.9 magnitude, most of the buildings in Manila would collapse but the nuclear reactor would still be standing. The reactor (core) would itself be isolated and confined within a huge containment vessel with walls made of steel 8 inches thick, which are surrounded by a 2 meter dense cement biological shielding, and all this to be encased by 2 inches of steel and highly reinforced concrete. It is so protected that not even a four-
engine jet plane crashing on the reactor vessel would dent it. And the dormant volcano some kilometers away hasn't erupted for the last fifty thousand years or so, like a woman who is fifty and hasn't given birth. The cost of the Bataan reactor is US$1.1 billion payable from a loan from the Export-Import Bank, and the plant was scheduled to be finished by 1983.

In 1978, after the contract had been signed by Westinghouse and by NPC for the Philippine government, another group of IAEA personnel (except for the geologist who came with the earlier batch, and no one among them was a volcanology or seismic expert) visited the Philippines unexpectedly and noticed that the site chosen was not Bagac but Napot Point, a few kilometers away. This new IAEA team went over the voluminous reports made by IBASCO, glancing over them in a matter of a few days what took two years to make, and recommended that the Bataan nuclear reactor plant be designed to withstand a still high earthquake magnitude, and it submitted an adverse report in Vienna, a copy of which was apparently sent to the executive branch of the US government which noticed that the site was only about 15 miles from the US naval base at Subic. The existence of a dormant volcano near the site and some inactive faults farther away seemed to have unduly alarmed the IAEA group of 1978, despite the indepth studies of the IBASCO Corporation made up of volcanology and seismic experts.
The Philippine Atomic Energy Commission has approved the site, and as a sovereign state the Philippine choice of the location should be respected, unless it can be claimed that Filipinos do not know what they are doing.

But aren't there protests even among Filipinos regarding the construction of the Bataan nuclear power plant?

Yes, there are some protests. They really started after the Three Mile Island accident on 28 March 1979, at Pennsylvania USA. The TMI nuclear power reactor utilized uranium as fuel, and light water (as distinguished from heavy water) as moderator and was of the two-loop type, similar in some ways to the Bataan reactor although not manufactured by Westinghouse. It was a pressurized water reactor, PWR, utilizing a pressurizer to keep the heated water (about 600 degrees Fahrenheit) from boiling. In the first loop (primary) of circulating water, water is heated by the heat from the nuclear fuel (uranium fissioning) but kept from boiling by the pressurizer as it travels in the tube towards the steam generator. In the steam generator, the heat from the first loop tube is absorbed by surrounding water and transformed into steam which is then sent through a tube forming part of the second loop and into the turbine to run an electric generator, and the steam is then condensed as it later passes through a condenser, and changed back into water and returned to the steam generator for another round, etc.
A mechanical failure started the accident, i.e., a valve (regulating the flow of feedwater) in the second loop which feeds the water from the turbine and condenser back to the steam generator, which in turn removes the heat from the reactor core and first loop, malfunctioned and would not open for some time, and the backup water pumps had been shut off earlier because of repairs. Loss of steam supposed to run through the turbine shut it off automatically, and this in turn automatically triggered the shutoff of the reactor, but with an eight second delay which was still enough for the reactor to produce more heat without the heat being removed or utilized. The pressure and temperature rose rapidly, and emergency water was supposed to cool off the system, but the valve leading to the quench tank failed to close and the pressurizer itself became filled with water, another malfunction. The injection of more water would cause overpressure, so the operator manually shut off the pumps.

By this time, contaminated water overflowed onto the reactor floor and into the adjacent auxiliary building, and the evaporation of some irradiated water resulted, although the radioactivity was below dangerous proportions. The overheated fuel (car) emitted hydrogen from zirconium oxide formation (since the uranium fuel cladding or covering was made of zirconium) and a hydrogen bubble was supposed to have formed inside the confinement building and vessel, but since not much oxygen was available there was really no danger of even a chemical explosion. After five days, a hydrogen recombiner was available to remove the supposed
hydrogen bubble. Nobody was hurt, but some panic among the civilians living in the neighborhood was created when it was announced that children and pregnant women should evacuate as a precautionary measure, to test the atmosphere. (Read the Staff Report on the Generic Assessment of Fuelwater Transients in Pressurized Water Reactors Designed by the Babcock & Wilcox Company, prepared by the Office of Nuclear Reactor Regulation, US Nuclear Regulatory Commission, Washington D. C.

Because of the Three Mile Island accident there was some need to investigate the safety of the proposed Bataan nuclear power plant, even if only to assure the Filipinos that the reactor will be safe within reasonable risk when it is constructed, assuming that it is needed to supply at least one-fourth of the power needs for electricity in Metro-Manila, and surrounding towns, including those of Bataan, since hydroelectric power is no longer available for this purpose of producing bulk power, and no other substitute is in sight. President Ferdinand Marcos appointed Justice Ricardo Puno to be the chairman of a committee of three to conduct hearings on the safety of the Bataan nuclear power plant. Among those who submitted and defended position papers and recommendations are the following: The National Power Corporation, the Philippine Atomic Energy Commission, Westinghouse Corporation, EBASCO Corporation, the Samahang Pisika ng Pilipinas (physics Society of the Philippines), opposing groups led by former Senator Lorenzo Tañada and representatives from Bataan, and others. Views, for or against the
establishment of the nuclear power plant, were ventilated openly but in orderly fashion, for the purpose was to arrive at the truth.

9. Is the Bataan nuclear plant safe within reasonable risk?

So far it can be deduced from the testimonies given that nothing is defective with the design of the proposed Bataan nuclear power plant. The Westinghouse scientists gave expert testimony to justify the safety of the proposed nuclear reactor within the reasonable limits of safety as specified in the contract, and it is hard to refute their claim since Westinghouse has constructed several nuclear reactors not only in the United States but also in Korea and in Taiwan and other parts of the world. By expert is meant one experienced and knowledgeable in a given field of knowledge or art, and in the field of nuclear reactors the Westinghouse panel are experts. Of course, we should not take the Westinghouse word alone, but scientists who interrogated them couldn't show cause to say that the Bataan reactor is defective even in design. Moreover, if one will consider the Three Mile Island accident as one out of one hundred PWR existing, then the probability of such an accident occurring is 1 out of 100 or one percent; in other words, it is ninety-nine percent safe. In fact many millions die in airplane accidents, and yet people still ride in airplanes. Indeed, in this world one can never be assured of absolute safety, not even at home, for the roof may suddenly collapse and kill one in one's house.
The TMI accident was not even the worst accident in nuclear history, there was the actual meltdown of a reactor in Windscale, England, sometime in 1960. Nobody was hurt, and the British government paid the surrounding dairy farms their losses. (See Ridenour, L. and Nierenberg, W., Modern Physics for the Engineer, published by McGraw-Hill, London, 1961, page 319, and Nuclear Energy in Britain prepared by the Central Office of Information, London, 1975.) There may have been worst accidents in Russia, but the only news about them come from unofficial dissidents' reports. Korea has eight nuclear reactors, Taiwan has four, and Japan has more than a dozen. The industrialized countries, including North and South America, the European countries, Russia and the communist bloc, are all determined to have more nuclear reactors in view of the oil shortage. If the Philippines doesn't look out, it might be left behind because some people may not want to take a reasonable risk, they want absolute safety, as if this were possible in this world!

9. Suppose we have the nuclear power plant, where will we put the radioactive waste?

The proposed Bataan nuclear power reactor plant will hopefully be made up of two 620 megawatt power nuclear reactors, so that if one breaks down the other would still function to keep the electric supply up. Apart from the power source, which is nuclear fission, the other parts are conventional, well known to electrical engineers who don't have to be
nuclear physicists or nuclear engineers. In fact, work in a nuclear power plant to supply electricity will after a time be routine and, provided the operators are well-trained, and there is assurance they would be, the plant operation is not a spectacular affair. We must, of course, guard against complacency and negligence, such as those that took place in Three Mile Island, if that accident can at all be useful to teach our operators to be careful. We must as much as possible try to avoid human errors and dependence on human indecisions by improving warning devices and automatic safety devices that work automatically. Granting that all these are well taken care of, there is still the question of waste disposal, where do we put all the radioactive waste when even America doesn’t know that to do with its waste? (Read Facts About the Philippine Nuclear Power Project, published by the Philippine Atomic Energy Commission).

From the point of view of storage, we can classify radioactive waste into low level and high level. Low level radioactive waste consists of contaminated clothes, gloves, pieces of instrument no longer useful, and the like, which may be sufficiently harmful if left out in the open; such low level waste would amount to about 330 tons per year, according to Westinghouse (Times Journal, 11 July 1979). High level waste consists of intensely radioactive elements of the spent fuel, about 16 tons of it per year, which however can be safely stored provided they are not removed from the containing fuel rods. There is enough storage space in the nuclear
plant to accommodate such waste for about ten years, which would give the NPC time to look for a burial site in which to safely deposit the excess waste. Another possibility is to have the high level waste in the spent fuel rods sent to the US for reprocessing, i.e., the process in which the spent fuel is dissolved and the fission products are separated from any remaining fuel, in which case the high level waste could be reduced to only about a cubic meter per year.

The problem of storage of radioactive waste, or even getting a burial site for it, would not be great for the waste product of one 1240 megawatt nuclear reactor plant (comprising really or two 620 reactors America has more than 70 and is building more, that is why the Americans find some difficulty in waste disposal of radioactive waste from their reactors. As the saying goes, if you have only one or two people using the toilet there is not much problem of waste disposal, but if you have more than 70, there would indeed be, particularly if people are allergic to radioactive waste or afraid of it. It is rather strange why the same people who would be happy should uranium mines be discovered in their country would be afraid to have radioactive waste buried deep under somewhere in an isolated place, when uranium mines are also radioactive with uranium emitting alpha-particles, while radioactive waste products are mostly beta emitters, less dangerous. But of course, one would get money from uranium mines and not from burying radioactive waste.
10. Will the people of Bataan not be exposed to contaminated air and water?

A person residing near the nuclear plant will probably receive a dose of 5 milli-cms over a period of one year added to the 120 milli-rem per year that he usually gets from the natural radiation of the earth's crust and surroundings and from cosmic radiation. (Read Pryde, L. Environmental Chemistry, published by Cannings Publishing Co., Calif., 1973; p. 62, pp. 47-48). One millirem is one-thousandth of a rem (roentgen equivalent mammal) which is the standard unit of the RBE (relative biological effectiveness) of radiation. For x-rays, gamma rays, and beta radiation, the RBE is 1, whereas for alpha particles the RBE ranges from 10 to 20 units. But this relative biological effectiveness of radiation is due to the radiation absorbed by the body whose unit is the rad (radiation absorbed dose) defined as "a unit of absorbed energy equal to 100 ergs per gram." (See Berry, J., Osgood, J., and St. John, P., Chemical Villains, A Biology of Pollution, published by The J. I. Mosby Co., Saint Louis, 1974; p. 180). A simple equation to bear in mind is the following: rems = RBE x rads.

In the early days of nuclear energy add radiation dosimetry, the standard unit was known as the roentgen or R specifically for x-rays and gamma
rays (since Roentgen discovered x-rays in 1895). The curie (in honour of Mme Curie and her husband Professor Pierre Curie who discovered the radioactive substance radium in 1898, which decays by emitting alpha particles and has a half-life of 1612 years, i.e., half of its activity will be gone every 1612 years until it all turns into isotopes of lead) is the standard measurement or unit of disintegrations per second, i.e., the number of emitted particles per second due to the decay of the nucleus of the radioactive atom. One curie is equal to (ave.) $3.7 \times 10^{10}$ disintegrations per second of radium) or 37,000,000,000 disintegration per second, it is the number of nuclear disintegrations per second and not of x-rays or gamma-rays. The roentgen corresponds to an energy exposure of about 100 ergs per gramme, and is about the same value as the rad.

All these disintegration and radiation produce breakdown of cells and tissues by ionization or by bombardment of the molecules (combinations of atoms) in the body, and in this sense they damage the organism. But 0.034 millimeter of lead or 0.13 millimeter of water is sufficient to stop the alpha particles emitted by radioactive substances, and beta particles or rays (which are essentially electrons) emitted can be stopped by a few millimeters of lead. Gamma-rays of about 2 mev (million electron volt) energy will not penetrate beyond 1.3 centimeter of lead. (See Lapp, R., Andrews, H., Nuclear.
Radiation Physics, published by Prentice-Hall, NY, 1955; p. 493). Escaping neutrons cause radiation damage too, but protection from them can be provided by dense shielding material such as lead, or iron and cement, the neutron decays in about 12 minutes. Enough precautionary measures and regulations to ensure safety are contained in such manuals as Basic Safety Standards for Radiation Protection (1967 Edition) published by the International Atomic Energy Agency, Vienna, as well as the TMI-2 Lessons Learned Task Force Status Report and Short Term Recommendations published by the Office of Nuclear Regulation of the U. S. Nuclear Regulatory Commission, Washington, D. C., July 1979.

There are two hypotheses regarding the effects of radiation on human beings. The linear hypothesis states that even low level radiation will eventually affect the human being by accumulated absorption increasing continuously over the years. The threshold hypothesis holds that low level dosage of radiation is not harmful below a certain critical or threshold level, but once the threshold is attained there the danger lies, e.g. a single dose of 800 rums would be fatal to everyone, of 400 rums to fifty percent of those exposed, and 200 rums are not fatal but will cause nausea and fatigue. (See Pryde, op. cit. p. 50). The alarmist usually points out to the linear hypothesis in order to produce the sweeping argument that all forms of radioactivity are harmful and that all kinds of nuclear reactors are dangerous.
even if they produce low level radiation. If no
is correct, then we shouldn't breathe anymore for
we are bound to inhale some radioactive substan-
ces from natural surroundings or from cosmic rays
to which we are exposed daily. Although there
are many high intensity radioactive products of
the fission process in nuclear reactors and in
the explosion of nuclear bombs (utilizing ura-
nium-235 or plutonium-239) in the testing of
such explosives by members of the so-called
"nuclear club nations"; the one must not be con-
fused with the other to give undue alarm to the
public. The products of nuclear fission contained
in the fuel rods are not released if there is no
reprocessing, but the products of nuclear fission
due to the exploding of nuclear bombs are released
and are the real cause of danger. The spent fuel
and radioactive waste of nuclear reactors can be
stored or buried in burial sites.

Since a good amount of water is used by a
pressurized water reactor, or PWR, either as coolant
or moderator, and water from external source, such
as the sea, is used for cooling the condenser,
some apprehension of course may be raised. The
water from the external source, such as the sea,
is sucked in and discharged back into the sea and
the effect is merely that the temperature around
the discharged point may be raised a few degrees
centigrade, about 5 degrees in fact. Studies have
been made in which it can be shown that not only
does this not have any adverse effect on fish and
marine life around, but that in fact the warm water
attracts the fish and this is beneficial to fishermen around. The water that runs in the first loop (the reactor loop) and in the second loop (the turbine loop) are demineralized for possible decontamination. All this is done according to regulation. The running of a nuclear power plant is the most regulated operation in industry to avoid possible dangers, and while some leaks may occur, and are expected, constant monitoring and precaution against maximum radioactive pollution is a routine procedure in any nuclear plant.

People must understand that due to oil shortage, the Philippines needs a major source of bulk power which today is the nuclear power reactor, even temporarily. Who knows, perhaps someday several years from now another source of bulk power, such as more efficient utilization of solar energy, or even fusion power, may be perfected as substitute to fission reactor power.

When almost all the nations in the world are resorting to nuclear power for their needs and industrial progress and to light their homes, shall the Philippines reject the use of nuclear power? What shall we tell the next generation if we remain behind and other nations advance industrially, shall we say we were afraid? Being in a democracy, let our people choose, but let them not be swayed or influenced by all sorts of fears without reasoning them out. People are often afraid of what they do not understand. Recent developments indicate that the questions regarding the proposed Bataan nuclear power plant are no longer on the
radioactive hazards, if any, that the power plant operation may pass on the radioactive waste products that the single power plant may produce. Westinghouse, PAEC, NRC and the Ministry of Health have given ample assurance on radiative safety, and the NPC will comply with safety regulations or lose their jobs. Neither has the Three Mile Island reactor accident anything much to do with the Westinghouse-designed Bataan nuclear power reactor, for not only has Westinghouse not designed the TMI reactor but that the Westinghouse reactor to be constructed in Bataan is of a different and safer design. Moreover, contrary to popular misconceptions raised by panic news on the TMI accident which were completely exaggerated, no deadly leakage of radioactivity took place at TMI. The dam accident in India killed thousands of people and the TMI accident didn't, in spite of that no one is terribly afraid of dams as they are of nuclear reactors.

Instead, there is much fuss over the imagined dangers arising from supposed volcanic eruptions and supposed big earthquakes when none has occurred in Bataan. But the modern study of earthquakes, the science of seismology, is becoming more and more sophisticated, and one thing is coming to the fore—earthquakes may soon be predicted and thus people may be protected ahead of time. The Philippines, like Japan, lies on the Pacific earthquake belt, and so also is Taiwan. But many nuclear reactors have been constructed in Japan, and Taiwan has four. Japan has experts on earthquakes, one came to the Philippines and gave splendid lectures.
to the Physics Society on the analysis and prediction of earthquakes, using highly advanced mathematics dealing with quantum mechanical analysis of waves, for earthquakes are scientifically revealed by P (for push) waves, S (for shake) waves, and L (for large) waves produced. Indeed, the advance of the science of earthquakes, seismology, is making earthquakes to be understood by scientists who are familiar with advanced mathematics and advanced technology, not those whose knowledge of earthquakes is based on the swinging of chandeliers and photographs of fallen buildings after the event. (Read Kosyrev, N., *On the Interaction between Tectonic Processes of the Earth and the Moon* as included in Symposium No. 47 Proceedings on THE MOON, published by D. Reidel Publishing Co. Deodrecht-Holland, 1972. This is an advanced study of the earthquake relations and predictions between the earth and the Moon with experiments made possible by Apollo space landings on the moon.)

If there is no real danger to the reactor coming from possible earthquakes or volcanic eruption, what conditions should still be considered necessary for the Batran nuclear reactor to be within reasonable risk?

Although Westinghouse Corporation may be deemed to have the experts in reactor construction, and the design of the proposed Batran reactor has been found to be in accordance with the safety requirements known during the time of its initiation, several years have already passed and surely new insights into improved reactor construction should be taken into consideration, particularly in the light of the Three-Mile Island accident, for whatever lessons may be derived from it,
without exaggerating the extent of the accident as some alarmists are prone to do. It may be well to note that right at the start of the nuclear plant investigations, members of the Physics Society of the Philippines (Sama-hang Pisika ng Pilipinas, 5 July 1979) submitted ten conditions as necessary for the Bataan nuclear reactor to be within reasonable risk.

Those conditions were orally discussed and defended by Prof. Salvador Roxas-Gonzalez, professor of theoretical physics at the De La Salle University, the secretary-general of the Society, as the group's spokesman. Among those who signed to document were: Dayani Rivera, Ph. D. assoc. professor of nuclear physics and head of the physics dept. and Alberto Campos, Ph. D., assoc. professor of nuclear engineering, both of De La Salle University; Rufino Ibarra, Ph. D., professor of atomic physics, and Lorenzo Chan, Ph. D., assoc. professor of elementary particle physics, both of the University of the Philippines (Diliman); Amando Kapauan, Ph.,D., professor of chemistry, and Jesus Rivas, M. A. T., assoc. professor of physics, both of the Ateneo de Manila University; Ester Garcia, Ph. D., assoc. professor and chairman of the chemistry dept. of the University of the Philippines (Diliman); and Manolito Natera, Ph. D., acting director of the nuclear research reactor at P.A.R.C. The following is the entire reproduction of the short straightforward document presented by the society in a manner more of a scientific journal report than in the often long and wurdy legalistic form.

COMMENTS OF MEMBERS OF SAMA-HANG PISIKA NG PILIPINAS (PHYSICS SOCIETY OF THE PHILIPPINES) REGARDING THE BATAAN REACTOR

We, the undersigned physicists and professors of physics and/or allied sciences, consider the following conditions as necessary for the Bataan nuclear reactor to be within reasonable risk:
1) **Additional warning devices and automatic safety devices** that will further minimize dependence on human operation and therefore lessen dangers from human failures, such as a gauge indicating the approximate extent to which a valve is closed or blocked, should be studied and installed.

2) **A simulator should be made available to the staff of the Bataan reactor.**

3) **Westinghouse should maintain a staff in the country composed of competent personnel to help remedy any accident,** and the Philippine government should set aside P100 million for such emergency (this is not exorbitant, when one considers the $1.1 billion cost of the reactors and the welfare of the people.)

4) **The local sites for storing the radioactive wastes should be indicated even before the reactor is put into operation by the National Power Corporation.**

5) **Constant monitoring of radioactive and heat effects on the environment should be made daily for the protection of the environment and the public.**

6) **There should be additional personnel for replacement in critical posts,** and all newly hired operators should be subject to as rigorous a training program as that of the initial batch of operators.

7) **Personnel training in physics and reactor operation should be started in the Philippines.** There should be created an Institute of Advanced Study for Physical Sciences and Mathematics to continue research in advanced
physics, particularly in nuclear physics and its applications, in the Philippines.

8) Up-to-date and advanced nuclear information from abroad should be made available to the technical staff and personnel of the reactor, and frequent up-dating seminars offered without, however, disrupting the work of running the reactor.

9) Public information on the nature, uses and precautions on radioactivity should be disseminated by the Ministry of Public Information, with the technical cooperation of the Philippine Atomic Energy Commission and the Ministry of Health, through mass media.

10) Greater security should be enforced at the reactor site, and proper and clear warning devices to warn the public in case of danger in the areas surrounding the reactor should be installed, similar to the air-raid signals to warn inhabitants in case of bombing.

We believe all this answers the questions of the Commission.

Lorenzo Chan, Ph. D    Salvador Raxas Gonzalez
                      M. A., M. Sc.
Danny Yanga, M. Sc.    Manolito Natera, Ph. D.
Alberto Campos, Ph. D. Bayani Rivero Ph., D
Jesus Rivas, M. A. T.  Luzviminda Rivero, Ph. D.
Marlene Ignacio, B. Sc. Rufino Ibarra, Ph. D.
Ester Garcia, Ph. D.   Amando Kapauan, Ph. D.
Claro Llaguno, Ph. D.  Victoria Vicente, Ph. D.

(Signatures of the above names appear in the original document.)
12. Hasn't the President of the Philippines permanently disconti- 
nued the construction of the Bataan nuclear plant as recommended 
by the Philippine Presidential Commission for the investigation 
into the safety of the plant headed by Hon. Ricardo Puno, 
Minister of Justice?

No. In fact what the President of the Philippines stated 
is that additional safety improvement should be incorporated 
so that the plant would be made safer still, and among them were 
precisely some (if not all) of the above-mentioned recommenda-
tions which the Philippine Physics Society had recommended to 
the Commission as early as 5 July 1979, right at the start of 
the investigation. Westinghouse Corporation, in statements 
published in the local press on 16 November 1979, one day after 
the order of the President to discontinue the construction of 
the plant until such conditions he deemed proper for the safety 
of the Filipino people were complied with, in effect agreed to 
make the plant "safer" to conform even with the United States 
Nuclear Regulatory Board's possible new requirements for 
safety. It may be good to include also placing the Philippine 
Atomic Energy Commission, which is the Philippine counterpart 
of a nuclear regulatory commission, under the Office of the 
President of the Philippines, as suggested in the (United States) 
President's Commission report on the Accident of the Three Mile 
Island on 30 October 1979, copies of which were provided to all 
U. S. embassies. This suggestion was also the suggestion of the 
Physics Society of the Philippines (Samahang Pisika ng Pilipinas) 
in the hearings held to make the Philippine Atomic Energy 
Commission an independent body subject only to the President of 
the Philippines. In fact, many of the suggestions in that report 
had been anticipated by the Physics Society of the Philippines' 
recommendation to the Philippine government. (SEE REPORT OF THE 
U. S. PRESIDENT'S COMMISSION ON THE ACCIDENT AT THREE MILE 
ISLAND, 30 OCTOBER 1979.)
SEMINAR

on

THE PAEC AND NATIONAL DEVELOPMENT

to be held at the NTI Lecture Room

on Tuesday, 4 December 1979

at 8:30 in the morning

NUCLEAR TECHNIQUES IN INDUSTRY

Mr. Peter Barnette
APPLICATION OF NUCLEAR TECHNIQUES TO THE DEVELOPMENT OF
THE TONGONAN GEOTHERMAL FIELD

PETER R BARNETT

KINGSTON REYNOLDS THOM & ALLARDICE (KRTA)
GEOTHERMAL POWER CONSULTANTS
NEW ZEALAND

ABSTRACT

The long term development and successful utilisation of the
Tongonan geothermal field for electric power generation is
ultimately a function of the response of the reservoir
to extensive exploitation.

A field drawdown test of several years duration has been
planned to test this response. A number of nuclear chemical
techniques have been incorporated into this to assist in
quantitatively tracing the subsurface movements of both
reservoir and reinjected fluids; and to provide an early
warning of changes in the physical and chemical properties
of the reservoir fluids which might indicate over-exploitation
with respect to natural recharge.

The programme will be implemented by PAEC under contract to
PNOC-EDC.
INTRODUCTION

Scientific and engineering geothermal studies have been in progress in the Tongonan area of N.W. Leyte since 1973. These studies were initiated as a joint technical cooperation project between the Governments of the Philippines and New Zealand. The executing agencies of the two governments have been, respectively; the National Power Corporation initially, and more latterly the Energy Development Corporation of the Philippine National Oil Company (PNOC-EDC Geothermal); and Kingston Reynolds Thom & Allardice Ltd.

By late 1976, a geothermal resource had been identified at Tongonan and a deep well drilling programme then initiated to enable utilising the high pressure/high temperature characteristics of the resource for electric power generation. Twenty three deep wells have been drilled to date; twenty one proving highly successful. The total steam reserve available presently exceeds 200 MW(e). Planning and design studies for a 112.5 MW(e) geothermal power station are nearing completion. This plant, due for commissioning in 1982/1983 will form a first stage development of future geothermal power complex with an ultimate total generating capacity of perhaps 500 MW(e).
Delimited geothermal area under study for power utilization and other industrial uses by the National Science Development Board, Commission of Volcanology and the Provincial Government of Leyte.
A number of modelling studies of the Tongonan reservoir have been undertaken (see for example, Barnett, 1979; Ward, 1979; Whittome & Smith, 1979). These have, however, all been based on the essentially pre-exploitation reservoir characteristics.

Observations on the longer term behaviour of known geothermal reservoirs such as Wairakei, New Zealand, demonstrate that exploitation can produce a considerable change in reservoir characteristics from the initial states. For instance, field pressures adjacent to wells may decrease, and sharp temperature and pressure flow gradients may occur (Truesdell and Frye, 1977). Of particular concern are the possibilities for near surface recharge and short circuitry flows from cooler parts of the field to production zones (Barry et al., 1979). These effects generally lead to rapidly declining mass outputs in geothermal wells (Bolton, 1973) and hence reduced power generating capacities.

The Tongonan field development is in an early phase as yet, with a limited discharge history presently available. Consequently, the large scale response of this reservoir to a sustained withdrawal of steam and hot water over twenty five years, the nominal plant life of the planned generating
equipment, is not known. This can only be assessed from a period of extensive exploitation that is of a sufficient duration, to induce in the deeper reservoir fluid, a measurable physical and chemical response to such.

A field drawdown test has thus been planned at Tongonan which will involve discharging, simultaneously, for a period of one to two years, most of the presently available wells. The data detained from this testing will be of considerable value in optimising longer term field management procedures and all future stages of power development, and in testing the viability of bulk reinjection of waste water from surface separators, back into the reservoir.

Radioisotopic and stable isotopic chemical methods have been incorporated into the drawdown test because of their utility in tracing the origin, subsurface movements and condition of both reservoir and reinjected fluids during exploitation. The various nuclear techniques presently available, and the intended specific application of each to the Tongonan field drawdown test, are now discussed.
RADIOISOTOPE TRACING TECHNIQUES

Two specific applications are intended. These are based on techniques developed by the New Zealand Institute of Nuclear Sciences, reported in Barry et. al., (1979).

A. Assessing if horizontal permeability connections exist between two well bores; an important factor in determining the minimum practical bore spacing (greatest well density) that can be achieved in field development without any interwell pressure reactions occurring, which could lead to rapidly declining mass outputs. Having obtained a minimum well spacing, the costs of drilling and steam collection systems can then be optimised.

Tests of this type will involve introducing a radioisotope into the standing fluid column of a shut well, while discharging a neighboring observation well to which a permeability connection test is required. The fluid discharged from the observation well (both steam and water phases) will be continuously monitored to determine to what extent, if any, the radioisotope migrates from the closed well with respect to activity with time. By this method, well bore permeability connections can be
quantitatively assessed.

B. Tracing the subsurface movements of a fluid that has been reinjected back into the reservoir following energy utilisation. The first programmed test of this type involves discharging well 101 to a steam/water separator from which the water phase will be piped under pressure into 105- a reinjection well (Fig. 2).

Immediately prior to flowing down 105, this water will be labelled with a radioisotope tracer. All wells within a 600 m radius from 105 will be then placed on a slow steam/water bleed and continuously monitored, for initially, one month. The fluids continuing to be produced from well 101, and the Mahiao river at a site opposite well 1R10, will also be monitored throughout this period.

A number of conclusions might be possible on the movement of reinjected fluid from 105 depending on which monitoring station(s) tracer return is noted. For example:

I. If tracer return is restricted to well 101 only, then cycling of reinjected water between the fluid
II. Tracer movement from well 105 to any of the wells remaining on bleed would indicate that interwell permeability connections exist. A dominant hydrologic directional component to the reservoir may also be apparent from this type of result.

III. Any tracer return to the Mahiao river would be diagnostic of rapid movement of reinjected fluids from depth to the surface, via the extensive structures present in the vicinity of well 105. As the primary purpose of reinjection is to isolate potentially toxic geothermal waste water from any contact with the environment, a result such as this would then preclude 105 as suitable for reinjection purposes.

After discussions with the Philippine Atomic Energy Commission (PAEC) and the New Zealand Institute of Nuclear Science (NZINS), two radioisotopes have been selected for use in the above tests - I131, a gamma emitter with a half life of 8.1 days; and S-35, a soft beta emitter of half life 87.2 days. A third nuclide,
Cr-51, was considered but later rejected because of the likely instability of the organic bonds in the supporting EDTA complex, at the high reservoir temperatures to be encountered (greater than 300°C).

It is proposed to initially use I-131 in test A above and at relatively low activity levels eg 10^{-3} to 10^{-2} curies. This is to avoid any significant activity contribution carrying over and contaminating later tracer tests. In test B, it will probably prove necessary to use S-35 to maintain tracer activity over the greater migration distances (and times) being investigated. Tracer velocities in well interference tests in New Zealand and Japan have yielded a range in velocities of 0.06 mm/sec to 9.4 mm/sec. Thus tracer migration from well 105 out to a 600 m radius, based on these figures, could take from to 116 days. This strongly suggests that test B will require a S-35 label.
STABLE ISOTOPE TECHNIQUES

The deuterium contents of geothermal waters can be used to determine the source area in which local meteoric water enters into and recharges a geothermal reservoir (Truesdell and Frye, 1977). If this source area is far removed from the immediate reservoir, then a large resource may be indicated. It would be of considerable interest to monitor deuterium and $^{18}O$ throughout the planned Tongonan field drawdown test for this purpose, and to also assess if extensive exploitation results in a rapid influx of cooler water into the field area, or if near surface recharge within the field is induced. By reference to tritium levels, it would also prove possible to date any cooler water inflows.

Any cooling in the reservoir that might occur as a function of exploitation can be quantitatively followed by chemical geothermometry. There are a wide variety of temperature calibrated chemical equilibria that may be used for such - inorganic aqueous equilibria; organic and inorganic heterogeneous gas equilibria. These different geothermometers equilibrate at different rates so that if a fluid is decreasing in temperature with time as it flows toward a well, then a comparison of the various indicated temperatures will reveal the temperature history of the fluids.
CONCLUSIONS

This paper is a brief resume only, of some intended applications of nuclear techniques in the Tongonan field development. Such techniques have proved invaluable, particularly stable isotope studies in geothermal exploration and reservoir interpretation, in projects in New Zealand, U.S.A., Italy, Japan, Mexico and Chile.

The Philippines is rapidly evolving toward becoming the second largest geothermal power producing country in the world. Consequently PAEC could well consider the merits of establishing a geothermal nuclear specialist group to actively participate in this thriving sector of the energy industry.
ACKNOWLEDGMENTS

The author would like to express his gratitude to PAEC for their invitation to attend this conference; to Dr. M. C. Berbano (PNOC) for mediating between PNOC and PAEC on issues arising in formulating the above discussed radioisotope test programme; to W.J. McCabe (NZINS) for valuable comments offered on the programme; and to the directors of KRTA for permission to prepare this paper.
REFERENCES


INTRODUCTION

With the continuing energy crisis, nuclear energy promises to be the major energy source in the immediate future. Hence, nuclear energy is expected to play an increasingly important role in the development of energy programs throughout the world.

Since its inception, the safety record of the nuclear industry is next to none. To ensure continuation of this enviable record, a comprehensive nuclear standards development program must be maintained.

HIERARCHY FOR NUCLEAR STANDARDS

To put nuclear standards in the proper perspective, let us consider Fig. 1, hierarchy for nuclear standards.

As shown schematically in the figure, atomic energy act and radiation protection regulations apply the generally recognized basic standards to the specific conditions of the country. They are issued by the national government and are mandatory. These are supplemented by regulatory guides which describe and make available acceptable methods for implementing specific parts of the regulations.

![Fig. 1 Hierarchy for nuclear standards](image)

The third level in the hierarchy consists of the basic safety standards which are set up by all parties interested for application, primarily in the licensing process. They require approval by the authorities, are mandatory, and may be issued by National Standards Institutes such as the American National Standards Institute, Inc. (ANSI).

The base of the pyramid consists of nuclear conventional standards which need no official approval and are not mandatory.

It is to the third level that most of this discussion is directed.

**NEED FOR NUCLEAR STANDARDS**

There are 3 major reasons for the existence of the nuclear standards, namely:

1. To simplify and improve the licensing process by offering generally accepted state-of-the-art guidance. The US Nuclear Regulatory Commission (USNRC) is committed to the use of standards as a tool for safety evaluation in the licensing process. In fact, most often than not, the USNRC regulatory guides endorse certain nuclear standards.

2. To increase nuclear safety by providing detailed and reliable technical information. Those involved in constructing, maintaining, and operating nuclear power plants find the standards invaluable, since starting from basic principles and devising suitable testing and inspecting programs in each instance would be both complex and time consuming.

3. To bridge the gap between the top of the "standards pyramid," consisting of basic long-term laws and regulations, and the changing and detailed problems of the day.

**STEPS IN STANDARDS DEVELOPMENT**

In outline form, the steps in the development of standards in the US consist of:

1. Anyone (in the industry) suggests needed standards

2. National Standards Management Board (NSMB) of the ANSI assigns priority

3. Working group of the concerned nuclear committee writes draft

4. Informal review

5. "N" Committee approval

6. Publication

7. 5-yr. life (revision within 5 yrs.)

The development of nuclear standards appears simple enough, but to gain an insight as to what it really takes to develop standards for the nuclear industry let us spotlight the ANSI-NSMB Nuclear Standards Program².

THE ANSI-NSMB NUCLEAR STANDARDS PROGRAM

In the US, the large standards development effort in the nuclear field in which about 8,000 individuals are participating resulted from the recognition of the need for good engineering standards and the commitment of the Nuclear Regulatory Commission to the use of standards as a tool for safety evaluation in the licensing process.

ANSI serves as the US clearinghouse and coordinating body for standards activity on the national level.

Overall management of the development of nuclear industry standards is the responsibility of ANSI's Nuclear Standards Management Board (NSMB), whose members are appointed by the more than 40 technical and professional societies that have interest in the nuclear field. Representative of these participating organizations are the American Society of Mechanical Engineers (ASME), the American Nuclear Society (ANS), the National Bureau of Standards (NBS), the Institute of Electrical and Electronics Engineers (IEEE), and the American Society for Testing and Materials (ASTM).

The societies serving on the NSMB sponsor the work, organize standards development and writing groups, and administer the processes involved in obtaining national consensus on the completed standards. The actual writing of the standards is done by experts in the field, most of whom are members of the pertinent technical and professional societies. The services of these experts are "volunteered" by their employers because of the need of good standards.

ROLE OF NSMB

It has been estimated that the standards which would have potential value in the construction and operation of nuclear facilities number about 5,000. Some of these exist as voluntary standards developed for non-nuclear applications but are nonetheless appropriate for nuclear uses. Other usable standards are available from federal government or military specifications.

In order to provide the needed new standards, ANSI-NSMB manages and coordinates the efforts of the individuals that develop nuclear standards. The sheer size of the group of talented contributors creates problems, such as:

- Effective direction of writing groups to prevent wasteful duplication of effort and unnecessary delays
- Standards writing organizations must be involved as efficiently as possible to take full advantage of their capabilities.
- The urgent need for most of the standards under development calls for close monitoring of work programs.
- All participants must be kept informed of government regulatory activities in order to coordinate the industries' standards program with the regulatory program.
NSMB Organizational structure

The management structure of ANSI-NSMB reflects the participatory nature of the standards development program. NSMB is headed by a chairman and is managed by various committees. These committees work to meet the challenges and solve the problems that arise in the management of the program, evaluation of the work, promotion of the use of standards developed, and maintenance of those standards.

Executive Committee

The responsibility for continuous management of the nuclear program lies with the NSMB Executive Committee, which consists of a chairman, two vice-chairmen, and eight members. In order to fulfill its responsibility, the Executive Committee is organized to emphasize participation in a responsible capacity by designated representatives of the principal technical and professional standards-writing organizations that sponsor the NSMB standards committees.

Practices & Procedures Committee

The Practices and Procedures Committee is responsible for developing and maintaining guides for program participants. These guides document practices and procedures for the development of nuclear standards and are recommended for use by groups in the nuclear program whose sponsor organization does not have documented procedures applicable to the circumstances encountered.

Training and Orientation

A responsibility of management is to provide proper training and orientation to those involved in the project. Training and orientation can help to familiarize participants with ANSI and NSMB procedures and also to communicate to them the philosophy and objectives of the nuclear program.

Program Evaluation

In an enterprise as large as the ANSI-NSMB nuclear program, it is necessary to be fully aware of the job that is being done. One of the needs of the program is a means of pinpointing areas where new standards are needed or where existing standards need evaluation. The critical areas in the NSMB self-evaluation structure are how much of the job is done and how much is yet to be undertaken. This need is met by several committees with the use of various informational tools.

Project Charters

Charters for Nuclear Standards Projects and Approved Standards gives the scope, technical bases, and professional interfaces with other standards and projects and the writing group members and their company affiliations. The charters form a basis for avoiding duplication and overlap and provides for appropriate interfaces.
Evaluation of Need for New Projects

The ANSI Staff receives and processes requests for new projects, changes in scopes of existing projects; requests for deletions of projects; and requests for interpretation, revisions, reaffirmations, or withdrawal of existing American Nuclear Standards. Recommendations based on these requests, together with input from the appropriate executive director are prepared by the ANSI staff and are acted upon by the NSMB Executive Committee.

Committee on Industry and Government Standards

NSMB realized that many codes, guides, and other documents that have already been promulgated could be used in the nuclear industry. Accordingly, a Committee on Industry and Government Standards was organized to review standards, criteria, guides, procedures, and similar documents developed outside the aegis of ANSI to establish their propriety as bases for American National Standards. Originators of the documents are technical and professional societies, industry and commerce, governmental agencies (including the military), etc. As a consequence of this review, a document may be referred to a cognizant American National Standards Committee or to an ANSI-accredited organization for appropriate action, including revision if necessary for adaptation, toward adoption as an American National Standard.

As an adjunct to this responsibility, the committee also provides liaison with other Technical Advisory Boards, reviews NRC regulatory guides to seek topics appropriate to standardization and to determine how existing standards referenced in guides may be revised to better serve that purpose, and publicizes to the nuclear community, within proprietary bounds, the existence of useful privately prepared standards.

Failure and Incident Reports Review Committee

In addition to developing and adopting new standards, NSMB is also responsible for seeing that those standards already developed are fulfilling the needs of the industry.

The Failure and Incident Reports Review Committee receives reports of nuclear and nuclear-related failures and incidents and reviews these reports to determine whether they indicate that action is necessary to revise existing standards or to develop new standards.

CONCLUDING REMARKS

From the foregoing discussion it is clear that the development of standards for the nuclear industry involves an enormous amount of resources in terms of manpower, expertise and money.

The staff of the Standards Development Division, PAEC, is not intended to engage in the original development of standards; rather, its role is to review the standards in use elsewhere, specially in the US, and adapt these to local conditions. To carry out this task, many of the staff have received training abroad and others will have to be trained likewise.
The Commission plans to involve local technical and professional societies in the review and adaptation of foreign standards. This way, these groups will become aware of the needs of the nuclear industry and become encouraged to actively participate in the national nuclear program.

The staff also actively encourages the formation of relevant societies such as the Philippine Society for Non-destructive Testing (PSNT), the organization of which is nearing formalization. Hopefully, the Society, like its US counterpart, the ASNT, will contribute its share towards the safe construction and operation of nuclear power plants, such as the PNPP-I.

Finally, we recognize that:

a) Standards are essential to nuclear safety

b) US standards are an excellent starting point but they must be modified for Philippine conditions

c) Developments in the area of nuclear standards should be monitored closely.
INTRODUCTION

One of today's major global concerns is the effect of the new technologies on national economies, on the well being of peoples who are ultimate beneficiaries. Some of these change mechanisms, go beyond socio-economic boundaries and turn a political color as their tremendous possibilities dawn on national leaderships. Their significance as instruments for development, not to mention dysfunctional implications of power and control, make them indeed very alluring. No small wonder then that prestige among nations is quite often gauged in terms of their degree of advancement in the various fields of science and technology. Thus we note the superpowers racing into the universe, exploring space, at the same time that the scientists left earthbound go about studying the infinitesimals that could lead to discoveries on the why's and wherefores of man and things. As the scientific rat race continues, decisions are made - by politicians and administrators on the utilization of the exciting breakthroughs. These decisions, particularly the impact they have on society, on people, become in the end the measure by which
technologies are judged and finally accepted or rejected by their intended beneficiaries.

Public attitudes in recent years have greatly affected decision making on the utilization of technologies. Such social response has in many cases focused on risks associated with such developments. This has stimulated interest in risk assessment research. One concern of such research is that of anticipating the totality of social response to risk situations and in understanding the mechanisms underlying the formation of this response. Clearly, response is not based solely upon theoretical or statistical risk predictions but rather, is multiply-determined through a variety of perceptual, information processing, and learning functions which are instrumental in the formation of attitudes toward the technology and its risks.

TECHNOLOGICAL RISKS AND PUBLIC ATTITUDES

Coping with risk has been an intrinsic aspect of life in all societies throughout history and problems of hazards and the environment always occur as socio-economic as well as political problems when effects resulting from manmade activities are no longer small in comparison to natural effects at the same place at the same time. For this reason, it seems government regulations have become a dominant mode of coping with technological and environmental hazards. We see thus, growth in the number of safety personnel and regulatory staff with increasing scientific research and public concern about
environmental and safety problems.

Participation of the public in matters concerning technological risks, even if it is assumed that there is neither the possibility nor the desire to participate in every or even any public decision, is of symbolic importance serving as a process of social identification and as a means to hinder alienation since "processes of social interaction in the making of decisions are a central part of social experience and meaning for the people". (Wynne, 1979)

Even if symbolic participation may sometimes delay or even paralyze technological projects, it is probably a constructive element of public decision making and may be counted as opportunity costs. Bearing in mind (1) that people are informed about a concrete technological project at a very late stage while at the strategic level the planning process is usually at best highly abstract and at worst plain secret and (2) that people are not invited to articulate demands and concerns during planning and are thus without opportunity to voice their views or priorities in the light of overall conceptions and constraints of public interest, the apparent apathy of the silent majority can easily be seen as into what appears to be arbitrary action against random technological targets as buried anxieties are expressed. Such protests may be the only language left in which the technically alienated can communicate more complex values and feelings. Without this outlet, the feeling of being pushed hastily through one-way gates into futures of uncertain benefit and further consequences continues to be at the
heart of opposition to various forms of technological development.

The recently often observed mistrust in the credibility of both scientific expertise and political decision-making (Coad, 1979), a world-wide situation, seems also quite understandable when the following factors are considered:

- the fundamental uncertainties with new technologies, their irreversible character and the dependence on professional expertise for their implementation;
- the knowledge that vested interests are always involved in, or connected with, a specific technology;
- society's values are diverse and frequently conflicting thus impeding a common value basis for overall risk-benefit decisions even if it is assumed that technology only serves as a means to specified ends;
- technical intelligence embodied in developmental expertise is also political intelligence (Wynne, 1979) to the extent that it influences the allocation of resources, and of benefits and costs between different social sectors and interests, and therefore legitimizes the power of institutions and interests of various sorts;
- the consequences of a technology are always unevenly distributed over different social groups (some may get jobs, others may lose them, etc.);
- basic decisions regarding technologies are rarely put at the disposal of the general public and scientific evaluation of
projects generally have only a legitimatory character (O'Riordan, 1978)

All these points to the possibility that the realization of certain technologies will continue to be blocked by public resistance and also puts to the fore the role of scientific expertise and of risk assessment.

In one paper (Green, 1978), the point was made that risk benefit assessment is useful for public policy decision-making in a democratic society only if the assessment is not taken too seriously by either the assessors or the decision makers. This was also expressed by the Council for Science Society (1977):

"Rather than continuing to demand an answer to the question whether a risk is fair in itself, we should redirect our attention to the ways that risks come about and are controlled. That is, we should focus on the procedures by which decisions are taken on the creation or persistence of risks, and ask whether these procedures are fair."

Legitimation by these procedures has brought out a serious need for consideration of continuous regulation rather than single decisions in dealing with risks and the participation of those affected. This could regain credibility, and thus the legitimacy, of decision-making institutions and lead to reaching an acceptable consensus (Pearce, 1977).

The role of information, the methods of public participation, and the involvement of scientific expertise continue to play a major
part in risk assessment. They point to the need for awareness of the following vital considerations:

- that substantial changes in public attitudes towards technological controversies and scientific advice are indispensable;
- that public information and debate on hazardous technologies must start before investments have been made and before principal decisions have been taken;
- that the political outcome should be a compromise as the basis for acceptable consensus;
- that the symbolic dimensions of technology and public participation be taken seriously;
- that it is important to take into account the influence of interest groups on the use, impact and control of technology (Council for Science and Society, 1977).

THE PUBLIC AND NUCLEAR POWER CONCERNS

Human imagination is often far worse than reality. Nowhere has this been more amply demonstrated than in the fears expressed about the risks of nuclear power. Compounding this is the perception of technical expertise as public relations efforts to convince people of the safety of a technology.

In a democratic society where there is a broad coverage of items of public interest by the mass media, public discussions are subject to certain basic structures. One of these is that a public issue
normally shows a certain chronological course. After a certain time, when all has been said about the issue, it begins to die and can only be reborn as another topic.

The case of nuclear power seems to belie this however. If we are to use newspaper coverage as an indicator of public awareness, nuclear power has been a recurring public issue in the Philippines and can be graphically seen in Table 1.

Interest in nuclear power as reported by the media from 1976 gives the following interesting trends -

1976 (January, February and May) - 13 news items.
1977 (January, February, May, July, August and December) - 16 news items.
1978 (January to September) - 29 news items.
1979 (January to November - 190 news items with two peaks, July with 57 and April with 44, in both months an almost daily coverage - 23 days in July and 21 days in April.

It will be recalled that the TMI incident accounted for the intense reporting in May and the public hearings on the PNPP-1 in July. November follows in print media coverage, this time highlighting the Puno Commission Report on the public hearings for the PNPP-1.

We have also monitored the nuclear issues and have come up with the following areas of concern for the period 1974-1979 through print media coverage:

1974
1. Environmental effects
2. Proliferation of nuclear weapons
3. Political implications (vehicle for a new kind of colonialism)
4. Reactor safety

1975
1. Environmental effects
2. Safeguards
3. Nuclear liability
4. Reactor Safety
5. Political (uranium dependence on a foreign source)

1976
1. Risk-benefit comparisons (also with alternative energy sources)
2. Reactor accidents
3. Siting (earthquakes)
4. Radioactive waste management

1977
1. Reactor safety
2. Environmental effects
3. Radioactive waste disposal
4. Safeguards
5. Social aspects
1978
1. Economics
2. Nuclear Safety
3. Siting
4. Waste disposal
5. Conflict of interest/choice of suppliers
6. Local capability (subcontractors of Westinghouse)
7. Quality assurance (construction materials)
8. Nuclear Fuel supply
9. Reliability of U. S. nuclear reactors
10. Regulatory staff competence
11. Proliferation of nuclear weapons
12. Social aspects
13. Reenforcement of urbanization
14. Sabotage/terrorism
15. Unreliability of reactors (frequency of shut-down periods)

1979
1. Social aspects
2. Waste disposal
3. Reactor safety
4. Siting
5. Cost-benefit assessment
6. Nuclear fuel supply
7. Local capability
8. Economic dependence on developed countries
9. Technical elitism
10. Environmental effects
11. T M I
12. Presidential order of Public hearing on PNPP-1
13. NRC freeze of export license

Most of these issues were aired in public symposiums, principally in four assemblages in 1978. Significantly, three of these were held in university campuses (Ateneo University, Loyola Heights, UST; and U.P., Los Baños) and the fourth at the Paulino Garcia Pavilion of the National Institute of Science and Technology. Organizers aside from student organizations were the National Federation of Women's Clubs, Inc. and the Consumers Federated Groups of the Philippines, Inc. Most of the other symposia or seminars where nuclear power was discussed was in school gatherings either during foundation days or science-oriented activities like Science Fairs, Atomic Energy Week and the like.

There are also a number of local organizations which have made the nuclear power project a major area of their concern. We assume their membership to be predominantly environmentalists in persuasions as their associations are aptly called Kilusan para sa Kapaligiran and Ecology Foundation of the Philippines, among others.

While we are not saying that news items and public seminars represent the sentiments of the public we also admit of their influencing role in the formation of attitudes and that they could
serve, in fact, as indicators of the amount, degree and level of public information.

RISK ASSESSMENT AND ATTITUDE RESEARCH

It will be noted that the nuclear controversies have developed over a period of time; the newspapers and other media, public meetings and hearings have been used as arenas of these conflicts. During this time, various groups and individuals formed opinions and made statements. Opinion polls in various countries have demonstrated that instead of varying opinions there is a growing disagreements among the public how to evaluate options for future developments of our technology-oriented society, including the nuclear. This has induced scientific interest towards improving our understanding of the beliefs, evaluations and attitudes of people vis-à-vis such issues. (Schaefer, 197 ). Of special interest is the question why there is increasing resistance against technologies currently developed and implemented, especially against nuclear energy.

People assess risks on the basis of what information is available to them. They may then distort the messages they have received or even refuse to listen to them, but always information flow from friends, from the media, from scientific papers, complements and interacts with personal experience to form judgements.

Today more than ever before, the risks from technological hazards are only seen that it is no longer only the layman and the public that depend on information flow to assess risks. It is also the scientist, the expert who need information from other scientists.
before he can evaluate the implications of his own data.

Risk assessment is therefore dependent on effective communication not only with the public but between scientists and decision-makers, and sometimes, it is at the mercy of willful individuals, inter-departmental jealousies and misunderstandings, and inter-disciplinary cliques and rivalries.

Thus the risk estimations that emerge at the end of the scientific and social process can never be really separated from the credibility of those who contribute to them, or from the communication that has, or has not occurred between them.

It is not simply scientists that estimate risks and others who evaluate them; scientists evaluate and laymen contribute to estimations. Our concern here is with both expert and public risk assessment and the information flows that link, or do not link them.

The existence of public debates about the acceptability of technologies suggest the difficulties which have been encountered in attempting to reconcile technological and social systems in public planning and decision processes. Technologists are often faced with the problem of equitably balancing complex technical data with the corresponding social attitudes. Aware of the importance of these attitudes, but unable either to measure them or to aggregate them with technical data, their recommendations are often based solely upon technical and engineering aspects. This, in effect, requires the ultimate decision makers, typically politicians, to assess the trade-offs between technical and social issues in a purely intuitive fashion.
An approach to attitude measurement is the work of Fishbein (1963, 1967) and his associates (Fishbein and Ajzen, 1975), that permits one to analyze the cognitive structure underlying attitudes. Figure 1 summarizes the relations between beliefs, attitudes, intentions, and behaviours with respect to a given object.\footnote{Definition: A belief is a probability judgment that links some object or concept to some attribute. For example, one might believe that Automobile A (an object) is expensive (an attribute). The strength of the belief is defined by the person's subjective probability that the object-attribute relationship exist, or is true. An attitude is an evaluative judgment that one likes or dislikes the object, that it is good or bad, that he feels favourable or unfavourable towards it. One may have attitudes towards concepts, people, institutions, events, behaviours, outcomes, etc. An intention is a probabilistic judgement that links the individual to some specific action, i.e., an individual's belief that he will perform some specific behaviour. Behaviour is an observable action.}

It may be seen that a person holds many beliefs about an object; that is, he associates that object with a number of different attributes. It has been found that knowledge of a person's beliefs about an object and his evaluations of the associated attributes allows an accurate prediction of his attitude toward any object. A person's attitude toward any object is a function of his beliefs about the object weighted by these evaluations; however, it is the entire set of salient beliefs that determines the attitude and not any specific belief.

Once an attitude has been formed, a person is pre-disposed to behave in a consistent manner with respect to that object. Although his attitude does pre-dispose him to perform a set of behaviours, it does not pre-dispose him to perform any specific behaviour. It had previously been assumed that a person's attitude towards some object would influence some particular behaviour with respect to that object;
it is now clear that attitudes towards an object may have little or no influence on any specific behaviour. Just as attitude is determined by the entire set of beliefs that a person holds, the attitude only serves to pre-dispose the person to engage a set of behaviours that, when taken together, are consistent with the attitude. Figure I also shows that a person's intention to engage in a specific behaviour with respect to an object is viewed as the primary determinant of that behaviour. In contrast to the relations between beliefs and attitudes, and attitudes and intentions, we do assume a one-to-one relation between intention and behaviour, barring outside interventions.

The way in which the beliefs linking the object to specific attributes combine with the evaluations of those attributes can be mathematically written as:

\[ A_o = \sum_{i=1}^{n} b_i e_i \]

where:
- \( A_o \) = the person's attitude toward object \( o \)
- \( b_i \) = the strength of belief \( i \) about object \( o \); i.e., the subjective probability that \( o \) is related to some attribute \( i \)
- \( e_i \) = the subject's evaluation of attribute \( i \)
- \( n \) = the number of salient beliefs the subject holds about object \( o \).

Although this model was derived from principles of learning theory, and, in particular, the notions of conditioning and mediated generalisation, it is structurally similar to Rosenberg's (1956) expectancy value model and Edwards' (1954) subjective expected utility model.
In a pilot application of the model (Niehaus, 1978), although only preliminary, the findings illustrated the complex nature of the cognitive structure underlying public attitudes toward nuclear power and its use. Not only are beliefs about the benefits of nuclear power relatively independent from beliefs about nuclear power risks, but people can believe that the use of nuclear power will lead to some types of risks (e.g., socio-political) without believing that it will lead to others (e.g., environmental).

For the sample of the public interviewed in this study, beliefs about psychological risks were responsible for the greatest differential contribution to attitudes pro and con. For the con group, the beliefs about psychological risks and socio-political risks together contributed more to attitude than did the combined environmental risk and economic benefit beliefs. This tends to support the suggestion (Otway, 1977) that the nuclear controversy is highly symbolic in nature with the psychological and socio-political implications of nuclear power being the crucial underlying issues rather than its environmental risks.

It should be clear that if decision makers wish to take public attitudes into account it will not be sufficient to simply view people as pro or con a particular technology. If a public is con primarily because of their concerns for the technology's potential socio-political risks, the decision maker faces a very different problem than if the basis for the public's con position is their concern for the environment. Moreover, it must be realized that there is not one, but many different publics, and these publics will vary in size and import.
Attitude research can identify different publics and provide information about the basis for the pro or con attitudes that are held by these publics. (Niehaus, 1978) There seems to be little question that information of this type should be used by decision makers. How, and to what extent, this information should enter into decision processes are questions that decision theorists will have to answer. And this is again another area of research.
NEWSPAPER RELEASES ON NUCLEAR POWER

Legend:
- Times Journal
- Bulletin Today
- Daily Express
- People's Journal
- Others

Year:
- 1979: 12
- 1978: 49
- 1977: 43
- 1976: 2

Number of Releases

[Graph showing the number of newspaper releases on nuclear power from 1976 to 1979]
Relationship between Beliefs, Attitudes, Intentions, and Behaviours with Respect to a Given Object

FIGURE 1
REFERENCES


8. Osgood, Charles E. Probing Subjective Culture: With Special Reference to Cross Cultural Social Psychiatry.


